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Socioeconomic Impacts of Climate Mitigation Actions in Greece: Quantitative Assessment and Public Perception

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Abstract: Appropriately designed and implemented climate mitigation actions have multiple co-benefits (yet some trade-offs cannot be excluded) that result in substantial social and economic value beyond their direct impact on reducing energy consumption and GHG emissions. Despite their wider acknowledgement by the research community, decision makers and the public have incomplete information on these multiple effects. This paper has a twofold objective: First, through analytical bottom-up approaches, it assesses, in quantitative terms, the macroeconomic effects and the public health benefits attributed to a variety of mitigation actions under consideration in the context of the Greek Energy and Climate Plan. Second, it investigates, through a social survey, how citizens perceive climate change and value these multiple impacts of mitigation actions, and to what extent they are willing to pay for them and support the adoption of policy measures aiming at the green transition of the Greek economy. We show that mitigation actions bring about significant health benefits, particularly in cities, and generate significant positive macroeconomic effects, particularly if mitigation actions focus on the decarbonization of the building sector and on the exploitation of local renewable sources. We also argue that most people do not realize that climate mitigation actions can have wider benefits for society, such as tackling energy poverty, improving public health, and creating new jobs. Unwillingness to pay tends to be the prominent attitude. People who are more reluctant to cover a part of the cost of environmental protection are less likely to perceive that climate change is one of the main challenges at global and national level and support the adoption of climate mitigation policies. In this context, the national strategy for climate change should focus on effectively informing and engaging the public in climate mitigation strategies, strengthening the public trust in government institutions, promoting mutually acceptable solutions with the local communities, and providing incentives for changing citizens' behavior towards climate-related actions.

Keywords: climate mitigation; socioeconomic impacts; co-benefits; trade-offs; public perception; climate action plans; willingness to pay; environmental behavior

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1. Introduction

Climate change has emerged as one of the most severe challenges facing our planet. We are already experiencing the impacts of climate change, while important sectors of the Greek economy and society are required to adapt to the future effects. Development of clean energy technologies, namely renewable energy sources (RES) and energy efficiency in all economic sectors (i.e., power generation, industry, buildings, transport, etc.), are the main pillars of the European policy to tackle climate change and achieve the transition to a climate-neutral economy. However, numerous barriers prevent the effective implementation of these clean technologies and their large-scale penetration into energy systems. Among the most significant of them are the financial hurdles such as the high up-front costs usually required to purchase and install clean technologies and, in several cases, their relatively low economic performance. On the other hand, an increasing number of studies [1–6] have shown that the exploitation of renewable energy technologies in energy systems and the promotion of energy conservation interventions in industry, buildings, transport, etc., result, apart from mitigating climate change, in several other co-effects, such as environmental improvement at local and regional level, significant economic benefits through job creation, expansion of the economy, increase of the income availability, etc., most of which promote social welfare and contribute to achieving the United Nations (UN) Sustainable Development Goals (SDGs). However, some trade-offs cannot be excluded. The multiple co-effects associated with the implementation of clean technologies in the various sectors of the energy system can be classified into four main categories, namely:

- Health effects, such as reduced mortality and morbidity from the improved indoor and outdoor air quality due to the promotion of RES and the implementation of energy conservation measures in industry, transport, buildings, and so on.
- Environmental effects, such as reduced impacts on ecosystems due to the improved outdoor environment, aesthetic impacts due to the large-scale exploitation of wind farms at local level, improved resource management, including water and energy sources, etc.
- Economic effects, as greater use of renewables and energy efficiency often result in job creation, economic growth, increase of income, productivity gains, and reduced needs for capital stock in the energy sector. Also, increased use of renewables and implementation of energy conservation measures reduces energy imports at national level and enhances security of energy supply. However, some of these effects may be partially counterbalanced due to less investment and lower production in other parts of the economy, particularly in sectors based on fossil fuels.
- Social effects, such as fuel poverty alleviation in virtue of the implementation of energy conservation measures, risks of food security due to increased role of energy cultivations, etc.

A number of studies [4,7] showed that the multiple benefits of clean energy technologies are significant. Quantifying and, if possible, monetizing these wider impacts of climate action would facilitate their inclusion in cost–benefit analysis, strengthen the adoption of ambitious emissions reduction targets, and improve coordination across policy areas reducing costs [8,9]. Moreover, to reduce or eliminate the antinomies and strengthen the synergies among environmental, social and development goals, social dimensions of climate action need to be intertwined in the planning and implementation of climate change policy.

Ultimately, the policy effectiveness is inextricably linked to the citizens' risk perceptions of climate change and its impacts, as well as to the behavioral change of the policy addresses. In this sense, a top-down model of policy implementation for mitigating climate change is inadequate because it is crucial for people to form motivated reasoning in order to adjust themselves to the emerging climate predicaments. Thus, mapping and understanding how the public perceives climate change and related mitigation policies, as well as whether they are willing to pay for them, is crucial for taking targeted action and prompting mitigation efforts. In this respect, the intention of citizens to bear a part of the cost of climate mitigation could be seen as an indication of public support for environmental policy measures.

This paper presents the work undertaken in the context of the Greek National Network for Climate Change and its Impacts (CLIMPACT) founded by the General Secretariat of Research and Innovation, and has a twofold objective. First, through analytical bottom-up approaches, to quantify some of the multiple effects associated with climate mitigation actions planned in the Greek energy system, namely the macroeconomic effects (i.e., impacts on employment and income) attributed to the spending required for the implementation of these actions, as well as the public health benefits due to improved outdoor atmospheric environment. Second, to investigate, through a social survey, how citizens perceive climate change and valuate these multiple impacts of mitigation actions, and to what extent they are willing to pay for them and support the adoption of policy measures aiming to the green transition of the Greek economy, such as the coal phase out and the development of the RES sector.

2. Methods and Materials

2.1. Quantification of Macroeconomic Effects

Investments required for the implementation of mitigation actions, mainly in the short-run, create increased economic output and employment in sectors delivering energy efficiency services and products, which are partially counterbalanced by fewer investments and lower production in other sectors of the economy [3,8,10]. Furthermore, energy savings due to the implementation of mitigation actions will result, mainly in the long-run, in increased disposable income for households and companies, which in turn may be spent to acquire other goods and services or new investments, resulting in economic development, the creation of new permanent employment, and positive public budget implications [1,3,8]. The magnitude of these impacts depends on the structure of the economy, the extent to which energy saving technologies are produced domestically or imported, but also from the growth cycle of the economy, with the benefits being maximized when the related investments are realized in periods of economic recession [8,11].

In the context of CLIMPACT, the macroeconomic impacts of several clean technologies that can be applied into the Greek energy system for reducing greenhouse gas (GHG) emissions were examined through input–output analysis. This choice was dictated by the large number of interventions analyzed and by the fact that the interventions were examined separately, with a view that the results derived will be utilized by other models and approaches aiming to identify a package of interventions that will contribute to substantial reduction of GHG emissions and simultaneously maximize social welfare. To this end, input–output analysis provides sufficient flexibility in relation to a fully specified modelling approach, as the economic system is disaggregated into a large number of sectors, allowing a detailed simulation of the interventions under consideration. Furthermore, input–output analysis is characterized by relative simplicity, which means results are easier to interpret, and relatively few resources are required. On the other hand, it should be noted that the analysis focuses on the macroeconomic effects attributed to the spending required for the implementation of clean energy technologies, and does not explore the possible effects on energy prices and how these may affect the economy at national and sectoral level.

Input–output analysis is based on input–output tables and provides a framework for evaluating the effects of an investment on key socio-economic variables considering the inter-sectoral linkages in the economy where the investment in question is realized. The standard representation of the input–output model in matrix notation is defined in the following Equation, which allows constructing disaggregated multipliers to estimate the direct, indirect, and induced impacts of an investment [12]:

$$X = (I - A)^{-1} Y \tag{1}$$

where,

X is the vector of output of the economy in question (all elements of the vector are expressed in EUR).

Y is the vector of final demand of the economy (all elements of the vector are expressed in EUR).

I is the identity matrix.

A is a $n \times n$ matrix of technical coefficients. A technical coefficient a_{ij} is defined as the amount of production of sector i used by sector j in order for the latter to produce one unit of output. Through these coefficients, one can estimate the direct impacts from an increase in final demand for a particular commodity on the various economic sectors.

The $(I-A)^{-1}$ is the n × n matrix of input–output multipliers, or the Leontief inverse. The rows and columns of the Leontief inverse matrix are the sectors of the economy, and each element b_{ij} of this matrix shows the total required increase in the production of sector i to meet an increase of one unit in the final demand of sector j. The sum of all the elements of the j column of the Leontief inverse matrix gives the output multiplier of the sector j, which shows the total change in gross output (or sales) of the entire economy created by a change in the final demand of sector j by 1 EUR.

For estimating the macroeconomic effects of clean technologies, the total investment required is disaggregated to a number of several distinct economic sectors, which are included in the input–output table. It is assumed that the marginal change MX_j in the activity of sector j caused by the realization of the project in question at hand incurs an analogous change in the level of various macro-economic parameters (i.e., employment, GVA (Gross Value Added), wages, taxes on products, and taxes on production) that can be approximated by the following simple formula:

$$ME_j = MX_j \cdot \frac{E_j}{X_j} \tag{2}$$

where ME_j is the marginal change of the macroeconomic parameter E, which characterizes sector j, from the marginal change MX_j of the output (X) of sector j. Thus, the direct effects on employment, GVA, wages, taxes on products and production, etc., from development and operation of clean energy technologies result from the sum of all marginal changes estimated in all sectors of the economy affected by the projects in question.

The indirect and induced effects on these macro-economic parameters can also be estimated by exploiting the input–output table through appropriate multipliers. As in the case of output, there are two types of macro-economic multipliers. Specifically:

- The Type I multiplier of the macro-economic parameter E ($M_{I,E,j}$) calculates the increase of E in the whole economy (direct and indirect effects) due to a unit direct increase of E in sector j:

$$M_{I,\ E,j} = \sum_{i=1}^{n} \frac{e_i \cdot b_{ij}}{e_j} \tag{3}$$

where $M_{I,E,j}$ is the Type I multiplier for the macro-economic parameter E and sector j, e_i (or e_j) is the corresponding macroeconomic effect creating in sector i (or j) per 1 EUR of total output per sector i (or j), and $b_{i,j}$ is the Leontief coefficient which depicts direct and indirect impacts on the demand for the output of sector i as a result of changes in the demand of sector j.

- The Type II multiplier of the macro-economic parameter E ($M_{II,E,j}$) measures the ratio of direct, indirect, and induced effects on E to the direct change of E in sector j:

$$M_{II,E,j} = \sum_{i=1}^{n} \frac{e_i \cdot b'_{ij}}{e_j} \tag{4}$$

where $b'_{i,j}$ is the Type II Leontief coefficient.

Under these terms, we examined the direct, indirect, and induced impacts of the domestic spending associated with implementation of clean energy technologies in question on value added, employment, and income at national level. The analysis was performed based on technical and economic data provided by energy experts and a literature review, and according to the most recent (2015) input–output table for the Greek economy provided by Eurostat. The gross effects of these effects have been estimated considering the following macroeconomic implications:

- Investment effects associated with the construction and implementation of the clean energy technologies in question.

- Operation and maintenance effects associated with the necessary operation and maintenance activities for the effective functioning of the interventions in question.
- Increased consumption effects in households due to reduced energy expenditures associated with the implementation of energy efficiency measures in the residential sector.

Conversely, possible negative effects on traditional sectors of the Greek economy (e.g., power generation, refineries, etc.) are not examined, as these sectors have the option to adjust their production processes and increase exports, while the aim of this analysis is a comparative evaluation of alternative options with a view to prioritize sectors and interventions towards the decarbonization of the Greek economy.

2.2. Analysis of Public Health Effects

Air pollution is a major cause of death and disease globally. The health effects range from increased hospital admissions to increased risk of premature death. According to the World Health Organization (WHO) [13], in 2019, 6.7 million deaths globally were attributed to the joint effects of ambient and household air pollution. According to the European Environmental Agency, "Air pollution is the single largest environmental health risk in Europe and has significant impacts on the health of the European population, particularly in urban areas" [14].

Fossil fuel consumption contributes to air pollution as well as to climate change. Climate change affects human health directly due to changes in temperature and precipitation (resulting in heat waves, floods, droughts, and fires) and indirectly due to ecological disruptions (e.g., vector-borne diseases) and increased risk of undernutrition resulting from diminished food production in poor regions. Measures to reduce GHG emissions, especially those dealing with fuel combustion, also hold the potential to significantly benefit human health [15]. These co-benefits are generated through improvements in energy efficiency that reduce GHG emissions and health-damaging pollutants [9], provided that these gains are not offset by increases in energy demand, increases of combustion efficiency that decrease emission of incomplete combustion products, and increased use of RES.

In the context of CLIMPACT, the health impacts of the clean technologies examined were estimated by calculating the change of emissions achieved (GHG and air pollutants) through these technologies. This change (per measure) is estimated by comparing the performance of the measure considered (by means of emissions generated) with a situation (reference technology/scenario) without the implementation of the measure. Positive results indicate that the implementation of the measures results in reduced emissions compared to the reference technology. The gases considered were carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O), nitrogen oxides (NOx), sulfur dioxide (SO_2), particulate matter with a diameter 2.5 µm or less ($PM_{2.5}$), and ammonia (NH_3). Emission factors used derive from the 2006 IPCC guidelines, the EMEP/EEA air pollutant emission inventory guidebook, as well as requirements defined in legislation (e.g., the ecodesign, the medium combustion plants directives). For electricity consumption, the average emission factor included in the National Plan for Energy and Climate for 2030 is applied.

The next step was to specify the relative contribution of this change per gas to the environmental impacts considered (here, health impacts). This was achieved by using Disability-Adjusted Life Years (DALY) as the characterization factor [16,17]. According to the WHO, "One DALY can be thought of as one lost year of 'healthy' life". DALY is estimated as the sum of the Years of Life Lost (YLL) due to premature mortality in the population, and the Years Lost due to Disability (YLD) for people living with the health condition or its consequences.

In the context of the present analysis, the DALY values estimated in the context of the LC-Impact project (http://lc-impact.eu/, accessed on 2 February 2020) were used. The values for air pollutants (in DALY per kg of air pollutant) are specific for Greece, while the values for GHG are global, for a time horizon of 100 years. Measures examined are evaluated on the basis of the following indices:

- DALY (during the lifetime of the investment) per million EUR of investment to measure the effectiveness of investments with respect to the health benefits achieved.
- DALY per TWh produced (for RES investments in the power generation sector—RES-e) or avoided (in terms of primary energy for energy conservation) to evaluate the relationship between energy and health impacts.
- DALY per kt of CO_2 reduction achieved due to the implementation of each measure to evaluate the relationship between climate change mitigation activities and health benefits achieved.

2.3. Exploring the Citizens Perception of Climate Mitigation and the Willingness to Pay (WTP) in Greece

The term pro-environmental behavior refers to practices that consciously seek to improve the quality of the environment and minimize the negative impact of one's actions on the natural and built environment, for example, by reducing energy consumption and waste production [18,19].

A great part of the relevant literature attempts to explain individuals' attitudes towards the environment by exploring their main drivers such as environmental knowledge, socio-economic and demographic factors, personal values, intentions and emotions, perceptions, risk assessment, and relevant personal experiences [18,20–27]. All these factors have been found in various empirical surveys to affect (pro-)environmental behaviors to a larger or lesser extent. Attitudes tend to be defined as the positive or negative emotional predispositions towards a person, object, situation, or issue within a certain period of time [18]. Moreover, they may be different towards particular environmental issues, but ultimately they reflect individuals' broader outlook towards the environment, or in other words, their overall environmental concern [28]. In relation to climate change, a general measure of the relevant attitudes is whether people tend to believe that it is human-induced or not [29].

People with high environmental concern tend to be more willing to pay for environmental protection [30–32]. However, the relevant literature reveals the significant correlation between high environmental concern and low-cost environmental behavior, not in a strictly economic sense, but in terms of time and effort required to take pro-environmental action [28]. People tend to engage in pro-environmental behaviors that require lower cost, such as recycling, and they are more reluctant to take actions that are more costly and require changing their habits, such as driving or taking fewer flights. Also, people with high levels of environmental concern may not be willing to personally make bigger lifestyle sacrifices, but may appear more willing to accept policy changes that will encourage pro-environmental behaviors, such as higher fuel taxes or stricter building regulations [18].

Therefore, high environmental concern does not necessarily imply people's willingness-to-pay (WTP), i.e., giving up a part of their income for environmental protection. Individuals' beliefs and perceptions regarding the potential consequences of a given measure for themselves seem to affect their WTP [23]. The intention of people to bear a cost for the environmental protection may also be influenced by product-related factors, such as the cost of green products and services, as well as various socio-economic and demographic drivers [33,34]. Gender may affect the WTP, but it does not seem to be a decisive factor [35,36]. Other socio-economic and demographic factors, especially age, income, and educational level, tend to affect more the intention of people to cover a part of the cost of climate mitigation and environmental protection. More specifically, younger individuals (20–39 years old) have been found to demonstrate a higher WTP compared to older ones (65+) [37], while the higher the income and the education level of respondents, the higher the WTP reported [31].

On the other side, individuals with higher intention to pay for environmental protection tend to be in favor of policy measures that mitigate climate change, such as the production of energy by renewable sources [33]. In addition, they tend to be more willing to pay for energy efficiency products and services, considering not only the environmental benefits from the reduction of GHG emissions, but also the reduced energy cost for themselves [38]. Moreover, people who acknowledge the individual's responsibility for climate change tend to be more willing to pay for climate mitigation in the form of a tax [39]. Therefore, WTP could be seen as an indication of public support to environmental policy measures. In this sense, investigation of environmental perceptions and attitudes against climate mitigation, its impacts, and relevant policies may improve the descriptive and predictive ability of studies eliciting WTP [40].

In the context of this study, we conducted a nationwide phone survey in a representative sample of the Greek population during November–December 2020. A net sample of 1201 people aged 18–65 years old was determined, following the demographic characteristics of the Greek population in terms of gender and age distribution, according to the census of the Hellenic Statistical Authority in 2011. The survey's questionnaire, metadata, and dataset are available at the Social Data Network (SODANET): https://datacatalogue.sodanet.gr/dataset.xhtml?persistentId=doi:10.17903/FK2/XMV8NZ, accessed on 10 March 2022.

For the design of the questionnaire, the empirical data of previous surveys were considered, which reflect the views and attitudes of Greek and European citizens on climate change and environmental issues [41–43]. In stark contrast to other relevant surveys, the 27-question questionnaire included an open-ended question to quantitatively and qualitatively capture the social representation of climate change through the free-association technique. In addition, instead of a pre-selected list of possible responses, we recorded open-ended spontaneous responses of the survey participants, regarding the perceived importance of contemporary problems in Greece and worldwide.

Our analysis focuses on the Greeks' willingness to pay (WTP) for climate mitigation and potential explanatory factors, such as their socioeconomic status (income, gender, employment status, educational level), pro-environmental behavior, and perceived impacts of climate change at the individual level, as well as their views on specific policy measures for climate change mitigation, such as the coal phase out and the development of the RES sector.

To this end, we used a four-items indicator with values 0–4, measuring the intention of citizens to pay for environmental protection. It draws from the environmental protection index developed by Ronald Inglehart [44] with a slight but important adjustment, which enables the more precise measurement of "willingness to pay" of the Greek public. The indicator consists of the first three items of the Inglehart's Environmental Protection Index, with the fourth item, "Protecting the environment and fighting pollution is less urgent than often suggested", being substituted with the statement, "I prefer to buy environmentally friendly products even if I pay more". Value "1" is given to the answer "I agree" to the statements, "I would give part of my income if I were certain that the money would be used to prevent environmental pollution", "I would agree to an increase in taxes if the extra money were used to prevent environmental pollution", and "I prefer to buy environmental friendly products even if I pay more"; and the answer "I disagree" to the sentence, "The state must reduce environmental pollution, without entailing a financial cost for me". Accordingly, value "0" is given to the answer "I disagree" to the first three sentences and to the answer "I agree" to the last sentence. Responses are grouped to "low/very low willingness to pay" (0–2) and "high/very high willingness to pay" (3–4).

This study does not measure the actual amount of money Greek respondents would be willing to pay for environmental protection; instead, it investigates the extent to which they are willing to pay. Then, we attempt to identify the key drivers of their WTP by investigating the statistically significant difference between two WTP groups according to z-test results for socioeconomic and demographic factors as well as individual perceptions, attitudes, and views of climate change and relevant policies.

3. Quantification of Selected Multiple Effects of Mitigation Actions through Bottom-Up Approaches

In the context of CLIMPACT, a total of 27 clean technologies were examined, of which 9 concern the use of RES to produce electricity, 8 concern energy saving actions, the use of RES for heat production and electrification in buildings of the domestic sector, 5 concern energy saving actions and electrification in buildings of the tertiary sector, and 5 concern the road transport sector. A common set of assumptions regarding the technoeconomic parameters of the clean technologies examined was applied.

3.1. Macro-Economic Effects

Table 1 presents the estimated gross macroeconomic effects adjusted per EUR 1 million of investment for all examined interventions. Among the various RES technologies examined in the power generation sector, the most significant macroeconomic effects are created from the development of biomass- and biogas-fired power units, which are mainly attributed to the significant expenditures required for the collection and treatment of the biomass. Further development of the most mature RES technologies (i.e., photovoltaic units and wind farms) creates significant macroeconomic effects, but which are relatively lower compared to other RES technologies. Specifically, the employment effects associated with the development of the photovoltaic (PV) systems examined are estimated at 23 person-years per EUR 1 million of investment, while the corresponding figures for wind technologies range between 25–31 person-years per EUR 1 million of investment.

Table 1. Estimated macroeconomic effects per EUR 1 million of investment for different categories of carbon mitigation technologies.

	GVA (Million EUR)	Employment (Person Years)	Income (Million EUR)
Power Generation			
PV	0.72	23.3	0.23
Residential PV	0.75	23.2	0.24
Wind	0.90	31.3	0.30
Off-shore wind	0.73	25.4	0.24
Small hydro	1.02	38.5	0.34
Biomass units	3.16	151.8	0.89
Biogas units	3.65	103.5	1.08
Geothermal	1.18	38.8	0.41
CSP	0.92	33.8	0.28
Residential Buildings			
Efficient lighting	11.65	316	3.28
Efficient appliances	0.53	15	0.17
New heating systems with natural gas in buildings constructed before 1980	2.88	82	0.84
Heat pumps in buildings constructed before 1980	1.06	34	0.31
Heat pumps in buildings constructed in the period 1980–2010	1.23	38	0.36
Deep renovations of buildings	1.21	39	0.38
Shallow renovations of buildings	1.43	45	0.45
Solar thermal systems	3.55	100	1.04

Table 1. *Cont.*

	GVA (Million EUR)	Employment (Person Years)	Income (Million EUR)
Tertiary Buildings			
Efficient lighting	0.33	12	0.11
Heat pumps in buildings constructed before 1980	0.37	15	0.12
Heat pumps in buildings constructed in the period 1980–2010	0.37	15	0.12
Deep renovations of buildings	0.85	29	0.28
Shallow renovations of buildings	0.85	29	0.28
Transport			
Electric buses	0.14	3	0.05
Electric cars	0.34	9	0.11
Biodiesel production	0.90	52	0.20
Bioethanol production	0.45	24	0.11
Hydrogen production	0.69	27	0.22

Most of the measures associated with the enhancement of energy efficiency in residential buildings were found to create more significant macroeconomic effects compared to those associated with the promotion of the basic RES technologies in the power generation sector (i.e., wind and photovoltaics). Specifically, focusing on the impacts on employment, the installation and operation of efficient lighting systems create 316 personyears of employment per EUR 1 million of investment (mainly due to the energy savings and the additional disposable income of households), the promotion of efficient heating/cooling systems 34–82 person-years of employment per EUR 1 million of investment, and the renovations of existing buildings 39–45 person-years per of employment per million EUR invested. In this respect, it is preferable to promote energy-saving measures in residential buildings, with emphasis on efficient lighting and energy upgrading of the buildings' shell, compared to the installation of RES technologies in the power generation sector.

Less important are the macroeconomic impacts associated with the implementation of energy saving interventions in tertiary buildings, especially as regards the promotion of efficient lighting (12 person-years of employment per EUR 1 million of investment) and the installation of heat pumps (15 person-years of employment per million EUR invested). This is mainly attributed to the fact that a significant part of the necessary equipment is produced abroad, while it is uncertain to what extent the benefits from energy savings will be re-invested in the domestic market. On the other hand, the energy upgrade of the buildings' shell in the sector creates significant positive macroeconomic effects (29 personyears of employment per million EUR of investment) at the same order of magnitude with those associated with development of wind parks and higher than the photovoltaic ones.

Finally, in regard to the transport sector, interventions aiming to promote electric vehicles in the Greek transport system have relatively small effects in the national economy (3–9 person-years of employment per million EUR invested), as most of the associated expenditures are directed abroad in countries with a strong automotive industry. The penetration of biofuels and hydrogen in the energy balance of the transport sector, and particularly biodiesel, which is considered to be 100% produced domestically, were found to be the interventions in the transport sector that create the most significant macroeconomic effects, mainly in the agricultural sectors and the associated industries.

3.2. *Public Health Effects*

Table 2 presents the performance of the clean technologies considered based on the indices defined (Section 2.2). The results presented do not address the health benefits due to climate change mitigation, since climate change is a global problem and its mitigation in a single country cannot ensure the estimated benefits. On the contrary, air pollution is a local environmental problem and reducing emissions can generate health benefits (ignoring the effect of transboundary pollution that is out of the scope of the analysis). It should also be noted that the selected emission factors and the technoeconomic characteristics of the technologies affect their performance.

Table 2. Public health benefits associated with the implementation of clean energy technologies/measures, excluding climate change effect. Positive values indicate that the implementation of the measure results in lower DALY value compared to the reference technology (avoided DALY), and therefore has a positive effect on public health.

	DALY per Million EUR of Investment	DALY per TWh Produced or Avoided	DALY per kt of CO_2 Reduction Achieved
Power Generation			
PV	8.76	105.90	0.26
Residential PV	6.18	105.90	0.26
Wind	6.52	105.90	0.26
Off-shore wind	3.91	105.90	0.26
Small hydro	6.72	105.90	0.26
Biomass units	−26.15	−396.79	−0.98
Biogas units	−9.75	−120.08	−0.30
Geothermal	9.39	105.90	0.26
CSP	1.85	105.90	0.26
Residential Buildings			
Efficient lighting	3.72	26.48	0.37
Efficient appliances	0.06	26.48	0.37
New heating systems with natural gas in buildings constructed before 1980	4.39	164.62	0.48
Heat pumps in buildings constructed before 1980	1.15	77.38	0.24
Heat pumps in buildings constructed in the period 1980–2010	1.57	80.71	0.24
Deep renovations of buildings	0.42	60.20	0.26
Shallow renovations of buildings	0.42	54.28	0.34
Solar thermal systems	0.92	26.48	0.37
Tertiary Buildings			
Efficient lighting	0.28	26.48	0.37
Heat pumps in buildings constructed before 1980	3.87	71.70	0.33
Heat pumps in buildings constructed in the period 1980–2010	4.10	84.49	0.33
Deep renovations of buildings	0.77	61.36	0.26
Shallow renovations of buildings	0.78	73.62	0.33
Transport			
Electric buses	2.38	130.32	0.46
Electric cars	0.005	2.97	0.01
Biodiesel production	−0.001	−0.47	−0.0002
Bioethanol production	−0.03	−44.66	−0.02
Hydrogen production	3.77	34.84	0.25

Out of the 27 clean energy technologies/measures examined, we calculated 4 with negative DALY values. This implies that these measures, though contributing to climate change mitigation and energy conservation, do not have a positive impact on public health given the assumptions made. Two of them concern the use of biofuels (solid biomass and biogas) for electricity generation, as the reference technology (natural gas given the phase out of lignite-fired power plants by the end of this decade, as officially announced) has slightly better environmental performance. The other two concern the use of biofuels for road transport, mainly due to higher SO_2 emission factors. The performance of the technologies (except for solid biomass for electricity generation) becomes positive when considering health benefits due to climate change mitigation.

The health benefits of the clean energy technologies/measures considered with respect to the necessary investment cost depend on the maturity of the technology and the lifetime of the investment. The technologies/measures that scored better on the "DALY per million EUR of investment" metric, are related to RES technologies (wind energy, photovoltaics (both utility and roof-top), small hydro, and geothermal energy). Buildings' renovations lay on the lower end, as costs are still high, and therefore policy tools should be developed. RES electricity technologies perform well with respect to health impacts per energy.

The best results regarding health impacts per energy produced or avoided are estimated for natural gas in old residential buildings (i.e., before 1980), solar water heating, and electrification of buses. The health benefits of heat pumps and buildings' renovation are lower than those of RES for electricity generation, but still significant, and -n the longer-term they would be even more significant (for buildings' renovation), given the decarbonization of the electricity generation system.

When considering health impacts per CO_2 emissions reduction achieved, interventions in buildings demonstrate better performance. Apart from using natural gas in old residential buildings, the interventions with the 10 higher scores are related to electricity use (heat pumps and renovation in tertiary buildings, solar water heating, efficient lighting and electric appliances, as well as electrification of buses) given the high consumption rates and the expected conservation.

With respect to electrification of road transport, it should be noted that results will improve further as the decarbonization of the electricity generation system advances.

4. Unpacking Public Perceptions and Attitudes on Climate Change and Mitigation Policies in Greece

4.1. What Is Climate Change for Greek Citizens?

Applying the technique of associative activation, we aimed to map the structure of the social representation of "Climate Change". In other words, how do Greek citizens perceive the notion of climate change? By eliciting a narrative based on the principles of free association, we can capture people's concerns and perceptions, which would probably not be visible using a structured questionnaire. To this end, we asked survey participants to "Tell us three things that come to mind when you hear the phrase 'climate change'". The analysis of the 3073 answers given by 977 respondents to this open-ended question reveals the central core, i.e., the most resilient part of the social representation of 'climate change', which is rigid, stable, and "marked by the collective memory of the group and the system of norms which it refers to". Figure 1 presents given answers, i.e., referred words grouped into specific thematic categories. According to the order and the frequency of utterance of each word (e.g., first, second, or third word referred/total frequency of reference as first, second, or third word), they are classified into central core, periphery, and intermediate zones. The peripheral elements are more flexible and indicate "the heterogeneity of the group" [45]. The central core consists of views and beliefs uttered first and with great frequency (the upper right grid of Figure 1).

Responses of high frequency

INTERMEDIATE ZONE	CENTRAL CORE
Extreme weather events/natural disasters (139 / 2.06) Forests (113 / 2.07) Emissions (107 / 2.04) Ominous predictions (82 / 2.09) Mitigation (79 / 2.10) Economy (79 / 2.25)	Rising Temperature (262 / 1.80) Disaster (252 / 1.73) Ice melting (251 / 1.73) Environment (231 / 1.79) Pollution (204 / 1.83) Weather Variation (155 / 1.88) Water (97 / 1.91) Floods (92/1.98) Ozone layer (88 /1.76) Greenhouse effect (84 /1.73)
High order utterance	Low order utterance
PERIPHERY	**INTERMEDIATE ZONE**
Migration (13 / 2.00) Heatwave (19 / 2.05) Desertification (14 / 2.07) Search for a positive way out (15 / 2.13) Negative feelings (25 / 2.16) Policy (64 / 2.17) Atmosphere (46 / 2.17) Future (21 / 2.19) Species extinction (67 / 2.19) Other causes (54 / 2.22) Treaties / Agreements (6 / 2.33) Other impacts (44 / 2.34)	Waste (69 / 1.99) Does not exist (25 / 1.44) Problem (26 / 1.62) Human (39 / 1.72) Skeptical help (18 / 1.78) Renewable Energy Sources (33/ 1.85) Geophysical consequence (28 / 1.86) Ecology (14 / 1.86) Sea level rise (16 /1.94) Change (22/ 1.95) Health (31 / 1.97)

Responses of low frequency

Figure 1. The structure of the social representation of "climate change".

It is striking that perceptions and concerns about climate change'**s** impacts (e.g., rising temperatures weather variations, water scarcity, ice melting, and floods) prevail at the core of the social representation, with very limited references to its root causes and specifically only in the "pollution" of the environment, air, water, and sea. In fact, the ways of dealing with climate change and adapting to its effects are completely absent from the core of the representation, while, notably, one in four respondents associate climate change with calamity and/or disastrous phenomena.

4.2. Measuring Willingness to Pay

To what extent do citizens intend to "pay" for climate mitigation? The results here are ambiguous. Even though high percentage of the respondents intends to give part of their income if the money will be used to prevent environmental pollution (74.6%), an equally high percentage believes that it is the state that should reduce environmental pollution without entailing a financial cost for themselves (76.3%). In addition, almost 50% does not agree with the tax increase if the extra money was directed to the prevention of environmental pollution. Hence, it seems that the public opinion is divided when it comes to actions that entail personal financial costs and state actors involved, indicating low trust and skepticism towards public institutions.

The WTP indicator (See above "Section 2. Methods and Materials") also reveals that low and very low willingness of Greek citizens to pay for environmental protection is the dominant attitude (60.7%) (Figure 2). However, we cannot overlook that around 40% of the participants in this survey would give a part of their income to environmental protection. Therefore, it may be more useful for future policy design and effectiveness to focus on those that are willing to pay, their socioeconomic status, as well as on their attitudes and perceptions against climate change and mitigation policies, which may motivate them to pay for the transition to a climate-neutral economy.

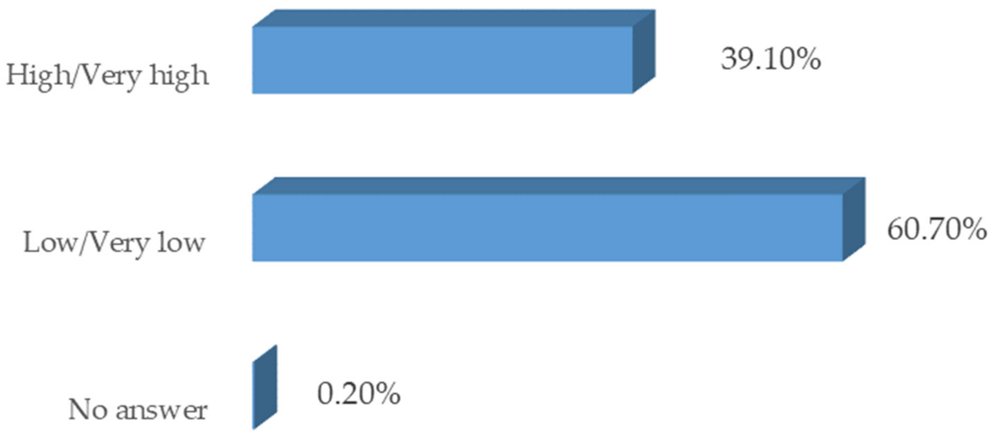

Figure 2. Willingness to Pay (WTP).

4.3. Analyzing Motivations, Perceptions and Attitudes Related with Willingness to Pay

In this Section, we analyze some explanatory factors that determine citizens' willingness-to-pay (WTP) and whether their intention to pay is associated with their support to specific policy measures for climate mitigation.

4.3.1. Socioeconomic and Demographic Factors

As Jacques [46] suggests, a sufficient level of income and education are necessary conditions for willingness to pay. To put it differently, citizens need to have appropriate means to pay for climate policies and the proper level of education to understand the necessity of these extra policy costs. We did not find any statistically significant difference between those who are more willing to pay or less willing to do so in relation to household income, educational level, employment status, gender, and age.

4.3.2. The Importance of Climate Change for Those Who Are Willing to Pay

Most of the respondents (96%) consider climate change as a real problem, with only 4% embracing the view that it does not exist. Contrary to other surveys [41,42], which ask respondents to select the most important global problems from a preselected list of possible answers, we used an open-ended question; the obtained spontaneous answers indicate that levels of environmental protection and climate change concern are clearly lower than expected.

Surprisingly, only 13% of the respondents spontaneously state that "climate change" is one of the three most important challenges globally. Percentages are even lower when respondents need to consider the main problems at the national level. Specifically, 4.9% of the respondents refer to "climate change" as being among the three most important problems in Greece (with only 1% ranking it first). However, significant differences are recorded between the perceptions of the two WTP groups. In total, 16.6% and 6.2% of people who are more willing to pay for climate mitigation stated that "climate change" is one of the most important challenges at global and national level, respectively, while these percentages of people who are less willing to pay are 10.7% and 4.1%.

4.4. Perceived Impacts of Climate Change at Individual Level: Vulnerability and Energy Poverty

It is worth noting that the intention of citizens to pay for climate mitigation is not associated with their exposure to the climate change impacts. Most respondents (66%) state that climate change affects them "to some extent" and "rather/very much", regardless of their willingness to pay.

This is reflected, inter alia, in the (declared) fact that one in three respondents reports that they cannot adequately heat their homes (30.4%). This is almost twice as much as in the survey conducted by Eurostat [46]. According to its latest data, the percentage of the population in Greece declaring inability to meet household energy needs for heating in 2020 amounts to 16.7%. Although there is a significant decrease compared to the economic recession period, when the said percentage ranged between 22.7 and 32.9% (2012–2018), it remains at high levels compared to the EU-27 average, which did not exceed 8.2% in 2020.

Apart from the ability to meet energy needs for heating—the indicator used by Eurostat for measuring energy poverty—our survey also investigates the ability to meet the household energy needs for cooling during the summer, which is crucial for measuring the vulnerability and adaptation capacity of the Greek population to the upcoming extreme heat events. It turned out that 27% of the sample cannot meet its energy needs for cooling during the summer months. In fact, 61% of the respondents who stated that they cannot adequately heat their home at the same time declared their inability to adequately cool it, while about 11% stated that they are able to meet their energy needs for heating but not for cooling. Overall, 18.7% stated that they are unable to adequately heat and cool their home. Therefore, a significant part of the population is vulnerable to climate change impacts, but it does not seem to motivate them to pay for climate mitigation policy.

Perceived effects of climate change at the individual level and the inability of respondents to meet their household's energy needs for cooling do not significantly affect the willingness to pay. However, it is worth noting that according to z test results, a statistically significant difference between two WTP groups is observed regarding the inability of citizens to cover the energy need for heating, with those who are less willing to pay being more vulnerable in terms of energy poverty (33.9%). Given that energy poverty tends to be measured as the inability to cover energy needs for heating and to be associated with the household's income level, this finding implies that respondents with less income are probably less likely to be willing to pay for climate mitigation.

4.5. Pro-Environmental Behavior and Level of Perceived Responsibility

Most of the participants in this survey are strongly in favor of adopting pro-environmental conduct. They acknowledge individual responsibility for climate change (83.3%), prefer to buy eco-friendly products even if they pay more (67.7%), and recognize that environmental protection is indeed a pressing issue (84.6%). This is also confirmed by the environmental concern index (scale 0–8), formed for the purposes of this research, which adds the positive and negative answers of the respondents to eight statements. The 0–8 scale index was formulated as follows: Value "1" corresponds to the answer "I agree" to the statements "I am personally responsible for climate change", "I prefer to buy ecological products even if I pay more", "I would give a part of my income if the money was used to prevent environmental pollution", and "I would agree to tax increase if the extra money was directed to prevent environmental pollution"; and to the answer "I disagree" with the statements, "The state must reduce environmental pollution, without entailing a financial cost for me", "Environmental protection is a less pressing matter than usually reported", "Recycling plastic, aluminum and electrical appliances makes sense if there is a direct financial compensation", and "The plastic bag fee is a purely revenue-oriented measure". Accordingly, value "0" corresponds to the answer "I disagree" to the first four statements, and the answer "I agree" to the remaining four statements. Based on this index, 63.9% of the survey participants report high environmental concern, as they express their support for the adoption of at least five to eight policy measures for environmental protection.

Furthermore, we assessed the self-reported pro-environmental behavior, asking survey participants to report if they have taken any of the following actions in the last 6 months?: "reduced my garbage", "recycled paper, plastics and aluminum", "recycled electrical/electronic appliances, batteries and light bulbs", "reduced the use of plastic bags", "reduced the consumption of disposable items", "participated in afforestation actions", "reduced the consumption of meat", "limited the unnecessary use of water", "When you are to cover a distance that takes 20 min on foot and you have time required, you usually cover it by car, by public transport, on foot legs, by other means". Most of the respondents appear to have incorporated pro-environmental behaviors in their daily lives, as 61% state that they have adopted at least 6 out of 9 actions related to tackling climate change and protecting the environment in general. Those who did not take any action or only one or two actions did not exceed 4.2%. The pro-environmental behavior of the respondents consists mainly in recycling (almost 90%) and the reduction of the use of plastic bags (82.8%), the recycling of electronic devices, batteries, and lightbulbs (73.4%), as well as the reduction of unnecessary water use (74.6%). This profile is probably due to a series of policy measures adopted in recent years in Greece that have greatly changed the incentive and, consequently, consumer behavior, such as the plastic bag fee, the ban on disposable plastics, and the provision of financial incentives for the recycling of old electronic appliances.

According to z test results, statistically significant differences are observed between those who report high/very high and low/very low willingness to pay for climate mitigation in relation to the adoption of environmental behavior. The percentage of respondents with high/very willingness to pay who behave pro-environmentally is much higher (69.3%) than those with low/very low willingness to pay (56.5%). However, we cannot overlook the fact that even citizens who adopt pro-environmental behaviors display low/very low intention to pay for environmental protection.

The perception that businesses and industry are responsible for climate change appears to be prevalent, with over 60% of the respondents supporting this view. The percentage of those who believe that national governments are responsible is markedly lower, but still high (47.8%). It seems that the citizens with high/very high willingness to pay tend to acknowledge to a greater extent the crucial role of individual behaviors in tackling climate change. Even though around 85% of the participants in this survey acknowledge that they are also responsible themselves for climate change, we observe statistically significant differences between those who are more willing to pay for climate mitigation (92.7%) and those who are less willing to do so (80.4%). The statistical difference is also high regarding the perceptions of two groups about the statement, "Whatever the citizens do they cannot change the situation if large industries do not implement international climate agreements"; 32.9% of those who intend to cover a part of the costs of climate policy disagree with this statement, while the respective percentage for those who are less willing to pay is much lower (21.6%).

4.6. Attitudes and Perceptions about Climate Mitigation Policies

We found a statistically significant difference between the perceptions of the two WTP groups regarding specific policy measures for tackling climate change. Respondents who are more prone to pay are much more in favor of the withdrawal of diesel cars (67%), the higher share of renewable sources in energy production (59.6%), the coal phase-out of the

Greek economy even if it means the closure of lignite plants (70.8%), and the single-use plastic ban (90.4%) (Figure 3).

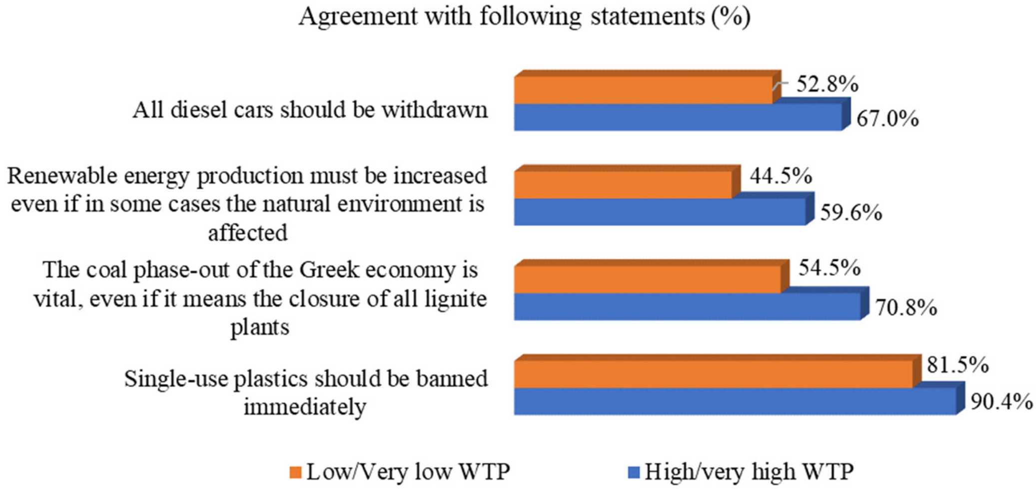

Figure 3. Willingness to Pay and public support of mitigation policy measures (%).

5. Discussion

The results of the analysis carried out clearly show that the implementation of mitigation actions in both energy production and final energy consumption sectors contribute to economic growth, increase output, and create new jobs. These positive effects may limit or even exceed economic losses that will inevitably occur in traditional sectors of the economy based on the use of fossil fuels.

The magnitude of the overall macroeconomic effects that will be created in the economy depends on the extent to which the technologies used are produced domestically or imported from abroad. For example, the macroeconomic impact of interventions, where the major part of the required investment concerns the purchase of imported equipment (e.g., vehicles in the transport sector, appliances in buildings, wind turbines, and photovoltaic panels in the power sector) is relatively low. On the contrary, in the cases where a significant part of the required costs of the considered interventions concern construction works (e.g., in building renovations), the production and collection of domestic biomass and biofuels, etc., the effects on the local economy increase significantly. Consequently, the execution of a significant part of the manufacturing activities domestically through the development of the corresponding industries is a prerequisite for maximizing the positive macroeconomic effects of the development of clean energy technologies in the national economy.

Another reason that the promotion of mitigation measures in the residential sector has a greater impact on the economy than in other sectors is that much of the resources saved from reducing energy costs are reinvested in the economy to purchase other goods and services from households. Something similar can happen in businesses as well. However, this is more uncertain, and depends on the policies of each company.

With respect to public health, the analysis shows that the implementation of mitigation actions has a positive effect. Different indicators have been used relating public health effects (as addressed by DALY values) with the investment needed, the energy conservation achieved or the energy generated (for RES technologies), and the emission reduction potential. The choice of emission factors, reference technologies, and techno-economic characteristics of the technologies affect the results. Also, the maturity of the technologies, the lifetime of investments, and the efficiency in terms of energy savings and greenhouse gas emission reduction potential differentiate the estimated public health benefits.

Considering the maturity of RES technologies for electricity generation, the high RES potential in Greece, and the share of fossil fuels for electricity generation, RES electricity generation scores well in all indicators examined. Energy conservation measures in buildings show higher values when energy conservation or emissions reduction are considered as the low energy performance of the building stock in Greece and the high energy consumption result in a high energy conservation potential.

When considering both the macroeconomic effects (as discussed above) and the public health benefits generated, the need to increase ambition with respect to energy conservation targets becomes more evident. This is in line with the European policy priorities, as the Fit for 55 package envisages the revision of the current energy efficiency directive and reinforce/operationalize the 'energy efficiency first' principle, which means that where efficiency improvements are shown to be most cost-effective, taking full account of their co-benefits, they should be prioritized over any investment aiming to reduce GHG emissions.

To this end, of paramount importance is the sector of buildings and the realization of a massive program of energy renovations in conjunction with the installation of more efficient heating/cooling equipment, as more than 40% of the existing building stock in Greece presents low energy performance. In the transport sector, it is crucial for the decarbonization strategy to focus on interventions aiming at upgrading the infrastructures in the fields of public and rail transport (including the electrification of buses) with a view to increase their share of the total transport work. It is also worth mentioning that more ambitious goals of improving energy efficiency imply fewer requirements for the installation of new RES systems, facilitating their integration into the energy system but also their social acceptance, as the carrying capacity of various areas with rich wind and solar energy potential will not be exhausted. Also, the decarbonization of the electricity generation system (which advances faster than the decarbonization of final consumption sectors) is expected to further improve the performance of measures related to electrification of energy demand.

According to the findings of the fieldwork survey, conducted in the context of CLIMPACT, most respondents tend to be engaged in pro-environmental behaviors. Although this attitude may potentially attest to the gradual change of public opinion in favor of green transition and the decarbonization of the Greek economy, when people are asked to cover themselves part of the cost of climate mitigation, they are more reluctant to do so.

Despite the respondents' high awareness of the detrimental effects of climate change, they do not associate the notion of "climate change" with mitigation and adaptation policies. This demonstrates that they are not really cognizant of, or they misunderstand the actual purpose of, the measures already taken against climate change, and do not sufficiently perceive their potential contribution in climate mitigation and in strengthening the resilience of Greek society and economy. Contrary to the findings of other surveys, most of the participants do not perceive "climate change" as one of the most important challenges at global and national level. This indicates, at least at a first glance, the low-risk perception and the psychological distance that Greek citizens feel vis à vis environmental issues, probably considering that the effects of environmental degradation and climate change are not so acute.

It is worth noting that there are statistically significant differences between those who are more willing to pay and those who are less willing to do so regarding their pro-environmental behavior, the perceived impacts of climate change for themselves, the individual responsibility for climate change, as well as the support of main policy measures for climate mitigation. People with low/very low willingness to pay for climate mitigation and environmental protection are less likely to perceive that climate change is one of the main challenges at global and national level and to follow a pro-environmental course of action. They tend to think that they are not themselves primarily responsible for climate change and that individual action cannot make a real contribution to climate change mitigation, which indicates low political efficacy. Therefore, a milieu is formed that is not particularly favorable for radical initiatives to mitigate climate change and adapt to its impacts in the upcoming years unless, however, major environmental disasters in the near future force people to alter their views.

6. Conclusions

Mitigation actions for tackling climate change have multiple co-benefits (but also some trade-offs) that result in substantial social and economic value beyond their direct impact on reducing energy consumption and GHG emissions, contributing to the achievement of almost all the United Nation's SDGs. Most studies agree that the quantification of these co-effects and their inclusion in decision-making processes will strengthen the adoption of ambitious reduction targets and improve coordination across policy areas. The analysis undertaken in the context of this study provided quantitative evidence on the public health benefits due to improved outdoor atmospheric environment and the macroeconomic implications associated with the implementation of the main mitigation technologies planned to be implemented for reducing GHG emissions in Greece. Specifically, we found that mitigation actions bring about significant health benefits, particularly in cities (the highest number of avoided DALYs per TWh of energy generated or saved due to mitigation actions in question is attributed to electric buses and the use of natural gas for space heating in residential buildings), and generate significant positive macroeconomic effects, particularly if mitigation actions focus on the decarbonization of the building sector (e.g., energy renovations and promotion of energy efficient appliances and equipment) and on the exploitation of local renewable sources (particularly biomass). The results can be utilized in future climate plans to adopt the appropriate package of policies and measures that not only contribute to decarbonizing the Greek economy, but maximize the social welfare. The mix of clean technologies that will be deployed to accelerate the decarbonization of the Greek economy and its transition to climate neutrality should consider their emission reduction potential, their co-benefits, and trade-offs, as well as the perceptions and attitudes of Greek citizens towards climate change, its impacts, and mitigation policies.

On the other hand, the paper, through a survey, found that the public in Greece considers the problem of climate change as a relatively low-priority issue, while only a small percentage know its causes. Most of the participants in the survey conducted, in the context of this study, are less willing to pay for environmental and climate-related actions, and even citizens who adopt pro-environmental behaviors may express low/very low intention to bear the financial cost of environmental protection. Also, most participants do not realize that climate mitigation actions can have wider benefits to society, tackling energy poverty, improving public health due to better indoor and outdoor environmental conditions, creating new jobs, etc. Moreover, the dominant pro-environmental stance is not reflected in the support of policy measures that will contribute to the radical transformation of the Greek economy, such as the coal phase-out and the development of RES.

The participants do not seem to be aware of the urgency of dealing with climate change and the large reductions in GHG emissions that will be required to this end. Of course, further research is needed to validate this finding. These prevailing public perceptions are likely to hinder the social acceptance of measures aimed at reducing GHG emissions and decarbonizing economies.

In this context, the green transition of the Greek economy and society faces major challenges. The national strategy for climate change should focus on effectively informing and engaging the public in climate mitigation strategies, strengthening the public trust in government institutions, promoting mutually acceptable solutions with the local communities, and providing incentives for changing citizens' behavior towards climate-related actions. In this respect, ignoring the public attitudes and perceptions and underestimating the social aspects of climate policies can no longer be a viable option.

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Informed Consent Statement: The study was conducted in accordance with the Declaration of Helsinki and approved by the Institutional Review Board of the National Observatory of Athens in Athens, Greece.

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References

1. International Energy Agency (IEA). *Capturing the Multiple Benefits of Energy Efficiency*; IEA: Paris, France, 2014; p. 232.
2. Von Stechow, C.; McCollum, D.; Riahi, J.; Minx, J.C.; Kriegler, E.; van Vuuren, D.P.; Jewell, J.; Robledo, C.; Hertwich, E.; Tavoni, M.; et al. Integrating global climate change mitigation goals with other sustainability objectives: A synthesis. *Annu. Rev. Environ.* **2015**, *40*, 363–394. [CrossRef]
3. US EPA. Quantifying the Multiple Benefits of Energy Efficiency and Renewable Energy: A Guide for State and Local Governments. U.S. Environmental Protection Agency (EPA). 2018. Available online: https://www.epa.gov/sites/default/files/2018-07/documents/epa_slb_multiple_benefits_508.pdf (accessed on 2 February 2020).
4. Ürge-Vorsatz, D.; Kelemen, A.; Tirado-Herrero, S.; Thomas, S.; Thema, J.; Mzavanadze, N.; Hauptstock, D.; Suerkemper, F.; Teubler, J.; Gupta, M.; et al. Measuring multiple impacts of low-carbon energy options in a green economy context. *Appl. Energy* **2016**, *179*, 1409–1426. [CrossRef]
5. Creutzig, F.; Niamir, L.; Bai, X.; Callaghan, M.; Cullen, J.; Díaz-José, J.; Figueroa, M.; Grubler, A.; Lamb, W.F.; Leip, A.; et al. Demand-side solutions to climate change mitigation consistent with high levels of well-being. *Nat. Clim. Chang.* **2022**, *12*, 36–46. [CrossRef]
6. International Energy Agency (IEA). *Multiple Benefits of Energy Efficiency*; IEA: Paris, France, 2019. Available online: https://www.iea.org/reports/multiple-benefits-of-energy-efficiency (accessed on 2 February 2020).
7. Payne, J.; Weatherall, D.; Downy, F. Capturing the multiple benefits of energy efficiency in practice: The UK example. *ECEE 2015 Summer Study Proc.* **2015**, *1*, 229–238.
8. Thema, J.; Suerkemper, F.; Thomas, S.; Teubler, J.; Couder, J.; Chatterjee, S.; Ürge-Vorsatz, D.; Bouzarovski, S.; Mzavanadze, N.; von Below, D. More than energy savings: Quantifying the multiple impacts of energy efficiency in Europe. *ECEEE 2017 Summer Study* **2017**, *4*, 1727–1736.
9. Smith, A.C.; Holland, M.; Korkeala, O.; Warmington, J.; Forster, D.; ApSimon, H.; Oxley, T.; Dickens, R.; Smith, S.M. Health and environmental co-benefits and conflicts of actions to meet UK carbon targets. *Clim. Policy* **2016**, *16*, 253–283. [CrossRef]
10. European Commission. *The Macroeconomic and Other Benefits of Energy Efficiency*; Final report; European Commission, Directorate-General for Energy: Brussels, Belgium, 2016; p. 139.
11. Mirasgedis, S.; Tourkolias, C.; Pavlakis, E.; Diakoulaki, D. A methodological framework for assessing the employment effects associated with energy efficiency interventions in buildings. *Energy Build.* **2014**, *82*, 275–286. [CrossRef]
12. Eurostat. *Eurostat Manual of Supply, Use and Input-Output Tables*; Eurostat: Brussels, Belgium, 2008; ISBN 978-92-79-04735-0.
13. World Health Organisation (WHO). *World Health Statistics 2023: Monitoring Health for the SDGs, Sustainable Development Goals*; World Health Organization: Geneva, Switzerland, 2023.

14. European Environment Agency (EEA). *Air Quality in Europe 2021*; Report no. 15/2021; European Environmental Agency: Copenhagen, Denmark, 2021; ISBN 978-92-9480-403-7.
15. Bikomeye, J.C.; Rublee, C.S.; Beyer, K.M.M. Positive Externalities of Climate Change Mitigation and Adaptation for Human Health: A Review and Conceptual Framework for Public Health Research. *Int. J. Environ. Res. Public Health* **2021**, *18*, 2481–2510. [CrossRef] [PubMed]
16. Gao, T.; Wang, X.C.; Chen, R.; Ngo, H.H.; Guo, W. Disability adjusted life year (DALY): A useful tool for quantitative assessment of environmental pollution. *Sci. Total Environ.* **2015**, *511*, 268–287. [CrossRef]
17. Bachman, T.M.; van der Kamp, J. Expressing air pollution-induced health-related externalities in physical terms with the help of DALYs. *Environ. Int.* **2017**, *103*, 39–50. [CrossRef]
18. Kollmuss, A.; Agyeman, J. Mind the Gap: Why do people act environmentally and what are the barriers to pro-environmental behavior? *Environ. Educ. Res.* **2002**, *2*, 239–260. [CrossRef]
19. Yang, M.X.; Tang, X.; Cheung, M.L.; Zhang, Y. An institutional perspective on consumers' environmental awareness and pro-environmental behavioral intention: Evidence from 39 countries. *Bus. Strategy Environ.* **2020**, *30*, 566–575. [CrossRef]
20. Dunlap, R.E. The Impact of Political Orientation on Environmental Attitudes and Actions. *Environ. Behav.* **1975**, *7*, 428–454. [CrossRef]
21. Jacques, O. Explaining willingness to pay taxes: The role of income, education, ideology. *J. Eur. Soc. Policy* **2023**, *33*, 267–284. [CrossRef]
22. Hines, J.M.; Hungerford, H.R.; Tomera, A.N. Analysis and synthesis of research on responsible environmental behavior: A meta-analysis. *J. Environ. Educ.* **1987**, *18*, 1–8. [CrossRef]
23. Stern, P.C.; Dietz, T.; Kalof, L. Values orientation, gender, and environmental concern. *Environ. Behav.* **1993**, *25*, 322–348. [CrossRef]
24. O'Connor, R.E.; Bard, R.J.; Fishel, A. Risk Perceptions, General Environmental Beliefs, and Willingness to Address Climate Change. *Risk Anal.* **1999**, *19*, 461–471. [CrossRef]
25. Dietz, T.; Fitzgerald, A.; Shwom, R. Environmental Values. *Annu. Rev. Environ. Resourc.* **2005**, *30*, 335–372. [CrossRef]
26. Taylor, A.L.; Dessai, S.; Bruine de Bruin, W. Public perception of climate risk and adaptation in the UK: A review of the literature. *Clim. Risk Manag.* **2014**, *4*, 1–16. [CrossRef]
27. O'Brien, K.; Leichenko, R. Toward an integrative discourse on climate change. *Dialogues Hum. Geogr.* **2019**, *9*, 33–37. [CrossRef]
28. Diekmann, A.; Preisendörfer, P. Environmental behavior—Discrepancies between aspirations and reality. *Ration. Soc.* **1998**, *10*, 79–102. [CrossRef]
29. Cruz, S.; Manata, B. Measurement of Environmental Concern: A Review and Analysis. *Front. Psychol.* **2020**, *11*, 493793. [CrossRef] [PubMed]
30. Liobikienė, G.; Dagiliūtė, R. Do positive aspects of renewable energy contribute to the willingness to pay more for green energy? *Energy J.* **2021**, *231*, 1208–1217. [CrossRef]
31. Poortinga, W.; Steg, L.; Vlek, C.; Wiersma, G. Household preferences for energy-saving measures: A conjoint analysis. *J. Econ. Psychol.* **2003**, *24*, 49–64. [CrossRef]
32. Gökşen, F.; Adaman, F.; Zenginobuz, E. On environmental concern, willingness to pay, and postmaterialist values: Evidence from Istanbul. *Environ Behav.* **2002**, *34*, 616–633. [CrossRef]
33. Lujala, P.; Lein, H.; Ketil Rød, J. Climate change, natural hazards, and risk perception: The role of proximity and personal experience. *Local Environ.* **2014**, *20*, 489–509. [CrossRef]
34. Streimikiene, D.; Balezentis, T.; Alisauskaite-Seskiene, I.; Stankuniene, G.; Simanaviciene, Z. A Review of Willingness to Pay Studies for Climate Change Mitigation in the Energy Sector. *Energies* **2019**, *12*, 1481. [CrossRef]
35. Johnson, E.; Nemet, G.E. *Willingness to Pay for Climate Policy: A Review of Estimates*; La Follette School Working Paper No. 2010-011; La Follette School of Public Affairs: Madison, WI, USA, 2010; p. 35.
36. Viscusi, W.P.; Zeckhauser, R.J. The Perception and Valuation of the Risks of Climate Change: A Rational and Behavioral Blend. *Clim. Chang.* **2006**, *77*, 151–177. [CrossRef]
37. Zarnikau, J. Consumer demand for 'green power' and energy efficiency. *Energy Policy* **2003**, *31*, 1661–1672. [CrossRef]
38. Ward, D.O.; Clark, C.D.; Jensen, K.L.; Yen, S.T.; Russell, C.S. Factors influencing willingness-to-pay for the ENERGY STAR label. *Energy Policy* **2011**, *39*, 1450–1458. [CrossRef]
39. Brouwer, R.; Brander, L.; van Beukering, P.J.H. "A convenient truth": Air travel passengers' willingness to pay to offset their CO_2 emissions. *Clim. Chang.* **2008**, *90*, 299–313. [CrossRef]
40. Luzar, E.J.; Cosse, K.J. Willingness to pay or intention to pay: The attitude-behavior relationship in contingent valuation. *J. Soc. Econ.* **1998**, *27*, 427–444. [CrossRef]
41. European Commission. *Special Eurobarometer 490 Report: Climate Change*; European Union: Brussels, Belgium, 2019; p. 130, ISBN 978-92-76-09336-7.
42. European Commission. *Special Eurobarometer 513 Report: Climate Change*; European Union: Brussels, Belgium, 2021; p. 134, ISBN 978-92-76-38399-4.
43. ELLET. *Greeks and Climate Change 2019: Presentation of the 1st Nationwide Research*; ELLET: Athens, Greece, 2019.
44. Inglehart, R. *Modernization and Postomodernization. Cultural, Economic, and Political Change in 43 Societies*; Princeton University Press: Princeton, NJ, USA, 1997; pp. 240–241, ISBN 9780691011806.

45. Abric, J.C. Central system, peripheral system: Their functions and roles in the dynamics of social representations. *Pap. Soc. Represent.* **1993**, *2*, 75–78.
46. Eurostat. Inability to Keep Home Adequately Warm—EU-SILC Survey 2020. Available online: https://ec.europa.eu/eurostat/web/products-eurostat-news/-/ddn-20211105-1 (accessed on 2 February 2020).