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Benefits and Synergies in Addressing Climate Change via the Implementation of the Common Agricultural Policy in Greece

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Abstract: This study aims to provide a comprehensive analysis of the effects of climate change on Greek agriculture, by evaluating and refining the current policy measures and interventions to address them through the lens and funding opportunities of the new Common Agricultural Policy (CAP) 2023–2027. To this end, we conducted a diagnostic analysis of the current strategic framework in Greece and provided policy recommendations around five key areas: education, consulting services, agri-food cooperation, coupling of innovation, and digitalization, as well as risk management on climate change. Overall, we found that the national strategic framework is consistent with the objectives and priorities of European policies regarding the environment and the climate, but targeted actions are needed to enable the management of the Greek agricultural sector while addressing the risks of climate change, environmental degradation, and the excessive use of natural resources. The findings highlight the importance of much-needed revisions in national strategic planning. We have suggested key interventions and actions for dealing with climate change with regards to Greek agriculture and the overarching goals of the new CAP to promote sustainability, knowledge, and innovation in the agri-food sector.

Keywords: Common Agricultural Policy (CAP); climate change; Greek agriculture; green deal



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1. Introduction

Agriculture is one of the most important sectors of economic activity that both affects and is affected by climate change [1], as its sustainability depends directly on the duration and intensity of climate phenomena and factors such as temperature, precipitation (rainfall, hail), solar radiation intensity, and the concentration of carbon dioxide in the atmosphere [2]. Especially in the case of Greece, the exposure of agricultural producers to the risks of climate change is important, as they are already experiencing a range of adverse effects on the productivity, diversity and durability of their crops, the fertility of their soils, the availability, adequacy, and quality of irrigation water, etc. These in turn affect their income and largely determine the sustainability of their farms, their standard of living, and in general their life and ability to remain located in the Greek countryside [3].

Recognizing that the risks of climate change to agriculture are not only economic but also environmental and social, the EU is promoting important institutional initiatives aimed at protecting agricultural production, ensuring food adequacy and food security, and protecting the environment and social cohesion of its rural areas. The new Common Agricultural Policy (CAP) for 2023–2027 [4–6] is called upon to respond to the challenges of

climate change through the adoption and implementation of these actions, incorporating into its objectives the increased level of European ambition for environmental and climate policies. Its main objective is the transition to a new resilient, green, and digital agri-food model, combining sustainability with the EU's environmental friendliness objectives [7]. This has been reflected in its various policies, from the European Green Agreement and its specialized strategies for "Farm-to-Fork" and biodiversity initiatives to the European Climate Law, the Recovery and Resilience Facility, and the Just Transition Mechanism etc. [8]

Climate change in the agricultural sector is pushing Europe and the world to change their approach to policies and strategies related to their production and development models. Inevitably, Greek agriculture must also seek its own strategic orientation that will lead and enable it to meet the new requirements of the "European Green Architecture" and to ensure the competitiveness and sustainability of its production structure. Towards this new perspective, a need emerges to reorient the production model of Greek agriculture on the basis of adopting a "greener" approach that takes advantage of agri-environmental and climate actions and policies. Published in June 2018, the EU Commission's proposal for the next CAP included some promising elements from a climate and environmental perspective, such as a newly expanded set of mandatory actions (e.g., to protect peatlands) or "eco-schemes" as a new, voluntary-based instrument to incentivize farmers to deliver public goods. However, some studies indicated that the proposed actions may not achieve their goals, as simply classifying 40% of the CAP's budget as "climate-friendly" is unlikely to lead to reduced GHG emissions without a specific investment structure for agriculture decarbonization [9].

In this context, the present study aims to provide a comprehensive description of the relationship between Greek agriculture and climate change, through a coherent diagnostic study of their interaction. We examine the key aspects of a better consolidation of the new European Union's (EU) environmental and climate strategies in the agricultural sector in the context of the European Green Deal. Through the appropriate theoretical framework, we highlight the needs of Greek agriculture in respect of the proposition of specific policy measures and interventions to address the effects of climate change and the financial opportunities that the new CAP 2023–2027 offers. Furthermore, we aim to suggest appropriate interventions and actions towards enriching the mechanisms and tools for the management of Greek agriculture in the face of the risks of climate change, environmental degradation, and irresponsible use of natural resources. The proposed measures can be embedded within a national strategic framework consistent with the European environment and climate policies and can serve the objectives and priorities of the new CAP 2023–2027, which will be its main source of funding. The timing of the promotion of such a new agri-food development model appears to be appropriate, as an integrated and ambitious framework of environmental and climate policies seems to have matured in principle at the EU level, particularly regarding the new CAP, which has considerable resources to finance its implementation.

The novelty of the present study lies in its comprehensive examination of the relationship between Greek agriculture and the effects of climate change, and its aim to highlight the key aspects of consolidating the new European Union's environmental and climate strategies in the agricultural sector in the context of the European Green Deal. The study proposes specific policy measures and interventions to address the effects of climate change and the financial opportunities that the new CAP 2023–2027 offers and suggests appropriate interventions and actions towards enriching the mechanisms and tools for the management of Greek agriculture in the face of the risks of climate change. The study is particularly noteworthy for its timing, as an integrated and ambitious framework of environmental and climate policies seems to have matured in principle at EU level, particularly regarding the new CAP, which has considerable resources to finance its implementation. The study also provides a theoretical coverage, as well as a historical and geographical overview of the linkages between CAP and climate change, combining them to form strategic policies, measures, and interventions.

The remainder of this study has been structured as follows. In the second section we provide the theoretical coverage revealing the historical and the geographical overview of CAP, as well as the linkage between CAP and climate change. This comprehensive mapping allows us to formulate strategic policies, measures, and interventions, which are presented in Section 4. Section 5 contains some conclusions, and the Section 6 outlines the limitations of this study and future research perspectives.

2. Literature Review

2.1. Overview of CAP and CC Adaption Measures for Regional Agri-Food Activities

Through the years, successive reforms of the CAP have progressively included more environmental objectives and as a result, required policy instruments to tackle them. To this end, CAP payments for Less Favored Areas (LFAs) were first introduced in the 1970s, having a compensatory role for lower incomes earned by farmers located in disadvantaged areas and achieving various levels of success [10–12]. These payment structures were also developed to foster environmentally advantageous agricultural activities, as their implementation could limit farmland abandonment while preserving landscape and biological diversity and [13]. Agri-Environment Schemes (AESs) were introduced from the 1980s in the Netherlands and the United Kingdom in specific areas of environmental interest, with the intent to support producers who were voluntarily implementing environmentally friendly farming practices [14]. In 1992, these AESs became mandatory, with half of their financing needs being supported by EU resources, helping the agri-foods sector's adaptation to the novel economic and agronomic conditions [13].

The CAP “Health Check” [15] of 2009 extended the thematic coverage of AESs by adding climate objectives, coupled with an increase in the co-financing rates coming from the EU's budget, while the aforementioned AESs were from 2015 renamed Agri-Environment and Climate Schemes (AECSs). The striking differences in environmental conditions among EU member states were part of the reasoning for delegating the design and implementation aspects of AESs and AECSs to decentralized state authorities, as they were deemed more suited for addressing regional issues and incorporating local interests and preferences into environmental objectives and practices. Despite the voluntary nature of farmers' participation and the compensation being limited to “*incurred costs and/or foregone income*”, these instruments covered about a quarter of EU agricultural area in the early 2010s [13].

During the previous phase of the CAP (2014–2020), environmental issues were addressed through a combination of measures in both Pillar 1, including cross-compliance and direct payments to farmers to help with volatility in market prices and adverse weather conditions, and Pillar 2, which intended to promote a more balanced territorial development and a sustainable agri-food sector, as well as enhancing competitiveness and innovation [16]. Indeed, the second pillar of CAP specifically focuses on rural development, as it aims to support the sustainable development of rural areas by providing funding for a wide range of initiatives, including measures to promote economic diversification, improve infrastructure and public services, and enhance the natural and cultural heritage of rural areas. The funding provided under this pillar was intended to support rural development projects that are in line with the EU's broader environmental and climate objectives, and was designed to be flexible in order to meet the specific needs and priorities of individual regions. The related measures were based on mixed compensation structures and can be understood as an explicit acknowledgement of the trade-offs between product competitiveness and environmental objectives, as the latter can result in elevated production costs.

During the last decade, ongoing research has emerged regarding the common agricultural policy in response to climate change [17], as well as the regional importance of such agricultural policies, with a special focus on the contribution of the EU CAP to protect biodiversity from global and unprecedented climate changes reported in Europe [18]. To understand the extend in which the CAP's framework has been adopted and applied in a wide spectrum of key domains (agriculture, climate change actions, environmental deple-

tion, governmental policies, and in-field EU and Greek priorities), we conducted a search of the related academic literature within Scopus, in specific fields, using the keyword “CAP framework”, and focusing on the EU and the Greek context. This literature overview also revealed the linkages between the introduction of models and the conformity of regulations with the CAP measures, policies, and priorities. The results are presented in Table 1, organized per year of publication (from recent to oldest) and region.

Table 1. Overview of selected CAP-related literature for EU and Greece.

Source	Region	Key Aspects and Main Findings
[19]	EU	In this study an agricultural partial equilibrium model (CAPRI) was used to estimate the potential uptake of GHG-reduction subsidies in EU regions, finding that a budget-neutral re-allocation of financial resources towards subsidized emission savings can reduce EU agricultural non-CO ₂ emissions by 21% by 2030. Assuming regional budget-neutrality condition, it can also introduce inefficiencies in the incentive system, thus threatening the EU farming sector’s GHG emissions reduction, but also leaving space for the design of more efficient agricultural policies for climate action.
[9]	EU	The assessment of the EU’s CAPs payment distributions indicated strong biases, calling the EU to address payment inequalities reported among farmers as well as direct subsidies towards impeding environmental degradation, promoting decarbonization in agriculture and controlling biodiversity losses. The efficiency of the proposed measures against environmental degradation in the EU necessitates well educated farmers, with sound knowledge and firm attitudes at both climate change issues and the role of policy analysis in order for the CAP to be effectively deployed.
[13]	EU	In this study it was found that Pillar 1 of CAP is considered as a new environmental instrument, the ‘eco-scheme’, under which the CAP would be implemented through national strategic plans enabling EU member states to deploy policies of the subsidiarity principle. This article explains the weak environmental effectiveness of the CAP effectiveness is low and there is a shared responsibility of the EC to some extent that could improve the regulation of the environment and climate impacts of European agriculture. Pillar 2 measures are considered unchanged with their strengths and weaknesses, implying a risk that short-run political pressures will moderate countries ambition in their eco-schemes. However, by following the principles of public economics and environmental federalism can responsibly tackle climate and biodiversity issues while defining simple and robust agri-environmental indicators.
[20]	EU	The strong affiliation of agriculture with climate change was investigated in terms of the developed relationship of economic performance-carbon dioxide emission as a high priority issue for CAP during the last decade. Within this socio-economic context the relationship between agricultural carbon emissions equivalents and income per capita for the agricultural sector in different EU countries with the assistance of the nonlinear autoregressive distributed lag (NARDL) co-integration technique, it was studied, showing the strong relationship between GHG emissions and agricultural income in all instances. An asymmetric impact on agricultural income due to carbon emissions could enable policy makers to implement relevant policies with suitable tools that successfully promote the increase of agricultural income along with mitigating GHG emissions.
[21]	Greece	Forestry in Greece, even though it has been characterized by limited funding, constitutes a key socio-economic and environmental determinant of local prosperity since it involves the production of goods and services while simultaneously contributing to the protection and the enhancement of mountainous and countryside areas. The accession of Greece to the EU, and its subsequent inclusion in the CAP framework, it can support funding for various actions that promote forests and unveil their multi-functional role to national economy and society.

Table 1. Cont.

Source	Region	Key Aspects and Main Findings
[22]	Greece	Important measures for the environmental protection of agricultural land in the EU countries are accompanied by measures of the reformed CAP. Such measures concern the Reg. 2078/92/EEC regarding “crop production methods, compatible with environmental protection and conservation of landscape”, the Reg. 2079/92/EEC regarding “farmers’ early retirement”, and the Reg. 2080/92/EEC (article 31 of the Reg. 1257/99/EEC) about “forest measures in agriculture”. In this study it was argued that while several thousand hectares of mixed agroforestry systems were set up in the rural areas of Greece, a high number of farming and non-farming applications within the framework of Regulation 2080/92 were rejected. The present study concerned the evaluation and the application of Regulation 2080/92 in the region of Pella’s Prefecture (Northern Greece), as a representative area, denoting that at the period 1993–1998, 2600 Ha of agricultural land was planted with forest species (mainly <i>Robinia pseudoacacia</i>, <i>Populus</i> sp., <i>Juglans regia</i>). The study was implemented through analysis of data supplied by the Forest Service and questionnaires filled in by beneficiaries. It was also shown that the 2080/92 Regulation led to the afforestation of 22,777 Ha of broadleaves species at a cost of approximately 22.2 billion drachmas (about 64 mil. euro).
[23]	Greece	The efficiency of LEADER+ action plans of seven rural areas in Northern Greece was investigated at this study with a Data Envelopment Analysis (DEA) model, based on data from LEADER+ provided by the Ministry of Agriculture. Through the DEA method the relative efficiency of local actions and for the investigation of the inputs and outputs were measured, revealing how the maximization of their relative efficiencies could be achieved through its use. The specifications and the characteristics of the DEA model were adapted to the empirical application of the input-oriented DEA method, showing that some Decision-Making Units could maximize their relative efficiency by making and considering internal adjustments of the input data employed.
[24]	Greece	Energy crops are subjected to persistent policy support by the EU, despite their limited or even marginally negative impact on the GHG effect. This study approached the optimization of the agricultural income generated by energy crops (created from soybean, sunflower, and corn) in a remote and disadvantageous region of mountainous Greece in alignment with the linear programming. Different policy scenarios they imposed restrictions on the value of the subsidies as a proxy for EU policy tools, the value of inputs (costs of capital and labor) and different irrigation conditions, revealing that corn cultivation contributes the most to income maximization, whereas the implemented CAP policy played an incremental role in choosing an energy crop. A key implication is that alternative forms of motivation should be provided to the farmers beyond the financial ones in order the extensive use of energy crops to be achieved.
[25]	Greece	The 1992 CAP reforms in Europe shaped the preconditions for a considerable amount of agricultural land to be withdrawn from food production in favor of wood production. Subsequently, productivity-related agricultural activities have lowered their predominant role in developmental processes in rural areas. This study investigated the personal and the social characteristics of poplar investors/cultivators as well as the determining factors of poplar plantations sizes according to the EEC Regulation 2080/92, through questionnaires administered within the Prefecture of Pella. It was reported that farmers constitute the majority of investors/cultivators while large land areas were privately owned. Moreover, the irrigated land size, the participation in European programs and other European regulations they were primary contributing factors of the establishment of poplar plantations.

2.2. Key Aspects of CAP and Climate Change in European Union and Greece

Agriculture plays an extremely important role in the environment and climate conditions as it directly affects the landscape and the preservation of the countryside, its biodiversity, ecosystems, and land physiognomy [26,27]. Agriculture is also a key determinant of biodiversity losses and a major contributor to land-use changes that accelerate climate changes and its impacts [28]. Subsequently, policies undertaken in order to shape farmers’ decisions and agricultural landscapes require careful and systematic monitoring of their impact. In this context, the recognition of the dangers of climate change for agriculture has urged EU to promote and put in action important, sustainability-inspired institutional initiatives. In this direction, the CAP is one of the most important policy frameworks that reflects the importance and vulnerability of agriculture, providing a significant impact on farm structures, agricultural employment, rural areas, as well as broader economic, social, political, environmental, and cultural implications for both old and new member states [29]. Accordingly, a significant portion of the EU budget has been traditionally accrued to the CAP. The new CAP for the period 2023–2027 [3–5] aimed to confront the

challenges of climate change through the adoption and the implementation of substantial and responsible actions. Through its main strategic priorities, it aims to:

- ensure fair income,
- increase competitiveness,
- rebalance power in the food chain,
- act against climate change,
- provide environmental care,
- preserve landscapes and biodiversity,
- support generational renewal,
- enhance vibrant rural areas, and
- protect food and health quality.

The evaluation of the implementation procedure of the previously set environmental and climate CAP measures (such as multiple compliance, greening or ecological orientation and other Pillar 2 measures) has recorded significant problems in the activation and the implementation of the planned interventions in both the EU and Greece [30,31]. However, without taking additional and more emphatic actions to further reduce GHGs, achieving the set goal of climate neutrality by 2050 (the reported goal of the European Green Deal) will be challenging. It is also noteworthy that operating the CAP under a new “green architecture” can be based on the systematic synergy and complementarity of the two foundation Pillars: Pillar 1 (direct aid) and Pillar 2 (rural development), through:

- the combination of a better balance between mandatory and voluntary Pillar 1 and Pillar 2 environmental and climate measures and standards,
- the establishment of a minimum budget framework bordering of the interventions,
- setting specific and measurable performance indicators,
- the provision of relevant incentives and flexibility in management and implementation,
- the deployment of supporting mechanisms to promote innovation and cooperation in the agricultural sector.

The aforementioned set of initiatives is ubiquitous for all member states but may also fall under the purview of single, national strategic plan, developed and implemented by each member state after receiving prior endorsement and approval from the EU. These objectives should have an impact that reflects the CAP’s increased ambition for the agriculture sector’s climate action and for a more incentive-based direct payment delivery system that is operated within tight budgetary restrictions. Despite the difficult economic climate, the Commission’s statement, and the CAP’s legal proposal, both of which were recently published [3–5], remained ambitious in their efforts to advance and foster the program’s three pillars—social, economic, and environmental—while delivering “more benefits with less money spent”. Therefore, effective coordination and transparency in managing the resources of the new CAP through the simplification and protection of the relevant institutional framework are key success factors, followed by awareness and active participation of all parties involved to ensure the required consensus, acceptance, and practical support of the terms, changes, and reforms of the “green transition” to the new productive and development models [32].

The direction and structure of the CAP’s funding in Greece is reflected on the budget allocation within the three main categories (direct payment expenditures, rural development expenditure, and market expenditure). In 2020, over half of direct payment expenditures have been directed to Basic Payment Schemes (BPS), which amounts to approximately one billion euros (Figure 1). The next largest amounts (about a third of the total) were directed to Greening schemes (about 518 mil. euros) and crop-specific payments for cotton less (than 10% of the total sum).

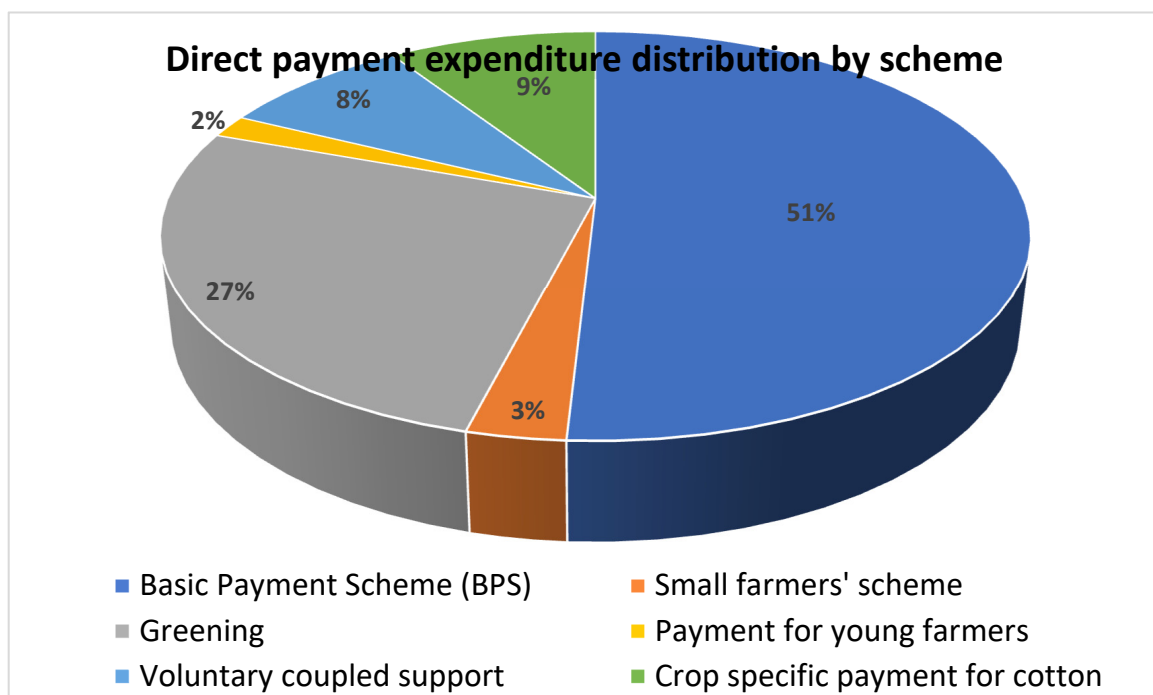


Figure 1. Distribution of direct payment expenditure by scheme for Greece (claim year 2020, including national co-funding). Source: EU Commission, “Financing the CAP”.

A similar structure was observed in the distribution of funding towards rural development. Overall, Priority 4 absorbed over half the funding, with Priority 2 following with about a third and the other Priorities with less than 7% each (shown in Figure 2).

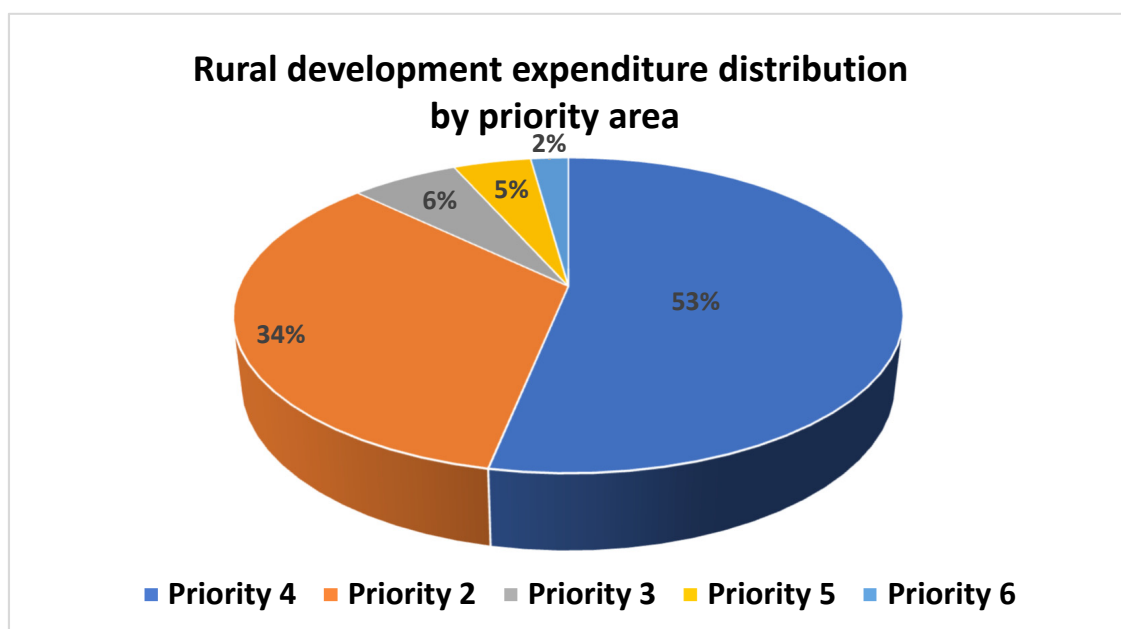


Figure 2. Distribution of rural development expenditure by priority area for Greece (claim year 2020, including national co-funding). Source: EU Commission, “Financing the CAP”.

Finally, the distribution of funding for market-specific purposes (shown in Figure 3) is related to the production structure of goods in the Greek agricultural sector, with 41.4% (or 20.9 mil. euros) directed towards wine production, 18% (or 9.23 mil. euros) towards fruit

and vegetables in general, and 14% (6.84 mil. euros) to programs of options specifically relating to remoteness and insularity (POSEI). Production of olive oil, honey, and relevant promotion initiatives account for 26.5% combined.

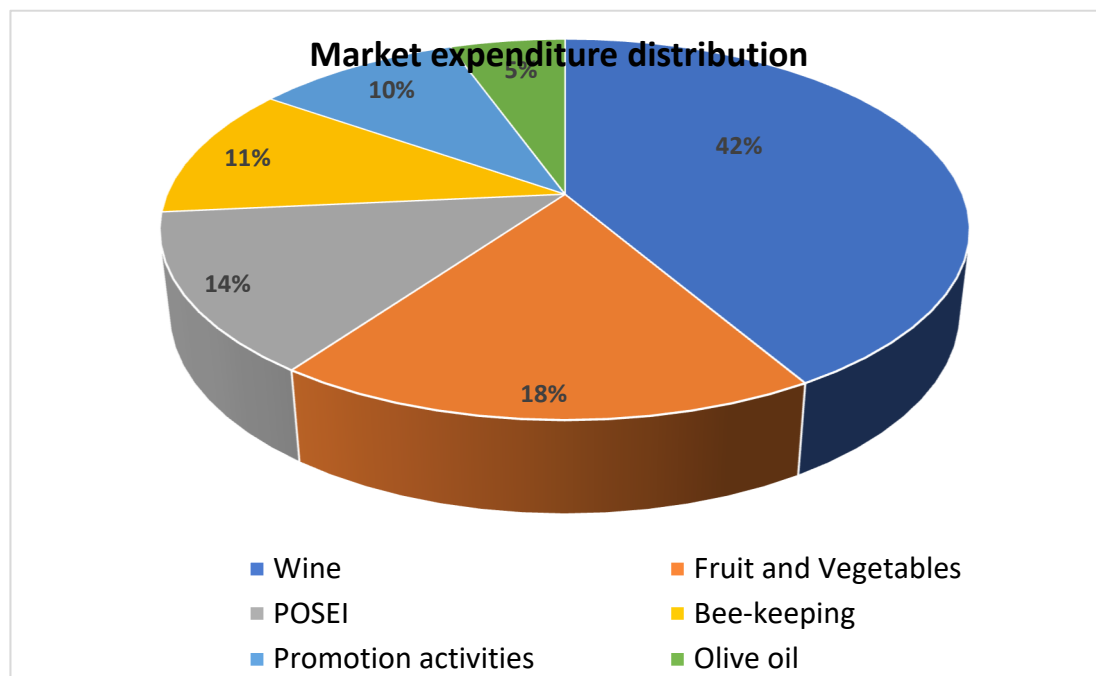


Figure 3. Distribution of market expenditure for Greece (claim year 2020, including national co-funding). Source: EU Commission, “Financing the CAP”.

It should be noted that the CAPs’ financial resources and synergies should be considered and developed in alignment with promising and ambitious targets for the environment and the climate, operating under the strategic priorities of the European Green Deal, other sustainable policy measures, and interventions for a green and digital agricultural production model [9]. Another critical issue refers to the problematic determination of what are the exact operational differences between the measures available under the Pillar 1 eco-schemes and the Pillar 2 AECSs’ [13]. In response to this critique, eco-scheme payments are part of Pillar 1 and they would be fully funded by the EU budget taking the form of annual aids per eligible hectare, being granted either as additional aids to basic income support or as compensating rewards for all (or part of) the additional costs incurred or foregone profits. Therefore, eco-schemes facilitate direct aids that go beyond only compensation of cost incurred or lost profits, and thus design and implement Payments for Environmental Services (PESs) within Pillar 1. The EC notify most of these payments as either direct payments or decoupled payments under the WTO green box. Setting the appropriate levels of these PESs remains challenging, as PESs could be also characterized by the transition from an obligation of “means and practices” to an obligation of “results and impacts”. Such a transition can further support farmers to choose practices and systems adapted to specific conditions, increasing/grounding the social image of CAP legitimacy and introducing PESs as financial sources funded not only by the taxpayer but also by the intermediate or final user [13].

The direction in which the implementation of the new CAP will proceed in Greece, according to the aforementioned objectives and constraints, is also reflected on the recently approved (November 2022) “Greece’s CAP Strategic Plan”. It defines a strategy covering all the main instruments funded under the CAP, such as direct payments, support for rural development and interventions specific to certain market sectors. Focusing on the specific figures of priorities and funding, in order to stabilize farmers’ incomes through basic income support and to reduce the risk of production declines brought on by price

changes and external causes, roughly EUR 4.3 billion will be allocated. Increased support (from EUR 176 per hectare to EUR 270 per hectare) is targeted and differentiated based on the agronomic land category (arable land, permanent crop land, and pasture/grazing land). A further EUR 885 million is allotted to ensure a more equitable assistance distribution and better targeting of the income support to the agricultural sector, which will increase the sustainability of small and medium farms.

The amount of agricultural area used for organic farming in Greece will more than double thanks to a EUR 1.4 billion commitment from the country. To support eco-schemes like using resilient species and varieties, enhancing green cover practices, bolstering biodiversity, circular economy, and environmentally friendly management practices, more than EUR 425 million per year (with an estimated impact on about 3 million hectares) has been allocated. By assisting young farmers, investing in the processing, and marketing of agricultural products, as well as in forestry technologies and the marketing of forest products, more than 70,000 new employment positions will be created in rural areas. More than 65,000 young farmers will benefit from setting-up support. Additionally, Greece is poised to spend an additional EUR 70 per hectare to supplement the income of young farmers (those under the age of 40), totaling EUR 140 million from 2023 to 2027.

More than 15,000 farms will take part in groups to share ideas and organize the supply chain better, while more than 200,000 people will benefit from guidance, training, and information sharing, as well as from participating in European Innovation Partnership (EIP) operational groups, in order to improve resource efficiency performance and sustainable economic, social, environmental, and climate growth. Farmers will be incentivized to keep their farms modern and innovative, for example, by investing in digital technologies and/or forming operational groups to develop innovative solutions and practices. Summarizing the most important and up-to-date funding information, the following Tables 2 and 3 provide the CAP's budget breakdown for Greece by payment type (Table 2), co-funding source and allocated objective (Table 3), respectively.

Table 2. CAP funding by payment type.

	EU Budget (EUR)	National Funding (EUR)	Total (EUR)
Direct payments	9,621,616,199		9,621,616,199
Sectoral support	170,228,225	30,594,225	200,822,450
Rural development	3,635,969,755	792,150,700	4,428,120,455
Total	13,427,814,179	822,744,925	14,250,559,104

Source: Greece's CAP Strategic Plan.

Table 3. CAP funding by allocated objective.

EU Funding Reserved for:	In EUR
Young farmers (generational renewal)	730,000,000
Environmental and climate objectives under rural development	1,480,200,791
Eco-schemes under direct payments	2,175,410,400
LEADER	200,000,000
Complementary redistributive income support	885,298,064

The framing of the current national strategic plan as well as the future perspectives of converging the Greek CAP with climate change future-oriented proposals, they are summarized and shown in Table 4 below.

Table 4. CAP enactment in the agriculture sector of Greece and the role of climate change.

Current situation/priorities	Strategic Plan	Future overview and perspectives proposed	Coupling CAP-Climate Change in Greece
	Farmer's income and food security.		Support the convergence of the European Green Deal targets to increase the environmental and the climate ambition of Greece's agricultural policy.
	Market expansion and internationalization, focusing on research, technology, digitalization.		Full implementation of standards, including protection of landscape features, ban on conversion of grassland in all Natura 2000 sites, requirements applicable to farmers for the birds' habitats.
	Farmers' position improvement through value chain upgrading.		The high share of livestock emissions and the specific agronomic and pedo-climatic characteristics of Greek agriculture need to be addressed by means of a specific set of responses.
	Climate change mitigation and adaptation, focusing on rational energy sources exploitation and sustainable energy pursuing.		Maintaining and restoring of farm and forest habitats as regards the habitats and species identified in the prioritized action framework for CAP funding in combination with the types of (mainly endangered) species and habitats relevant for the CAP, indicated in the EU and national species and habitats action plans.
	Sustainable development focusing on rational management of natural resources, water, soil, and air.		Ensuring that Greece achieves the objectives of the Water Framework Directive namely preventing the deterioration of water bodies and ensuring they attain of good status at least.
	Biodiversity protection focusing on enhancing ecosystem services, habitats preservation, and landscaping aesthetics.		Reversing soil erosion, reducing air pollution, and improving water use efficiency in terms of quantity and quality are important priorities.
	Business development in rural areas, focusing on young farmers' attraction on professional prospects.		Successful green transition of Greek agriculture through prioritizing those practices and challenges related to biodiversity, soil, air and water, including catch and cover crops, retention of crop residues on fields, switching to less water intensive crops and improved crop varieties, improving irrigation efficiency via water-saving systems and precision farming.
	Promotion of employment and socio-economic growth, focusing on social inclusion, regional development, bio-economy adoption, and sustainable forestry management.		Improvement and intensification of the high potentials in renewable energy production (in our case regarding biomass sources derived from energy crops towards biofuels production) or from waste and by-products in the agriculture and forestry sectors in Greece (with due consideration to the effects of air pollution).
	Linking national goals with EU regulations and directives, focusing on sustainable food, public health, animal welfare, through knowledge, innovation, digitalization of Greek economy.		Support of forest resilience and restoration in addition to afforestation, considering that Greece is particularly prone to forest fires, thus, damage to forests needs to be prevented.
			Designing of carbon farming approaches to support carbon sequestration linked to land systems such as agro-forestry, being coupled with the timely replacement of harvested or damaged forest and the maximization of long-term carbon capture (with sustainable eco-friendly species).
			Preserving stocks and increasing the carbon sinks in forests, their soils and harvested wood products through support and implementation measures beyond afforestation, agroforestry, and restoration but also of advice on species selection.
			Awareness raising of actions to decrease the impacts of extreme weather events, introducing more water efficient irrigation/crops, and investing in flood prevention/protection (such as natural water retention that also works in droughts) and in particular pastoral systems.

Table 4. Cont.

Priority actions • Fostering the resilience of agriculture against extreme weather events linked to climate change, being most professional farms. • Policy better targeting support measures towards extensive production, with a greater share of income support linked to environmental performance is therefore desirable. • 38% of Greek grassland has a favourable status, while the share of landscape elements and fallow land is very low, which negatively affects biodiversity. • Greece is among those EU countries where water abstraction is a problem, and where prolonged periods of water scarcity due to global warming is projected to intensify. • Enhancing the ongoing shift towards organic production and integrated pest and pathogen management, thus contributing to the reduction of the use of chemical pesticides. • Increasing the, albeit uneven, introduction of practices linked to precision farming, improved nutrient management, low input management commitments or bioenergy. • Knowledge and innovation have a key role to play in helping farmers and rural communities to meet future challenges. The agricultural knowledge and innovation system (AKIS) includes all “agriculture-related” farming and rural activities: environment, climate, biodiversity, landscape, food, and non-food systems including processing and distribution chains, consumers and citizens, and social aspects.
Recommendations: Based on the CAP-climate change overview, above, the following eight-step strategic design-framework is proposed, under which the EC should consider that the Greek CAP strategic plan needs to focus its priorities and concentrate its interventions considering the high territorial diversity of the Greek agriculture and rural areas: 1. Foster a smart, resilient, and diversified agricultural sector ensuring food security, 2. Bolster environmental care and climate action and contribute to the environmental—and climate-related objectives of the EU, 3. Addressing water-use efficiency, especially considering climate change projections for water scarcity, with practices and targeted management commitments by modernizing the existing irrigation infrastructure and installing more efficient and sustainable irrigation systems, 4. Improving the status of protected species and habitats, farmland birds and wild pollinators in line with the prioritized action framework for the CAP funding and the species and habitats action plans, thereby achieving biodiversity and climate mitigation and adaptation benefits coupled with increased productivity from enhanced pollination and natural pesticides control, 5. Contributing to climate change mitigation by encouraging carbon sequestration through carbon farming, the sustainable management of the existing forests as well as the timely replacement of harvested or damaged forest. Therefore, long-term carbon capture should be optimized and an increase the carbon sinks in forests, their soils and harvested wood products, to be achieved, 6. Support and implementation not only for afforestation, agroforestry, and restoration but also through advice on species selection, 7. Strengthening climate change adaptation measures including raising awareness, introducing water efficient crops, and investing in flood prevention/protection, 8. Adaptation to high wildfire risk, a forest cadastre and the review of the legal framework for prevention and suppression of wildfires.

Source: Adopted and modified from [33].

Within the nexus of the CAP and climate change, the links between water, energy, and food systems are particularly relevant as they highlight the need to consider the impacts of agricultural practices on resource management, as well as the potential for agricultural production to contribute to the energy sector [34]. As climate change results in more frequent and severe weather events, such as droughts and floods, it is important to consider how these events will affect the availability of water for agriculture and energy production. Additionally, as the demand for food and biofuels increases, there is a need to consider the impact of agricultural production on water and energy resources. In this context, the CAP plays a crucial role in ensuring that agricultural practices are sustainable and that the agricultural sector can adapt to these climate change-related impacts. The CAP can support the development of sustainable farming practices that reduce the pressure on water resources and promote the use of renewable energy in agriculture [35]. Additionally, it can encourage the development of agricultural practices that can contribute to the energy sector, such as the production of biofuels. Overall, the water—energy—food nexus highlights the need to consider the interdependent relationship between these systems in order to ensure sustainable agricultural practices in the face of climate change [32,36].

2.3. Climate Change Structural Characteristics of Greek Agriculture

Greek agriculture appears particularly vulnerable to climate change, which is reflected by its productivity, diversity, and resilience. Moreover, the agricultural sector is expected to be more affected than any other economic sectors in Greece. In detail, the effects of climate change on the most important high-productivity agricultural areas of the country, including Central and Eastern Macedonia, Thessaly, and Western Peloponnese, are reflected to the significant moisture deficit and the reduction of water reserves in the medium-to-long term, and are expected to affect both key crops (by varying their yield) as well as the nurturing zones, depending on the evolving climate conditions in the future [37].

Even though GHG emissions from agriculture have decreased by 24% in the period 1990–2019, the agricultural sector remains a significant source of emissions to date, being responsible for around 12% of total emissions in the EU, while in Greece the corresponding percentage amounts to 8.5% [38]. The GHG emissions directly related to Greek agriculture are mainly methane (CH_4) and nitrogen oxide (N_2O), both of which are showing a steadily decreasing trend over time. Agriculture and forest ecosystems can simultaneously contribute to GHGs' sequestration, considering that cultivated land and pastures act as important "carbon sinks".

Greek agriculture exerts significant pressure on natural resources, with the greatest risks from climate change being observed in the quantity and the quality of irrigation water and soil erosion. The main air pollutant from agriculture is ammonia, with a share of total emissions in Greece up to 91.47% in 2018, but with a decreasing trend over the period of 1995–2018—in contrast to the average increasing trend observed in the EU since 2013 [39]. It should be also noted that until recently the utilization of renewable sources in Greek agriculture for energy production is at a low level, compared to that of the EU, with significant margins for increase considering the particularly high and dispersed energy potential of Greece in renewable energy sources (RES). In addition, Greece's agriculture and animal industries produce a significant amount of waste that is not currently being used for biomass-related power generation. According to estimates [40], Greece's agricultural and animal industries generate over 57,983,751 tn/y of waste each year, with 53% of them generated by the agricultural industry and 47% by the animal industry.

From an economic perspective, agriculture in Greece is an important and dynamic sector of economic activity. Agricultural land in Greece covers 46% of its total area [41], employing 12% of the workforce and contributing 3.6% of GDP, higher than the EU average, where 4% is employed in agriculture and the sector's participation in EU GDP is 1.5%. Consequently, the primary sector offers income and employment to a significant part of the population of the Greek countryside, contributing substantially to the regional development and social cohesion of the country's rural areas, while at the same time showing

strong sectoral linkages with other sectors of economic activity, such as arts and crafts, manufacturing, and of course accommodation and tourism.

Regarding the structural characteristics of Greek agriculture, it is worth mentioning the large number of small farms with an average size about half that of the European market, with all the challenges this entails for their competitiveness and sustainability, also considering the small degree of organization of producers in collective schemes in relation to the EU. Cooperation could help improve their position in the agri-supply value chain and make them easier to adapt to new conditions and challenges, by increasing productivity and the added value of their production, by creating economies of scale and making appropriate investments, including those to address the effects of climate change.

In Greece, producers experience the effects of climate change, such as water scarcity, prolonged heat, rainfall, hail and frosts, floods, fires, landslides, soil erosion, even more often, intensely, and abruptly than in the past, causing major damage to their production, land and property. Some of the effects of climate change on Greek agriculture, which can seriously jeopardize agricultural activity, are related more directly with the changing landscape and conditions while others are indirect effects of changes in other environmental factors.

In the first category, crop yields are decreasing, with changes in the germination period and cultivation methods and practices (due to very high temperatures), along with water availability due to prolonged periods of drought and increased demand for irrigation, increasing soil salinity due to rising sea levels, as well as flooding in coastal, lake and riverside areas and basins, restriction of irrigated areas due to desertification. There is extensive destruction of crops, agricultural infrastructure, agri-food facilities and equipment due to an increase in the frequency and intensity of extreme weather events along with dwindling soil fertility and organic content, which hurt crop diversity and the availability of arable land. Some other indirect threats to agriculture include the increased risk of soil erosion due to frequent alternations in periods of drought and heavy rainfall, multiplication of diseases, parasites and weeds due to the increase in temperature and/or humidity that increases the use of plant protection chemicals and antibiotics. Animal-related effects of CC can also affect agriculture in Greece, mainly due to the reduction of pollinators and their efficiency, the thermal stress of farmed animals due to exposure to extreme temperatures, degradation of pastures—grassland with a decrease in feed yields and quality and resulting to malnourishing conditions and the overall reduction in the biodiversity of agricultural ecosystems and degradation of the country's rural landscape and rural areas, with implications for other extra-agricultural activities such as tourism and recreation.

Therefore, the agricultural sector is expected to be hit hardest from CC than any other sector of economic activity in Greece. The economic assessment of the damage from the effects of climate change by the end of the century in Greek agriculture ranges from 3% to 13%, depending on the RCP (Representative Concentration Pathway) scenario chosen for the average temperature increase (from 1.4 °C for the period 2046–2065 and 1.8 °C for the period 2081–2100 to 2 °C for the period 2046–2065 and 3.7 °C for the period 2081–2100) [42,43]. The impact of climate change on agricultural production for the period 2071–2100, with the reference period 1961–1990 and on the basis of an intermediate climate scenario based on the assumption that the concentration of carbon dioxide will reach 720 ppm in 2100 (already >400 ppm in 2016) with a temperature increase of 1.95 °C and up to 3.5 °C is expected to be more unfavorable on Central Greece—Thessaly—Central Macedonia—Thrace [42,44]. Similarly, for the period 2046–2065 compared to 1961–1990, the effects of CC on the most important agricultural areas of high productivity of the country, Central and Eastern Macedonia, Thessaly, and Western Peloponnese, are attributed to the significant moisture deficit and the reduction of water reserves due to reduced rainfall and warming, especially during the summer months, as shown by the study of changes in the relevant parameters (temperature, rainfall height, number of hot days, number of frost days, moisture deficit, and drought index) [37].

Regarding the effects of climate change on different crop types, based on the above changes in climatic parameters it is expected that the areas most affected (mainly in Thes-

sally) the greatest damages will be in hydro-intensive crops (maize, cotton) and crops that are sensitive to temperature changes, due to an increase in the moisture deficit and a reduction in water stocks, with a possible shift of producers towards crops and varieties with greater adaptability to dry-thermal conditions [45]. Basic crops, such as vines, olives, wheat, fruit, and vegetables, will be affected in the future, differentiating their yield and areas of prosperity according to the conditions. There is significant exposure, particularly in Thessaly and Central Greece, to the risk of a reduction in cereal production, while olive cultivation is expected to improve yields in the northern regions of the country compared to the southernmost regions.

In response to all the problem setting described in the section above, this study aims to contribute to the consolidation of the EU's new environmental and climate strategies for Agriculture under the European Green Deal by proposing certain interventions to address the impact of Climate Change on Greek Agriculture, which are eligible for funding by the new Common Agricultural Policy (CAP) 2023–2027, through its “green architecture”, as well as increased synergies with other EU funding instruments. Therefore, the methodology of this study adopted the following action course:

1. Diagnostic analysis of the existing situation.
2. Evaluation of the previous implementation of the CAP.
3. Determination of the needs of Greek agriculture.
4. Search for required policy measures and interventions.
5. Utilization of the resources of the new CAP.

The diagnostic analysis of existing situation is a key step in understanding the current state of the CAP and its effectiveness in addressing the challenges of climate change. This analysis involves a thorough examination of the CAP's current policies, programs, and measures related to climate change, as well as an assessment of their effectiveness in achieving their intended goals. The analysis also examines the potential barriers and gaps in the current CAP that may be hindering its ability to effectively tackle climate change, such as lack of funding, weak implementation, or lack of coordination with other policies. This information is then used to identify opportunities for improvement and to develop recommendations for more effective measures to address climate change within the CAP. This will help to ensure that the CAP is fully equipped to meet the challenges of climate change and to contribute to the EU's goal of a climate-neutral economy by 2050.

In more detail, our analysis is structured around the following procedural stages:

1. Gathering information on current CAP policies, programs, and measures related to climate change, as well as data on their effectiveness in achieving their intended goals.
2. Analysis of current policies by conducting a thorough examination of the current CAP policies, programs, and measures related to climate change, as well as an assessment of their effectiveness in achieving their intended goals. We also identify the barriers and gaps in the current CAP that may be hindering its ability to effectively tackle climate change.
3. Identification of opportunities for improvement, using the information gathered in steps 1 and 2 to identify opportunities for improvement and to develop recommendations for more effective measures to address climate change within the CAP.
4. Envisioning a sustainable agricultural model based on the findings of the diagnostic analysis, this model incorporates best practices for reducing emissions, protecting biodiversity, and promoting sustainable land use.
5. Development of policy measures: At the last stage, we use the information from all above steps to develop targeted policy measures and recommendations for achieving a sustainable agricultural model for Greece. This includes measures such as incentives for farmers to adopt sustainable practices, regulations to reduce emissions, and funding for research and development in sustainable agriculture.

These actions are contained in the following sections, which, along with the previous analysis on the key aspects of the CAP and climate change in EU and Greece, form the

basis for our proposed set of policies, which are presented in the sections below. We note that, ideally, the earlier steps should also be accompanied by a proper monitoring and impact assessment system. The implementation of the policy measures and recommendations should be tracked in order to verify their effectiveness in achieving the goals of a sustainable agricultural model for Greece—and more broadly, a climate-neutral economy by 2050. However, this is a procedural issue with the regulating authorities and does not fall in the scope of this paper.

3. Evaluation of Needs of Greek Agriculture in the Context of the New CAP

As mentioned in earlier sections, the CAP aims to support farmers and promote sustainable agriculture. However, the CAP also has to balance the goal of promoting competitiveness in the agricultural sector with the objective of achieving sustainable development. This can lead to conflicting objectives and trade-offs between the CAP and the Sustainable Development Goals (SDGs). For example, the CAP financing can support the competitiveness of farmers, but it may also lead to a decrease in the sustainability of farming practices. Additionally, the CAP's focus on maintaining high prices for agricultural products may lead to trade-offs with other SDGs such as poverty reduction and food security. The link between sustainability and competitiveness in agriculture is a complex and rather recently emerging research topic, while the coupled achievement of both these two goals it requires careful policy design and implementation [46]. Direct payments, which are largely used to protect farmers' earnings, account for close to 70% of the CAP budget. Direct payments were implemented 25 years ago to cushion the effects of reform, but their validity is now questioned. Further evidence that direct payments are indeed biased toward high-income farming regions comes from the fact that the per-hectare allocation of direct payments resulted in an unavoidable bias towards large farmers. As of 2018, 2.2% of farms in the EU-28 (receiving more than 50,000 euros) take up a total of 28.2% of all payments [44]. Such distributions, on the levels of farming and regions, are unlikely to revert inequalities within the agricultural sector, thus conflicting with both the income objective of the CAP and the UN's Sustainable Development Goal 10.

The financing of the interventions of the new CAP has been the subject of intensive and long-term consultation by the EU Member States, given the different national objectives and interests and competition with the other Union policies claiming resources from its budget. Brexit and the COVID-19 pandemic also put serious pressure on the availability and prioritization of resources ultimately allocated to its different strategies through the Multiannual Financial Framework (MFF) 2021–2027 and the European Recovery Instrument (EMA) set up to address the economic impact of the pandemic. This resulted in a reduction of about 12% in the total resources of the new CAP compared to the previous one, taking into account the EMA's contribution, with Greece recording noticeable losses from the new allocation, as it secured funding of about 14.3 billion euros [47].

The effects of climate change on the country's most important high-productivity agricultural areas, Central and Eastern Macedonia, Thessaly, and Western Peloponnese, are attributed to the significant moisture deficit and the reduction in water reserves due to reduced rainfall and rising temperatures, especially during the summer months. Basic crops, such as vine, olive, wheat, fruit, and vegetables, will be affected in the future, differentiating their yield and areas of prosperity according to the conditions. The CAP's reform towards increased environmental care and overall climate awareness is strengthened over time and is now becoming "irreversible" through ambitious EU strategies such as "Farm to Fork" and "Biodiversity" which fall under the European Green Deal, which set out the terms of agriculture's green transformation.

Aside from the centrally mandated policy, the total GHGs emissions from agriculture decreased by 23.26% between 1990 and 2020 [48]. The greatest share is emissions of methane (CH₄) and nitrous oxide (N₂O), whose main sources are the intestinal fermentation processes of animals and the use of synthetic fertilizers, respectively. However, at this point it is important to note that from the perspective of an agricultural policy it does

not seem appropriate to subsidize emission reductions which are accounted for in other sectors, assuming that they are already subject to specific mitigation measures from other policy areas. This is, for example, the case for emission reductions from nitrogen fertilizer production installations, which are already included in the scope of the EU Emission Trading System. Such emission mitigation technologies that can be adopted by agricultural producers. Indicatively, in the livestock sector, mitigation actions can include anaerobic digestion at farm scale, low nitrogen feed, linseed as feed additive, nitrate as feed additive, vaccination against methanogenic bacteria in the rumen, and specific breeding programs to increase milk yields of dairy cows, and ruminant feed efficiency. In the crops sectors, some mitigation actions could include precision farming, variable rate technology, better timing of fertilization, nitrification inhibitors, rice measures, fallowing histosols (organic soils), and increasing legume share on temporary grassland. An integrated framework of interactions among desertification, biodiversity loss and climate change is graphically presented in Figure 4, below.

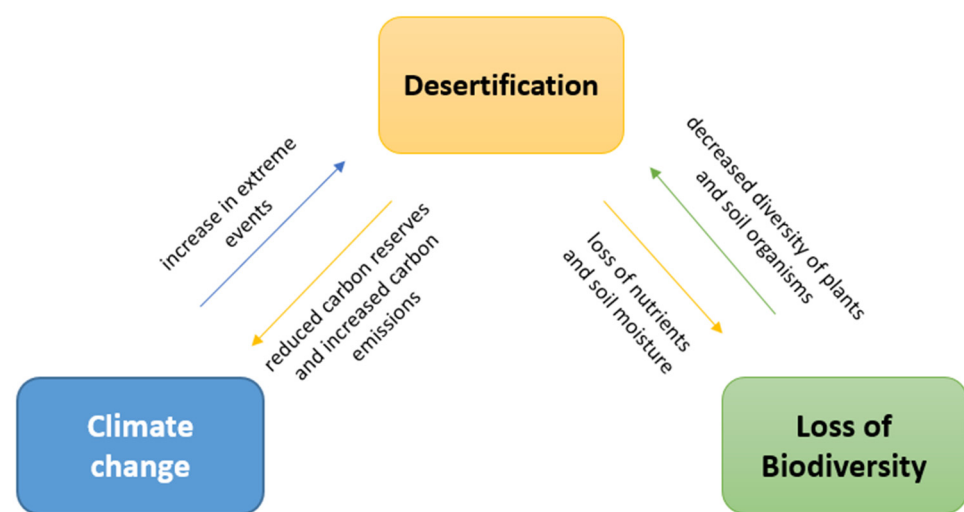


Figure 4. Relationship between desertification, biodiversity loss and climate change. Source: Adapted from European Court of Auditors, Special Report No 33, Combating desertification in the EU: a growing threat in need of more action.

In its recommendations for Greece’s CAP, the EU [43] showed that significant pressure has been exerted by Greek agriculture on national natural resources, with the greatest risks from climate change being observed in the quantity and the quality of irrigation water and soil erosion.

In terms of energy generation, the use of RES in Greek agriculture is low compared to the rest of the EU, though this is being remedied through long term investments in RES (including biomass power generation) which can also help Greece with economic growth [49]. This creates a definite margin for improvement, especially when considering the high energy-producing potential of Greece from solar and wind. Significant issues in the initialization and implementation phases of the planned interventions were revealed by the examination of the prior implementation of the CAP’s environmental and climate policies. Agricultural scientists have long warned that the EU’s CAP is inefficiently spent, while there is a glaring mismatch between the budgets and declared aims of the CAP, and the most money is allocated to the least successful initiatives [9].

Moreover, a pronounced bias of payments [50] is also reported toward regions with the highest rather than the lowest GHG emissions [51], in conflict with the climate objective of the CAP. However, the financial distribution also demonstrated that areas with low GHG emissions or substantial amounts of farmland with strong conservation values did receive significant support. Such situations might serve as illustrations of sound investment policy. These results also showed that one important path to CAP improvements should

consider spatial targeting. Here again, the EU can insist that its Member States provide evidence that pertinent CAP subsidies are directed to areas where they clearly provide benefit to the environment. This should also be on track with other complimentary climate change adaptation and mitigation actions [52], as it is also crucial to remember that Greek agriculture should make a “green transition” by combining economic, environmental, and social sustainability in a fair, gradual, and balanced way, as it has been visually represented at Figure 5, below.

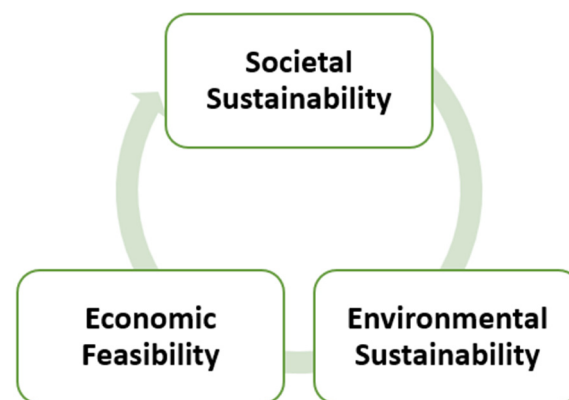


Figure 5. The three interrelated objectives of the CAP.

These three dimensions come together to form an integrated design of policy measures and interventions by general and specific objectives of the new CAP to address the effects of climate change requires broader reforms, synergies, and a change in the overall production culture. The relevancy of these three CAP objectives are also examined by similar studies, concerned that the evolution of human societies along with efforts to enhance economic welfare may well lead to the deterioration of the environment [53]. It was also stated that while over 24 billion euros are granted to EU regions with above-average farm income, regions with high GHG emissions, and urban areas, whereas biodiversity-rich areas, known as “high-nature-value” farmland, receive insufficient support. It could be further argued that strategic approach and proposals for policy measures—interventions should follow the actions of the “green transition” of Greek agriculture, so that they would be carried out in a balanced, fair, and uneventful manner, combining economic, environmental, and social sustainability aspects. Additionally, the production base and structure of Greek agriculture in combination with the natural environment and biodiversity of Greece can be leveraged to produce high-quality, diversified agricultural products of high added value ecological labels. This can be achieved by effectively utilizing its comparative advantages, the favorable climatic and geomorphological conditions, its rich energy potential, its culinary culture, the strong connections of agriculture with tourism, culture, and its agricultural tradition and heritage.

Within this broader context, relevant policy measures and interventions as per the general and specific objective of the new CAP should address not only the effects of climate change requires wider reforms, synergies, and a change in production culture through the information and awareness of producers and consumers in order to exploit new, dynamic value chains, such as the rational and sustainable management of natural resources, biodiversity and ecosystems, eco-tourism, circular economy and bio-economy, renewable energy sources, precision agriculture, and investments for prevention and protection of agricultural production from climate change, research, education and training, consultancy, cooperation and networking.

4. Results and Discussion

Against the backdrop of the literature review and the diagnostic analysis conducted in the previous sections of this study, several critical needs, and challenges regarding the

effects of climate change on the Greek agriculture have been identified, considering the impact and shortcomings of the existing CAP framework. These caveats are directly related to the sector's production structure, organization, and dependencies. Moreover, it can be deduced that efforts targeted towards addressing the effects of climate change in agriculture should not be limited to specific policy frameworks that have the sole purpose of achieving the “green” goals of the national and EU strategies, but instead should target the balanced, fair and a smooth transition to a new production model that will combine the economic, environmental, and social dimensions to achieve specific sustainability goals.

By adopting this strategic lens, and based on the findings highlighted in the previous sections, we proceed to an extensive discussion on a proposed set of policy measures and interventions regarding the new CAP, with a special focus on the adaptation of the Greek agriculture to climate change. The proposals are grouped by specific CAP 2023–2027 objectives (ES4, ES5, ES6), in coherence with the corresponding sections in the diagnostic analysis conducted in Section 3. We also include an introductory section of horizontal proposals that touch upon multiple dimensions, including, on the one hand, the overall strategic plan to address the effects of climate change in Greek agriculture, and on the other hand, the overarching goal of the new CAP to promote knowledge and innovation in the agri-food sector.

4.1. Horizontal Proposals for Policy Measures and Interventions

One of the most fundamental conclusions of the diagnostic analysis and evaluation was the need to immediately activate horizontal interventions that, on the one hand, will speed up the implementation of the measures and actions of the existing CAP for the environment and the climate, and on the other hand, will contribute substantially to the intended transformation of Greek agriculture, on the basis of the “green” development strategy described in the introduction of this chapter, through the promotion of knowledge, innovation and modern digital technologies. The proposals in this direction concern the following policy measures, which are consistent with the horizontal general objective of the new CAP 2023–2027 and are dictated by the need to respond to the requirements of the Agricultural Knowledge and Innovation System (AKIS), which becomes mandatory in the new programming period from the EU and in the development of which there are delays in Greece.

H1. *Promote Information Diffusion, Awareness, and Training/Education for Agriculture.*

The strategy for adopting and promoting the necessary interventions to mitigate the impacts and adapt agriculture to climate change needs to be adopted by the main partners involved in its implementation, to ensure the necessary consent/acceptance, and therefore have greater chances of success. At the same time, it is necessary to create the appropriate conditions for culture and mentality change, especially when the recipients/beneficiaries of the strategy are more cautious towards the new or attached to traditional perceptions about the ways and methods of practicing agricultural and livestock activity and in some cases are less aware of issues related to the environment and the climate. Therefore, the proposal for this measure focuses primarily on the following knowledge transfer interventions:

- Quantifying the effects of climate change mitigation actions in the agriculture sector is essential in understanding the potential benefits and impacts of different strategies. By using quantitative methods, it is possible to estimate the reduction in greenhouse gas emissions, the improvement in soil health, or the increase in crop yields that can be achieved through different mitigation actions. These estimates can be used to compare the effectiveness of different strategies and to identify the most cost-effective and efficient options. Additionally, quantification allows for the estimation of the costs and benefits of the mitigation actions, which helps in the allocation of resources and in the decision-making process. Furthermore, quantification can also help in monitoring and evaluating the progress and impact of the mitigation actions over time, and it

allows to assess if the goals are being reached, to adjust the strategy if needed and to communicate the results to the stakeholders and the general public [54].

- Informing/raising the awareness of all “partners” involved in the implementation of actions for mitigation and adaptation to climate change—with priority to producers, geotechnical and competent public, and private bodies—about the economic, environmental, and social effects of climate change, the long-term benefits of such interventions and the social and environmental sustainability criteria that provide their foundations, as well as what changes need to be made. This target could be achieved through workshops, seminars, printed and electronic materials.
- Training and educating producers in the matters of adoption and effective implementation of the even more ambitious environmental and climate commitments needed for the contemporary accomplishment of the new CAP’s goals in combination with the goals of the Green Agreement strategies for agriculture, as well as in actions for the demonstration and information on climate change adaptation and mitigation practices. This could be achieved through workshops and organized visits to prototype farms. Indeed, it is noteworthy that stakeholders’ engagement is critical in understanding the needs of Greek agriculture with respect to climate change. By engaging with farmers, researchers, policymakers, and other key stakeholders, it is possible to gain a comprehensive understanding of the perceptions, needs and priorities related to the impacts of climate change on Greek agriculture. Through stakeholder engagement, it is possible to identify the most affected regions and sectors, as well as the challenges and opportunities that farmers and other stakeholders face in adapting to the changing climate. This information is vital in the development of effective policies, programs, and measures to address the impacts of climate change on Greek agriculture. Furthermore, engaging with stakeholders throughout the process, from the identification of needs to the implementation of recommendations, ensures that the solutions developed are inclusive, realistic, and well supported by the target groups. This will increase the chances of successful implementation and achieving the desired outcomes [55].

H2. Provision of Agricultural Advice and Consulting Services.

A key success parameter of the strategic promotion of actions to mitigate and adapt agriculture to climate change is the creation of a permanent and sustainable mechanism for providing agricultural advice to producers by geotechnicians. This mechanism will facilitate their technical support, based on the real needs and requirements of their agricultural holdings. In this sense, the proposal for the specific measure focuses on the following interventions:

- Provision of consulting services for the management of pro-environmental and pro-climate agricultural activities and practices dictated by the new CAP (increased airworthiness with ecological schemes, ambitious voluntary actions of Pillar II, etc.), for producers to understand the need to adopt them and to apply them in the most correct and effective way.
- Provision of consulting services for the exploitation of innovation and new technologies (e.g., precision agriculture to reduce the use of chemicals and save irrigation water, energy production from RES, genetic improvement of domestic breeds and varieties to adapt to climate change).

H3. Actively Promote Cooperation in the Agri-Food Sector.

The third key factor in the promotion of environmentally friendly projects and practices in the context of the new CAP 2023–2027 concerns both cooperation and networking. A prerequisite for their promotion is the development of a strong mechanism of interconnection between research, innovation, technology and investments partners. Such mechanisms will ensure the transfer of scientific knowledge and innovation to agricultural practice, as well as the dissemination of research results and good practices. It will also aim to

utilize complementarities and synergies with other funding instruments and tools, such as ESIF, Horizon Europe, RIS (research and technology programs and policy support for regional smart specialization in the EU), the Life-IP AdaptInGR and Life ClimaTree program, Interreg, Climate-KIC, etc.

In this direction, the proposal for this specific measure focuses on the following interventions, which are also consistent with the promotion of the objectives of the European Innovation Partnership for Agriculture (EIP—Agri):

- The development of a public digital platform, which will include all the good practices in agriculture resulting from the cooperation of the operational groups, pilot studies and experimental results, to ensure their free access and wide dissemination.
- The creation of operational groups, in which producers, researchers, as well as market operators involved in the agri-food chain will participate, with the aim of implementing pilot projects in agriculture's climate change mitigation and adaptation programs and actions in the field, as well as investment in innovative technologies, agricultural practices and methods to improve the resilience of Agriculture and accelerate its green and digital transformation.

H4. *Mobilize Investments towards Innovation and Digitalization in Agriculture.*

As already mentioned, a necessary component of agriculture's green transformation is its digitalization ("smart and green" agriculture), which is expected to contribute significantly to not only to its modernization and competitiveness but also its resilience and sustainability in the face of its challenges climate change. The new digital technologies and applications in the agri-food sector, through the utilization of broadband infrastructure to all the rural areas of the country, provide multiple possibilities, especially when considering the significant interaction of the primary and the ICT sector in Greece [56]. The strategy to promote green and digital investments should be used to support economic diversification and the creation of new businesses and employment opportunities in areas significantly affected by the transition to a climate neutral economy. As an example, there will be a need to transition the rural lignite-intensive areas of Western Macedonia and Megalopolis, which will need to reorient their economic activity, investing in diversification through sustainable and digital investments in the primary sector. In this context, the proposal for this specific measure focuses on the following public and private sector interventions:

- Providing incentives for the promotion of digital, private investments in new technologies in agriculture, which simultaneously serve the goals of the "green economy" and "sustainable development". Use the funding tools of the new CAP to support them, in synergy and with other funding sources, such as the InvestEU Fund, the European Investment Fund, the Recovery and Resilience Fund, the Just Transition Fund, and the other ESI Funds.
- Development of public open data infrastructure in agriculture, which will be freely accessible and usable by all production and social partners of the agri-food system and will be compatible with the common European data space for Agriculture and Climate (e.g., Copernicus Climate Change Service/C3S, Global Agriculture Sectoral Information System, Agricultural Climate Advisory Services/AgriCLASS, Climate Adaptation Platform/Climate ADAPT, Technical Center for Agricultural and Rural Cooperation/CTA), as well as with the Farm Sustainability Data Network (FSDN).
- Expansion of high-speed broadband networks in rural areas of the country, with financing of public expenditure from the new CAP, to improve access to digital services, in order to achieve the goal of 100% access by 2025. The free and fast access to internet services is a key condition for the success of the strategy to promote the green and digital transformation of Greek agriculture, especially in isolated, mountainous, disadvantaged, and insular areas, which are more vulnerable to poverty, abandonment and social exclusion. The expansion of broadband technologies in these areas can contribute decisively to the improvement of the quality of life of their inhabitants, to the

retention of the population and the attraction of new people, to the preservation of agricultural activity (which is often the main source of income), to the diversification of employment and the creation supplementary income.

H5. *Manage the Climate Change related Risks for Agriculture.*

The effects of climate change create serious risks for agricultural production, the relevant infrastructure and the equipment of agricultural holdings (damage to fixed assets, partial or total loss of production and/or degradation of product quality, etc.). As a result, the appropriate risk management tools under the new CAP, in order to protect producers' income from its sharp, intense and unpredictable fluctuations, are activated due to specific risks [57]. These risks may concern economic damages to the producers caused by adverse climatic events, animal or plant diseases, infestation by pests or environmental events. To this end, the proposal for this measure focuses on the following interventions:

- Subsidizing the insurance premiums paid by producers to cover against production losses (based on the calculation of the percentage of production reduction compared to the average of the last three or five years) due to climate change, as an incentive to manage risk, the corresponding adjustment is required of the statutes of the Hellenic Agricultural Insurance Organization (ELGA), in order to expand its activity in voluntary insurance, defining the new categories and the corresponding risk premiums based on a relevant actuarial study, while the possibility of private insurance's contribution in the same direction should also be examined.
- Establishment of mutual aid funds, which will be subsidized for their management costs, as an incentive for their formation and the encouragement of producers' participation in them. The aim of mutual aid funds is to share the risk among their members, which usually concern groups of producers in the same sector, so that those affected are compensated when necessary and for the risks foreseen, from the contributions of all the members to the fund.
- Activation of an income stabilization tool, in the form of financial contributions from producers to mutual aid funds, which will provide them with compensation in cases of a serious reduction in their income due to crises (mainly environmental, climate, sanitary, phyto-sanitary). This specific tool differs from the rest, because it concerns the granting of compensation based on the calculation of the percentage of reduction in income and not production, in relation to a predetermined period of time in the past, while it also requires a clear identification of the reasons that justify the compensation in question.

4.2. *Proposals for Policy Measures and Interventions on Specific Objectives of the New CAP*

4.2.1. *Proposals for Policy Measures and Interventions on Specific Objective 4 (ES4)*

In the context of Specific Objective 4 (OS4) of the new CAP, which concerns mitigation and adaptation actions to CC, as well as the production of sustainable forms of energy, the diagnostic analysis of agriculture and the assessment of the existing situation highlighted a set of needs and priorities for the design of policy measures and interventions related to the management of greenhouse gas emissions and the sector's energy potential and prospects. Special considerations should be directed towards the design of the new climate actions, ensuring that no overlaps between the different policy instruments of the Pillars of the new CAP (enhanced air quality, ecological schemes, agro-environmental—climate measures for rural development) will occur while at the same time establishing their synergy and enhancing their complementarities. The distinct and clear definition of commitments per action will make them easier to understand and implement by producers, while significantly reducing the administrative costs of their implementation and controls.

On this basis, the proposals concern the following policy measures, which are consistent with the increased ambition of the new CAP for the environment and the climate, as well as with the objectives of the "Farm to Fork" strategy, in the context of the European Green Agreement.

ES4-SP1: Mitigate Climate Change Effects in Agriculture

The proposal for this specific measure is based on the need to further reduce greenhouse gas emissions and increase carbon sequestration by agriculture, and focuses on the following interventions:

- Implementation of new actions regarding organic agriculture and animal husbandry, which will concern more eligible crops and breeding, with the aim of increasing the beneficiaries and the agricultural lands included in them, to maximize the results of their application in mitigating climate change. Actions will enhance the loss of income or additional costs caused by organic production compared to conventional production.
- Promotion of new actions of extensive coverage, with the aim on the one hand of improving the carbon sequestration capacity of agricultural lands and permanent pastures that are part of them, through the increase of their biomass cover using the appropriate plant species, and on the other hand the promotion of low intensity and inputs agricultural and livestock activity that contributes to the reduction of GHG emissions.
- Integration with the ecological schemes of Pillar I, increased ambition of environmental and climate commitments [58], through voluntary actions to limit the use of inorganic fertilizers and reduce GHG emissions concerning the application.
- Enrichment of climate actions, with new ones related to agro-ecology and leading to the undertaking of commitments above the baseline of the mandatory standards of the CAP, with the aim of mitigating climate change.
- Application of specialized agricultural practices and methods to reduce greenhouse gas emissions, with a focus on Natura protected areas, on areas of High Natural Value and in areas of the Water Framework Directive, which will focus on the mildest possible management of agricultural and livestock holdings in the target areas, based on the guidelines of the respective thematic studies and management plans. The aid that will be granted under the new CAP for the actions in question will relate to the loss of income or the additional costs caused by their implementation.

ES4-SP2: Adapt to the Climate Change Effects in Agriculture

The proposal for this specific measure is based on the need to take more initiatives and increased care through incentives of the new CAP (compensations for lost income or additional costs for commitments above the enhanced optional/voluntarily undertaken by producers, attractive financing rates for adaptation investments, reduction in insurance premiums risks as an incentive to implement investments to prevent and protect agricultural production, etc.), for more ambitious actions to adapt agriculture to climate change, and focuses on the following interventions in harmony with the National Strategy and the Regional Climate Change Adaptation Plans:

- Supporting actions to protect and preserve domestic genetic material of plants (domestic varieties) and animals (domestic breeds), with priority to those most threatened, and improve resistance to risks caused by the effects of climate change.
- Adopting practices in livestock production that increase livestock resilience, fertility, well-being, longevity, and adaptability to changing climate conditions.
- Extensively restructuring towards crops and varieties more resistant to climate change (e.g., to pest and disease, dry heat conditions, with lower water requirements, etc.), through investment plans to improve agricultural holdings, at the same time utilizing appropriate agricultural practices integrated plant protection, nutrition and management of natural resources.
- Promoting the implementation of irrigation management actions, as a means of adapting agriculture to the intensifying dry heat conditions due to climate change, in the most affected areas.
- Promoting investments to prevent damage to agricultural production from catastrophic events, disease and extreme weather events (e.g., investments for anti-hail and anti-freeze protection of agricultural production, to prevent the spread of zoonotic diseases, to relocate agricultural and livestock units from high to low risk areas, etc.),

as well as investments in controlled environmental conditions (e.g., greenhouses), in order to ensure the quality of production and protect the income of farmers. Investments in production protection will simultaneously contribute to the sustainability of the agricultural insurance system (ELGA), which is under great pressure to pay disproportionate compensation due to the rapid increase in the frequency and intensity of extreme weather events.

ES4-SP3: Pursue Sustainable Energy Production from Agriculture Activities

The proposal for this specific measure is based on the need to increase sustainable energy production from agriculture, according to the principles of the circular bioeconomy, through the provision of investment incentives from the new CAP and focuses on interventions in the promotion of private investments, for the utilization of renewable sources (RES), as well as by-products and by-products of plant (biomass) and animal (animal waste) origin.

A key condition for the success of the proposed interventions is to ensure greater synergy and complementarity of sectoral policies for sustainable energy, especially in terms of accelerating their planning and implementation, in order to facilitate the implementation of the corresponding “green” investments. Areas of more effective synergy are the policies for the siting and licensing of investments (e.g., photovoltaics on otherwise non-productive land, availability, and degree of saturation of the electricity grid, offsetting of produced/consumed energy—net metering), the pricing of produced sustainable energy in relation to conventional, the diversification of self-production and trading of energy from RES.

4.2.2. Proposals for Policy Measures and Interventions on Specific Objective 5 (ES5)

The diagnostic analysis and assessment of the current situation of Agriculture highlighted the priorities of Specific Objective 5 (ES5) of the new CAP, to promote sustainable development and the effective management of natural resources, their strong interconnection and interaction with the climate mitigation and adaptation objectives, a fact that is reflected in the proposed interventions, which concern the protection and more efficient use of natural resources, but at the same time contribute to the reduction of GHG emissions, increased carbon sequestration and adapting to climate change. In the context of interdependence, synergy, and complementation of the specific objectives of the CAP for the environment and the climate, the following proposals for policy measures and interventions are formulated.

ES5-SP1: Reduce Ammonia Emissions in Agriculture

The proposal for these specific measures is based on the need to plan and implement more intensive and more targeted interventions to limit ammonia emissions, with an emphasis on animal husbandry, which is the main cause of the problem. In this direction the proposed interventions mainly focus on:

- Promotion of organic agriculture and animal husbandry.
- Preservation and expansion of permanent pastures.
- Rational management of manure and mineral fertilizers.
- Diversification of livestock nutrition, in terms of the composition of the mixture of rations with a reduction in their protein content, making use of the relevant results of scientific research, through the development of pilot collaborations in the context of the corresponding horizontal measure for their transfer in livestock practice.

ES5-SP2: Promote Sustainable and Efficient Management of Water Resources in Agriculture

The proposal for this specific measure is based on the need to immediately manage the problem of the adequacy and quality of irrigation water. The seriousness and criticality of the problem prioritizes it among the major issues that must concern the design of the new

CAP in our country, in synergy with the provisions in complementary national policies on water and climate change, such as the updated Watershed Management Plans for Rivers. Interventions aimed at more effective management and more efficient use of irrigation water should focus on:

- Supporting private water-saving investments in agricultural holdings, by providing incentives (such as high aid rates and preferential access to flexible financial lending tools to cover the investors' own participation),
- Implementing a specialized investment program for the restructuring of water-bearing crops or varieties, with new ones that demonstrate adaptability/resistance to drier conditions and have a shorter biological cycle, with priority in the areas most affected by climate change based on modern agro-climatic zoning,

ES5-SP3: Sustainable and Effective Soil Management in Agriculture

The proposals for this specific measure are based on the need to protect the soil resources from pollution, erosion and flooding, degradation of their fertility, salinity and desertification, so that they continue to provide vital services in plant nutrition and agricultural ecosystems. Interventions aimed at sustainable and effective soil management focus mainly on the implementation of extensive practices to improve the structure of agricultural soils, enrich them with organic materials and protect them from erosion and flooding, with an emphasis on the areas most exposed to the effects of climate change, such as permanent pastures and sloping agricultural land. In particular, the interventions concern:

- Preserving and upgrading the quantity and quality of pastures via natural re-vegetation and/or artificial regeneration (e.g., mulching with legumes to enrich them in high nutritional value animal feed and improve their productivity [59]), as well as their expansion and controlled grazing in order to protect the soil from overgrazing, erosion and the leaching of nutrients.
- Raising awareness, training, and providing advisory support for producers in the implementation of more effective methods, practices and technologies for protection and effective soil management, through the corresponding actions of the horizontal measures described previously. In addition, important synergies of the CAP can be created within the framework of the "Horizon Europe" mission for soil health.

4.3. *Proposals for Policy Measures and Interventions on Specific Objective 6 (ES6)*

As established by the analysis so far of interventions to serve specific objectives 4 (ES4) and 5 (ES5) of the new CAP, Agriculture and Climate Change interact, determining the balance of GHG (emission and absorption) based on implementation efficiency of climate measures on natural resources. This is reflected on the health and sustainability of agro-ecosystems, biodiversity, and landscapes, which constitute the specific objective 6 (ES6) of the new CAP and a key strategic priority of the European Green Deal which sets specific and measurable objectives. In this sense, the set of policy measures and interventions that have already been proposed to reduce greenhouse gas emissions, increase carbon sequestration, and protect natural resources, also contribute positively to the satisfaction of the specific objective 6 (ES6) of the new CAP to protect biodiversity, enhance ecosystem services and preserve habitats and landscapes.

4.3.1. ES6-SP1: Protection of Ecosystems Vulnerable to Agricultural Activity and Climate Change

This measure is based on the need to protect agro-ecosystems vulnerable to agricultural activity and the effects of climate change, located within protected and/or degraded areas (e.g., Natura 2000 areas, areas of high natural value, agricultural areas included in river basin management plans, and grazing management plans), and focuses on interventions regarding:

- Improvements in the recording and data collection systems (e.g., of wild fauna and flora, indigenous genetic resources at risk of extinction, pollution of natural resources,

degree of pasture degradation and soil desertification, zoonotic and phytopathogenic organisms, insects, and plants), as well as monitoring and controlling the progress of the implementation of the relevant measures and actions.

- Raising awareness of producers, providing training and advisory support, as well as aiding the development of synergies and partnerships for the promotion of sustainable agricultural practices for the protection of biodiversity, natural resources, and landscape characteristics in their agricultural holdings, through the actions of horizontal measures proposed earlier.
- Implementing specialized sustainable agricultural practices that contribute to the preservation and upgrading of agro-habitats, through commitments of increased ambition and sensitivity.

4.3.2. ES6-SP2: Protect and Improve Genetic Diversity

This measure is based on the need to protect genetic resources and strengthen the genetic diversity of agricultural ecosystems and focuses on interventions on the:

- Promotion of the cultivation and breeding of traditional domestic varieties of plants and breeds of animals, respectively, with an emphasis on those that are most at risk of extinction and show greater resistance to the effects of climate change (erosion, water scarcity, dry-thermal conditions, and spread of invasive species).
- Genetic improvement of domestic genetic resources of plant and animal origin in situ and in seed and genetic material banks (of the Thessaloniki Genetic Material Bank and in selected Scientific Institutions and Agricultural Schools), so that they become more resistant to worsening climatic conditions and changes.
- Registration, limitation, and control of invasive—invasive species, through early detection, prevention, and information—awareness of producers, as well as the adoption of appropriate agricultural practices and methods to avoid their spread (e.g., biological control), in combination with the protection of endemic species threatened by them.

4.3.3. ES6-SP3: Protection of Rural Landscapes and the Promotion of Rural Tradition and Heritage

This measure is based on the need to preserve and protect rural landscapes and to promote rural areas as poles of interest for their non-agricultural exploitation, and focuses on the following interventions:

- Restore and maintain landscape features in agricultural lands, encouraging their diversity to provide habitat and ecosystem services to wild flora and fauna (wild animals and birds, plants, pollinators, and beneficial insect fauna), through implementing best practices.
- Enriching them with buffer zones, plant hedges, and non-productive elements (trees, terraces, small lakes).
- Increasing the natural agents of biological control of harmful organisms and their population control (by releasing beneficial predators, using pheromones and natural substances to prevent their uncontrolled reproduction).
- Promotion of rural landscapes and habitats, in combination with the rich agricultural and cultural heritage of rural areas, through their promotion and the provision of incentives for their sustainable, balanced, and sustainable environmental and economic development, in the direction of creating new economic off-farm activities and jobs, in service sectors such as ecotourism, rural tourism and recreation. Especially protected areas and areas of high natural value, which are ecosystems of particular natural beauty, can be the focus of diversification of the rural economy and the creation of alternative employment and income for their producers—residents, through relevant actions of the local LEADER development programs of the new CAP.

A summary of the proposed policy measures can be found in Table 5 below.

Table 5. Policy Measures and Interventions per General (GO) and Specific Objective (SO) of the CAP 2023–2027 for Climate Change.

GO/SO CAP 2023–2027		Proposed Measures		Action Items				
GO	Horizontal	Promote information diffusion, awareness, and training/education	Raise awareness of all “partners” involved in the implementation of actions for mitigation and adaptation to CC.	Train and educate producers in the adoption and effective implementation of environmental—climate commitments				
		Provision of agricultural advice and consulting services	Procure advisory services for managing the climate actions of the new CAP.	Procure consulting services for the exploitation of innovation and new technologies.				
		Actively promote cooperation in the agri-food sector	Development of operational teams for the implementation of pilot programs and innovative investments.	Develop a public digital platform with good environmental practices in Agriculture.				
		Mobilize investments towards innovation and digitalization in Agriculture	Provide incentives to promote green and digital private investments in new Agricultural technologies.	Develop public open data infrastructure of Agriculture for personalized utilization by producers.	Expansion Broadband in rural areas to promote the green and digital transformation of Agriculture			
		Manage the climate change related risks for Agriculture	Subsidizing insurance premiums paid by producers to cover production losses due to CC.	Establish mutual aid funds with incentives to encourage producers’ participation.	Activate an income stabilization tool to compensate producers in severe reduction in their income due CC			
SO 4	Greenhouse Gas Emissions	Climate change mitigation in Agriculture	Activate of new actions of organic agriculture and animal husbandry, which will concern more eligible crops and breeding.	Improve the carbon-binding capacity of agricultural soils and promote low-intensity/low-input agriculture.	Specialized agricultural practices for protected Natura areas, areas of High Natural Value and areas of the Water Framework Directive.	Incorporate environmental and climate commitments within the ecological schemes of Pillar I of the new CAP.	Enrich climate actions with agro-ecology and undertake commitments above the CAP mandatory standards.	Limit methane emissions, based on the guidelines and objectives of the relevant EU strategy.

Table 5. Cont.

GO/SO CAP 2023–2027	Proposed Measures		Action Items				
	Adapting Agriculture to Climate Change.	Encourage actions to protect and conserve indigenous genetic material, as well as improve its resilience to the risks and impacts of climate change.	Adopt livestock production practices that increase their resilience, fertility, well-being, and adaptability.	Aim for extensive restructuring towards crops and varieties more resistant to climate change.	Implement irrigation management actions and seek means of adapting Agriculture to intensifying dry heat.	Promote investments to prevent losses in agricultural production due to CC.	Emphasize organic agriculture and animal husbandry, agro-ecology and low-intensity agriculture actions.
	Sustainable energy production.	Seek sustainable energy production in Agriculture.	Promote private investment for the exploitation of renewable sources, agricultural and animal by-products.	Develop specialized information, training, collaboration, and advisory support actions for the promotion of innovation and new technologies.	Create appropriate financial tools to support the beneficiaries in the implementation of their “green” investment plans.		
SO 5	Air	Reduce ammonia emissions from Agriculture.	Promote organic agriculture and animal husbandry.	Preserve and expand permanent pastures	Rational management of manure and inorganic fertilizers.	Differentiate livestock nutrition, in terms of the composition of the ration mix.	
	Water resources	Sustainable and effective management of water resources in Agriculture.	Encourage private investments in water conservation on farms.	Implement a specialized investment program to restructure water-bearing crop varieties in the most vulnerable areas.	Design and execute an integrated plan of public investments for the utilization of surface run-off and maintenance of existing irrigation networks.	Ensure synergies with the corresponding climate actions of the CAP, which promote water saving through the application of appropriate agricultural practices.	Provide information, training and advisory support to producers regarding the implementation of more efficient practices and technologies for saving water.
	Soil	Sustainable and effective soil management in Agriculture.	Preserve and upgrade pastures, in combination with their expansion and controlled pasture grazing.	Apply farming practices to protect the soil from erosion, maintain and increase its organic matter, etc.	Raise awareness, train and support producers for more effective implementation of soil management practices.		

Table 5. Cont.

GO/SO CAP 2023–2027		Proposed Measures		Action Items	
SO 6	Biodiversity, Agricultural Ecosystems and Rural Landscape	Protection of vulnerable ecosystems from agricultural activity and CC.	Improve of data recording and collection systems monitor and control the progress of implementation of the relevant measures and actions.	Raise awareness, training, and advisory support to producers to promote sustainable biodiversity protection practices.	Apply specialized sustainable agricultural practices that contribute to the preservation and upgrading of agro-habitats.
		Protection and improvement of genetic diversity.	Promote cultivation and breeding of traditional indigenous plant varieties and animal breeds, with emphasis on those most at risk of extinction.	Genetic improvement of domestic plant and animal genetic resources in situ and in seed and genetic material banks.	Register, limit, and control invasive species and adopt the appropriate agricultural practices to avoid their spread.
		Protection of rural landscapes and the promotion of rural tradition and heritage.	Restore and preserve landscape features on agricultural land, encourage diversity and provide habitat and ecosystem services to wild flora and fauna.	Promotion rural landscapes and habitats and provide incentives for their sustainable and balanced environmental and economic development.	

5. Conclusions

The effects of climate change are becoming increasingly intense and damaging, affecting all economic activities. Agriculture is one of the most exposed sectors, resulting in farmers experiencing severe losses in their production and changes in the way they exercise their profession and manage their farms and natural resources. Faced with the risks stemming from climate change, the EU has made addressing its impact on agriculture one of its highest priorities, setting ambitious targets that are reflected in its policies which are incorporated into the new Common Agricultural Policy (CAP) 2023–2027. The new CAP, with its considerable resources, is the EU's main mechanism for promoting its environmental and climate policy in agriculture. However, the definition of a new 'green architecture', its implementation, and funding structure have not been without obstacles that have significantly hampered its effectiveness. We therefore highlight that the improvement of the contribution of the new CAP to addressing the effects of climate change should be pursued by ensuring complementarities and synergies with relevant EU financial instruments in order to meet the increased financial needs caused by its ambitious objectives.

In this context, the present study provides a diagnostic analysis of Greece's agricultural sector in relation to the specific objectives of the new CAP on climate, natural resources, and biodiversity (2023–2027), as well as the evaluation of the results of its previous (2014–2020) implementation. Furthermore, we have highlighted the needs and priorities that can lead to the adoption of an appropriate strategy to address the effects of climate change through concrete, realistic, and effective interventions, and policy measures. On this basis, we developed a strategic approach for the development of Greek agriculture in relation to climate change, which is in line with the principles and objectives of both the new CAP and EU climate policies. This strategy, which advocates the transition to a new development model compatible with the productive structure and structure of Greek agriculture, is oriented towards the principles of the green economy, which will utilize knowledge, innovation, and modern digital technologies in combination with Greece's comparative advantages.

These proposals range from shifting cultural perceptions and raising producers' awareness of the principles of sustainable development, their education and training, their cooperation and networking, their advisory support, and their participation in pilot research and knowledge transfer programs in agricultural practice, to the specialized application of new environmentally friendly methods of rational use of fertilizers and pesticides, animal waste management and sustainable energy production, and the adoption of new farming practices and management tools, such as precision farming, as well as digital technologies for the prediction and prevention of extreme phenomena. These proposals also include actions to restructure crop production around varieties that are more adaptable and resistant to new conditions, to encourage the implementation of public and private investments, on the one hand, to make more efficient use of natural resources, in particular irrigation water, and, on the other hand, to protect production from natural disasters, adversities, and diseases, and to extend the applications of organic modes of cultivation. This includes the conservation of pastures and their low-intensity use, animal welfare, the protection of sensitive ecosystems with mild agricultural practices, the protection and improvement of genetic diversity, and the promotion of agroforest and agro-economic systems that will further contribute to the conservation of biodiversity and landscape in the Greek countryside.

By extension, the proposals for the new CAP that were formulated in the context of this study respond to the basic strategy of a balanced, fair, and sustainable development of the primary sector, through policy measures and interventions that approach holistically the structural needs and the green transformation of Greek agriculture with the ultimate goal of its climate neutrality. We find that greater emphasis should be placed on the development of climate change risk management tools in agriculture, such as mutual funds, and tools to stabilize producers' incomes, as well as on the introduction of new environmentally friendly measures and environmental measures with maximum financial weight as

possible in all available resources under the new CAP, in order to ensure the critical mass required to increase their implementation efficiency.

The results of this study can be used both theoretically and in practical terms, as they relate both to the formulation of a strategy and to the implementation of concrete measures and actions to mitigate the effects of climate change and adapt agriculture to it within the framework of the new Common Agricultural Policy (CAP) 2023–2027. In particular, the diagnostic analysis, the evaluation of the previous implementation of the CAP in our country, and the highlighting of the needs of Greek agriculture in dealing with the effects of climate change have drawn useful conclusions that can be used in the implementation of the appropriate national strategy, which was very recently finalized by the Ministry of Rural Development and Food. At the same time, these conclusions can be used in the process of ensuring synergies with the relevant strategies on the environment and climate, as developed by the Ministry of Development and Investment and the Ministry of Environment and Energy.

Regarding the estimation of budget-neutral subsidy rates, the introduction of an emissions-related savings subsidy for farmers could trigger both a decrease in agricultural supply and changes in production systems in favor of more emission-efficient farming practices. In cases where the production level effects dominate and agricultural markets are sufficiently isolated, prices might increase significantly. Assuming higher producer prices, *ceteris paribus* (“other things equal”), the incentive to cut agricultural emissions to the same degree also needs to increase, leading to higher unit subsidy rates. More emission-efficient technologies can come at a significant adoption cost, increasing producer prices and concurring higher unit subsidy rates.

Finally, the present study can be updated in the future on the basis of the progress made in implementing the new CAP in our country, in order to assess the contribution of the financing of specific environmental and climate measures and actions, and the development of synergies with other financial instruments, in the achievement of its objectives, as well as the objectives of the European Green Agreement.

6. Limitations and Future Research

The EU’s ambitious environmental and climate strategies create high expectations, which in turn raises reasonable questions as to whether the EU Member States, including our country, have the political will and the necessary managerial—administrative and technical—competence to meet these objectives effectively and in a timely manner. Moreover, at this stage we cannot account for the uncertainty of whether the ‘green architecture’ of the new CAP will ultimately make a substantial contribution to achieving the objectives set out in the European Green Agreement on agriculture, as it is questioned by the producers themselves, who are called to make even greater concessions to environmental and climate objectives with reduced resources in a challenging economic environment. Another limitation of this study is that we do not provide a monitoring system that could keep track of the implementation and success of the measures we propose, as such an effort would undoubtedly be subjected to multiple technical and legal obstacles.

However, future research could benefit significantly from exploring whether the policy mix that is eventually adopted for the green transformation of Greece’s production model can respond effectively to the challenges related to agricultural competitiveness and sustainability, ensuring food adequacy and security, dealing with crises, revitalizing the Greek countryside, and maintaining—improving the standard of living in our rural areas. Agriculture is the most vulnerable sector of economic activity to climate change and at the same time a serious cause of it; this, combined with its important role in the economic and social structure of the country’s rural areas and with the considerable resources allocated to it by the CAP to achieve a number of ambitious objectives and priorities, needs to be studied in depth in order to further explore their relationships, links, and interactions. Another interesting area of research would also be the identification and the adoption of additional indicators, measuring the effectiveness of CAP interventions on the environment and cli-

mate, and contribute to a more efficient use of resources coupled with enrichment of the existing monitoring and evaluation.

Ultimately, the key question about the prevailing strategy—and eventually a measure of its success—will be its ability to inspire and create the conditions for the consolidation of the proposed reforms by all involved stakeholders—particularly the producers—towards a greener and more sustainable Greek agricultural sector. The results, immediate and long-term, remain to be seen.

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