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Evaluating Natural Climate Solutions in Long-Term Climate Strategies: Opportunities for Enhanced Mitigation Across the European Union

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Abstract: Effective national strategies must be carefully planned in advance to position the land sector as a pivotal contributor to achieving the 2050 climate neutrality target set by the European Union (EU) under the Paris Agreement. Governments define their pathways to achieve the climate goals through the long-term low emission development strategies (LTSs), which describe policies and measures for a just and socially fair transition to low greenhouse gas. This paper explores the natural climate solutions foreseen by the available twenty-five LTSs in the EU to assess each country's use and potential of land mitigation. Subsequently, it evaluates if better planning is possible to increase carbon storage and reduce greenhouse gas emissions. We found that most of the analyzed twenty-five EU countries envisage a wide set of natural climate solutions, demonstrating an understand of importance of land policies and measures to meet their climate targets. Sustainable forest management, agroforestry, and healthy and sustainable diets emerge as solutions mostly reported and with the largest mitigation potential across the EU, albeit with large variability among countries. However, some countries could further harness the potential for mitigation in the land sector. This study highlights how some countries could improve their LTSs, accounting for their specific land mitigation potential.

Keywords: agriculture forestry and other land uses; long-term strategy; natural climate solutions; agroforestry; climate neutrality

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1. Introduction

In 2021, the European agricultural emissions were about 378 Mt CO_2eq and the land-use, land-use change and forestry (LULUCF) sector resulted in a net sink of −230 Mt CO_2eq, accounting, respectively, for 10.9% and 6.6% of the total European Union (EU) emissions [1]. Considering the period from 2010 to 2020, on average, about 17.5% of the total EU emissions are attributable to the land sector (agriculture and LULUCF) [1]. To achieve the climate neutrality objective by 2050, the EU has established to act jointly, bringing together a common vision, resources, financing and regulatory regimes to implement coherent policy actions across all its member states. In this sense, the European Climate Law set the target to reduce net greenhouse gas (GHG) emissions by at least 55% by 2030. This intermediate target is part of the general trajectory defined by the EU Green Deal, towards climate neutrality goal to be achieved by 2050 [2]. Urgent actions are needed to make the land sector contribute to the ambitious EU climate targets. Acting quickly is key, as well as the identification of the most effective natural climate solutions, especially in the land

sector, that will provide an optimal trade-off between climate change mitigation and other services.

Currently, land-based carbon removals are the only operational action promptly available to compensate for hard-to-abate residual emissions, besides technical solutions such as direct air capture and storage technologies, still under development at scale [3]. Therefore, natural climate solutions, which largely overlap with the terms "land-based solutions" and "land-based response option" [4–6], play a key role in climate change mitigation and adaptation [3,7] and encompass land use and land management actions that conserve, restore, and increase carbon storage and/or reduce GHG emissions across forests, wetlands, grasslands, and agricultural lands. The EU largely relies on the LULUCF sector to counterbalance residual hard-to-abate emissions, and the LULUCF sink would be required to nearly double to achieve the desired net removal of 425 Mt CO_2eq needed to achieve climate neutrality by 2050 [8].

EU countries are required to develop national long-term strategies (LTS)—sometimes called long-term low greenhouse gas emission development strategies or mid-century strategies—as determined by Article 4.19 of the Paris Agreement, in which they must describe how they plan to meet the long-term goal of the Paris Agreement and the EU climate goals [9]. Commonly, LTSs deal with mitigation; however, countries can add other relevant aspects, such as adaptation and SDGs. The EU Regulation on the governance of the energy union and climate action [10] highlights the importance for the LTSs to cover, with a perspective of at least 30 years, the total GHG emission reductions and the enhancements of removals by sinks for the relevant sectors (e.g., electricity, industry, transport, agriculture, and LULUCF). In order to have a coherent framework among the EU objectives and targets and the single states pledges, the EU Commission provides technical and scientific support to countries and possibly integrates the strategies with additional information. Finally, the EU Commission evaluates the national LTS, framing them in the broader context of EU objectives and targets, and provides information on any remaining collective gap. Whenever necessary, the countries can modify the submitted version, for example, expressing new policies, clarifying existing ones, and improving the planned solutions.

The aim of this study is to examine the natural climate solutions foreseen by EU member states in the land sector in their LTSs and to assess whether the mitigation potential of the solutions, as reported in the literature, is well utilized, thus evaluating if a better planning of solutions is possible to increase carbon storage and reduce GHG emissions.

2. Materials and Methods

We analyzed all the available LTS reports submitted by EU member states and collected from each one the proposed natural climate solutions for climate change mitigation and adaptation. We only collected natural climate solutions from countries that provided an explanation on either how they could be implemented or their expected potential benefit through specific actions or objectives. Therefore, we collected all the solutions excluding statements of general objectives, for example, "promote sustainable agriculture". Since the LTSs do not include quantitative or qualitative estimates of the mitigation potential achievable through the proposed activities, we quantified the mitigation potential achievable for each proposed natural climate solution based on the existing literature.

Recent studies have assessed natural climate mitigation potential globally, providing aggregated [11] and disaggregated [12] estimates up to 2030 and 2050. Other studies also provide the mitigation potential for specific land categories in Europe or in some European countries. For example, Yigini and Panagos [13] predicted the current soil organic carbon stocks and projected such prediction to 2050 for Europe, indicating an

overall increase in consequence of changes in land cover and climate. Another study, by Chapman et al. [14], provided current and potential aboveground woody carbon storage in agricultural systems by countries, finding that there is a significant potential to contribute to nationally determined contributions (NDCs); however, their analysis conservatively accounts for aboveground biomass only. Several other studies analyze the future land mitigation contribution for single countries, taking into consideration different management practices [15–17].

There are numerous studies like those already mentioned; however, the available estimates vary rather widely, depending on the methodology, data sources, definitions, system boundaries, and scenario assumptions used. Therefore, a straightforward comparison of estimates from different studies may not be applicable. Furthermore, studies often have specific objectives, thus only covering some carbon pools, products (e.g., wood and food), and functions (e.g., material and energy substitution effect). In this study we took into consideration the natural climate mitigation potential provided by Roe et al. [18], which is a comprehensive and updated assessment of natural climate mitigation potential built on previous studies and including several advances beyond these, such as the inclusion of a wider set of solutions at the country level, attempting to avoid potential double-counting of mitigation opportunities. Their estimates concur with previous analysis [4,19–21].

The solutions collected in the LTSs were compared and associated with the natural climate measures defined in the study by Roe et al. [18], which provides a quantitative estimate of the annual mitigation potential (in CO_2eq) achievable for each EU country for a set of twenty solutions from 2020 to 2050 (Supplementary Materials). With respect to those twenty solutions, we excluded the following five, which are not relevant for the European context and for which they have no data available for the EU: reduce deforestation, reduce mangrove loss, manage grassland fire, restore mangroves, increase clean cookstoves. Improved rice cultivation was not considered since the mitigation potential is negligible [1]. We also excluded "bioenergy with carbon capture and storage" (BE-CCS) because although it is presented as a single aggregated value, bioenergy largely overlaps with afforestation, reforestation, and biomass plantations, while other existing CCS solutions have minor impacts on land [4,22]. A brief definition for each solution is provided in Appendix A. Roe et al. [18] derived the estimates of the mitigation potential from individual and/or sectoral studies and datasets that use a range of methods, including sectoral economic modeling, optimization modeling, and spatial analysis. However, the successful implementation of the solutions depends on country-specific enabling conditions and barriers (e.g., available funding, socio-cultural context, environmental conditions) that were not taken into account. Moreover, Roe et al. [18] did not consider the substitution effects of bioenergy, biochar, and wood products on fossil fuel emissions due to a lack of country-level data. They estimated two types of mitigation potential: the "technical" potential—possible with available technology, regardless of the cost—and the "cost-effective" economic potential—possible up to EUR 100/t CO_2eq.

Calculation of the Mitigation Potential Score

We took into consideration the "technical" potential as a metric for the definition of a qualitative score (i.e., categorical and ordinal score) of the mitigation potential deriving from the implementation of the natural climate solutions. Therefore, we converted the quantitative estimates provided by Roe et al. into a 5-score classification system, where one [+] indicates very low or negligible, [++] low, [+++] moderate, [++++] high, and [+++++] very high mitigation potential for each EU country. The conversion was performed by assigning the highest score to the natural climate solution with the highest value of

mitigation potential, and accordingly, we calculated all the other scores proportionally. The following formula was used to calculate the mitigation potential score of each solution:

$$\text{MPscore } ic = \text{MP } ic/\text{MaxMPc},$$

where MPscore *ic* is the mitigation potential score for a specific country C of a solution *i*, MP *ic* is the mitigation potential (in CO_2eq yr^{-1}) and MaxMPc is the value (in CO_2eq yr^{-1}) of the solution with the highest mitigation potential for a country C. The formula returns five possible values from 0, corresponding to [+], to 4, corresponding to [+++++]. In this way, a score reflecting the relative mitigation potential was assigned to each solution for a specific country. We calculated the scores of both the solutions envisaged in the LTS and those that were not mentioned to highlight if the LTS included all natural climate solutions with large mitigation potential or not.

3. Results

We collected and analyzed the 25 available LTSs from the EU Commission [23] and the UNFCCC [24] (updated January 2024). The majority of member states submitted it in English, while 25% used the national language and provided an English summary. LTS reports often vary considerably from one country to another, both in content and format; for example, not all provide details on the contribution of each sector in the achievement of their national long-term target. To organize the data in a systematic and comparable way, the next three sections present the natural climate solutions divided into three mitigation categories: forests and other ecosystems, agriculture, and demand side.

3.1. Natural Climate Mitigation Potential in EU

While some countries have identified many natural climate solutions, especially affecting land, that have a relatively large mitigation potential at the national level, other countries have planned less effective solutions considering their national potential (Figure 1). The mitigation potential score is a categorical indicator that reflects the extent to which a country has planned to employ its own mitigation potential, rather than an absolute measure of emissions reductions. This score does not directly translate into absolute emission reductions, as it reflects only the level of alignment between planned measures and the country's estimated potential rather than actual mitigation outcomes. Based on our assessment, the countries that least harness their land mitigation potential are Greece and Denmark. In fact, Denmark does not define the role of LULUCF in relation to the 2030 and 2050 targets, and Greece does not include any information on LULUCF. Finland is one of the poorest countries at harnessing the mitigation potential through natural climate solutions. Nonetheless, this does not imply a lower contribution to GHG mitigation in absolute terms (i.e., tons of CO_2eq) compared to other countries. As the mitigation potential score is relative to each country, it is not possible to compare them in terms of contribution to reaching the climate target.

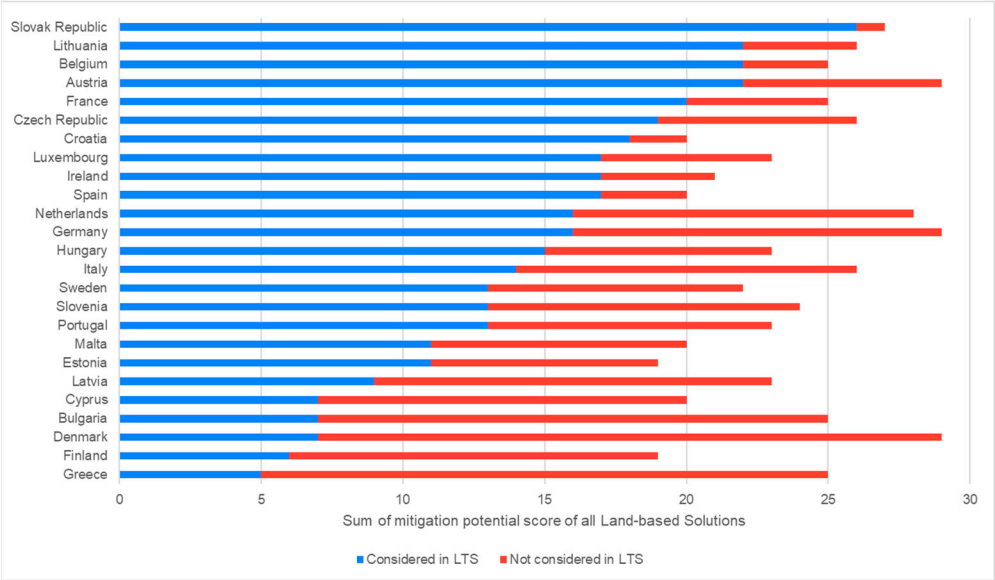

Figure 1. Overview of the mitigation potential of natural climate solutions is utilized by European Union countries according to the long-term strategies. The mitigation potential score is a categorical indicator of the climate change mitigation potential relative to a specific country. This figure allows to evaluate how much of the mitigation potential from land has been planned to be utilized by each country. Comparisons among countries is not possible, because the mitigation potential score is specifically relative to single countries.

3.2. Forests and Other Ecosystems

The mitigation category "Forests and other ecosystems" includes three classes: restoration, management, and protection (Table 1). Results show that the mitigation potential of forest management is very large, and over 70% of the countries intend to utilize forests through a management aimed at increasing carbon sequestration. Austria, Slovakia, and Sweden, which are likely aware of the very high relative contribution that forests can provide in their specific context, consider forest management in their LTSs. Denmark does not mention forest management and does not clearly define the role of LULUCF in relation to the 2030 and 2050 targets in its LTS, although it has a very high mitigation potential. Cyprus, Ireland, Italy, Malta, and the Netherlands, where forest management would provide a very low or negligible contribution, do not include it in their LTSs. Afforestation and reforestation (defined as the shifting from non-forest cover to forest cover at a 30% tree cover threshold) are carbon dioxide removal methods that 18 out of 25 countries report in their LTSs; the mitigation potential of these solutions resulted in low in over half of the countries, and for the remaining ones the potential is very low or negligible, excluding the Czech Republic, where it is moderate.

"Peatland restoration" and "Reduce peatland degradation" (important for their contribution to reducing CO_2, CH_4, and N_2O emissions) are included in 32% and 40% of the analyzed LTS reports, respectively; these solutions concern very specific geographical areas and ecosystems mainly located in Northern Europe. While "Reduce peatland degradation" has very low or negligible potential across all countries, the "Peatland restoration" potential varies considerably. Only three North European countries, i.e., Estonia, Ireland, and Lithuania, plan to put into practice solutions to restore the original form and function of peatland habitats. The other five countries do not consider it, in their LTSs, as a possibility to reduce CO_2 emissions, even though the contribution would be high or very high: Denmark, Finland, Germany, Latvia, and the Netherlands.

Table 1. Forests and other ecosystems natural climate solutions envisaged in the LTS.

Mitigation Classification	Restoration				Management		Protection	
Natural Climate Solution	**Afforestation and Reforestation**		**Peatland Restoration**		**Sustainable Forest Management**		**Reduce Peatland Degradation**	
	Score	**$MtCO_2eq\ yr^{-1}$**	**Score**	**$MtCO_2eq\ yr^{-1}$**	**Score**	**$MtCO_2eq\ yr^{-1}$**	**Score**	**$MtCO_2eq\ yr^{-1}$**
Austria	++	1.7	+	0.0	**[+++++]**	4.7	+	0.0
Belgium	+	0.4	+	0.0	**[++]**	1.6	**[+]**	0.0
Bulgaria	**[+]**	0.4	**[++]**	0.0	**[+]**	1.6	**[+]**	0.0
Croatia	**[++]**	1.1	+	0.0	**[++]**	1.5	+	0.0
Cyprus	**[+]**	0.0	+	0.0	+	0.0	+	0.0
Czech Republic	**[+++]**	2.4	**[+]**	0.0	**[+++]**	2.7	+	0.0
Denmark	**[+]**	0.6	++++	5.5	+++++	8.1	**[+]**	0.0
Estonia	+	0.8	**[+++++]**	12.6	**[++]**	2.5	**[+]**	1.1
Finland	**[+]**	3.5	+++++	44.7	+++	25.6	**[+]**	0.0
France	**[++]**	13.4	**[+]**	4.0	**[++]**	11.1	**[+]**	0.4
Germany	**[++]**	5.4	+++++	36.7	**[+++]**	17.0	**[+]**	2.2
Greece	++	2.5	+	0.0	++	2.3	+	0.0
Hungary	**[+]**	1.1	+	1.3	**[++]**	1.5	+	0.1
Ireland	**[+]**	0.6	**[+++++]**	11.6	+	1.1	+	0.0
Italy	**[++]**	6.4	+	0.0	+	2.9	+	0.0
Latvia	**[++]**	1.5	+++++	11.2	**[+++]**	4.2	+	1.1
Lithuania	**[++]**	1.1	**[+++++]**	7.7	**[++]**	1.9	**[+]**	0.8
Luxembourg	+	0.0	+	0.0	**[++]**	0.1	+	0.0
Malta	**[+]**	0.0	+	0.0	+	0.0	+	0.0
Netherlands	**[+]**	0.2	+++++	9.1	+	0.5	+	0.1
Portugal	**[++]**	1.6	+	0.0	**[+++]**	5.0	+	0.0
Slovakia	**[++]**	1.0	**[+]**	0.0	**[+++++]**	3.1	**[+]**	0.0
Slovenia	+++	0.6	+	0.0	**[+++]**	1.1	+	0.0
Spain	**[++]**	10.4	+	0.2	**[++]**	11.2	+	0.0
Sweden	++	5.2	**[++]**	8.8	**[+++++]**	28.3	**[+]**	0.0

Legend: The bold signs in brackets indicate that the natural climate solution is reported in the country's LTS, while signs without brackets indicate that the natural climate solution is missing in the country's LTS. The mitigation potential is expressed as follows: [+] very low or negligible, [++] low, [+++] moderate, [++++] high, and [+++++] very high. Absolute values source: Roe et al. [18].

3.3. Agriculture

The mitigation category "agriculture" contains two classes: emission reduction and carbon sequestration (Table 2). The analyzed LTS reports indicate three natural climate solutions for emission reduction in agriculture: enteric fermentation reduction, manure management, and nutrient management. Overall, emissions reduction in agriculture has relatively modest potential compared to other categories, with the majority of the solutions having very low or low mitigation potential for most countries. Nonetheless, almost all countries aim to reduce emissions from enteric fermentation and manure management up to 2050, which can be achieved by improving feed quality, animal genetics and breeding, reducing intensive grazing, and promoting animal health. Manure management involves the incorporation of small-scale or large-scale anaerobic digesters. Solutions to reduce emissions via nutrient management involve optimized fertilizer application rate, fertilizer type (organic manures, compost, and mineral), fertilization timing, precision application, and use of nitrification inhibitors; their mitigation potential is very low, and only Bulgaria,

Croatia, Finland, Ireland, Lithuania, and Luxembourg report these natural climate solutions in the LTSs.

Table 2. Agriculture natural climate solutions envisaged in the LTS.

Mitigation Classification	Emissions Reduction						Carbon Sequestration							
Natural Climate Solution	Reduce Enteric Fermentation		Manure Management		Nutrient Management		Soil Carbon Croplands		Soil Carbon Grasslands		Agroforestry		Biochar Application	
	Score	$MtCO_2eq\ yr^{-1}$	Score	$MtCO_2eq\ yr^{-1}$	Score	$MtCO_2eq\ yr^{-1}$	Score	$MtCO_2eq\ yr^{-1}$	Score	$MtCO_2eq\ yr^{-1}$	Score	$MtCO_2eq\ yr^{-1}$	Score	$MtCO_2eq\ yr^{-1}$
Austria	**[+]**	0.5	**[+]**	0.3	+	0.2	**[++]**	1.2	**[+++]**	2.0	+++	2.7	[+++]	1.9
Belgium	**[+]**	0.6	**[++]**	0.8	+	0.4	**[++]**	1.5	**[++]**	1.1	**[++]**	1.4	[++]	0.7
Bulgaria	**[+]**	0.6	++	0.8	**[+]**	0.4	++	1.5	++	1.1	++	1.4	++	0.7
Croatia	**[+]**	0.2	**[+]**	0.2	**[+]**	0.4	**[+++]**	1.8	**[++]**	0.9	**[+++++]**	4.2	[++]	1.7
Cyprus	+	0.0	**[+]**	0.0	+	0.0	+	0.1	+	0.0	**[+++++]**	0.9	+	0.0
Czech Republic	**[+]**	0.5	**[+]**	0.2	+	0.3	**[++]**	1.8	**[++]**	1.7	+++++	6.2	[+++]	2.4
Denmark	+	0.5	++	1.4	+	0.2	+++	3.2	+	0.2	+++	4.4	++	1.8
Estonia	+	0.0	**[+]**	0.0	+	0.0	+	1.5	+	0.2	++	2.0	[+]	0.4
Finland	+	0.3	**[+]**	0.2	**[+]**	0.4	+	4.0	+	0.2	+	1.3	[+]	0.6
France	**[+]**	4.4	**[+]**	1.9	+	3.2	++	10.7	++	7.6	**[+]**	0.7	[+++]	20.8
Germany	**[+]**	3.2	**[+]**	3.7	+	3.4	++	9.8	++	6.7	+++	22.0	[++]	10.2
Greece	+	0.5	+	0.4	+	0.3	++	1.3	++	1.4	+++++	7.4	[++]	2.2
Hungary	**[+]**	0.1	**[+]**	0.2	+	0.2	**[++]**	1.4	**[+]**	0.6	+++++	10.3	[++++]	8.0
Ireland	**[+]**	1.4	+	0.5	**[++]**	1.6	**[+]**	0.6	**[++]**	1.5	**[++]**	3.6	+	0.3
Italy	**[+]**	1.8	**[+]**	1.8	+	2.1	**[++]**	5.9	**[+]**	3.1	+++++	28.0	[++]	8.2
Latvia	**[+]**	0.0	**[+]**	0.0	+	0.0	++	2.5	++	1.8	++	3.0	[+]	0.9
Lithuania	**[+]**	0.0	**[+]**	0.0	**[+]**	0.0	**[+++]**	4.2	**[+]**	0.9	++++	5.0	[++]	1.6
Luxembourg	**[+]**	0.1	**[+]**	0.0	**[+]**	0.0	**[++]**	0.1	++	0.1	**[++]**	0.1	+	0.0
Malta	**[+]**	0.0	**[+]**	0.0	+	0.0	+	0.0	+	0.0	+	0.0	+	0.0
Netherlands	**[++]**	1.2	**[++]**	2.9	++	1.2	**[++]**	1.2	**[+]**	1.1	++	2.1	+	0.5
Portugal	**[+]**	0.5	**[+]**	0.4	+	0.6	+	0.5	+	0.1	+++++	10.6	[+]	0.6
Slovak Republic	**[+]**	0.0	**[+]**	0.0	+	0.1	**[++]**	1.0	**[++]**	0.6	**[+++++]**	3.4	[+++]	1.9
Slovenia	**[+]**	0.1	**[+]**	0.1	+	0.1	**[+++]**	0.5	**[++]**	0.2	+++++	1.3	[++]	0.2
Spain	**[+]**	2.0	**[+]**	4.5	+	3.3	**[+]**	5.9	**[+]**	4.4	**[+++++]**	78.2	[+]	7.6
Sweden	**[+]**	0.4	**[+]**	0.1	+	0.4	++	4.4	+	1.8	++	4.1	[+]	1.1

Legend: The bold signs in brackets indicate that the natural climate solution is reported in the country's LTS, while signs without brackets indicate that the natural climate solution is missing in the country's LTS. The mitigation potential is expressed as follows: [+] very low or negligible, [++] low, [+++] moderate, [++++] high, and [+++++] very high. Absolute values source: Roe et al. [18].

Increasing carbon sequestration by the application of biochar derived from crop residues is not reported by any country, even though it can have a moderate or high potential in five of them. Agroforestry has the largest potential to reduce emissions and increase removals among the agricultural solutions in all countries, but only eight included it in their LTSs. Seven countries that could rely on high and very high mitigation potential do not consider it in their strategies. At the same time, agroforestry is the approach with the most diverse potential, based on the country of implementation: the mitigation potential in many North European countries results being very low and low, while it is very high in some central-west and southern countries. Finally, increasing soil carbon in cropland and grassland may provide a low or moderate contribution to carbon sequestration. These solutions may include a shift to no-till management or to a management of grasslands that reduces grazing pressure or, for rangelands, avoiding land degradation practices and promoting nominally managed areas; thirteen out of twenty-five countries considered these natural climate solutions in the LTSs.

3.4. Demand Side

The mitigation category "demand side" includes two natural climate solutions: food waste reduction and healthy diets (Table 3). In particular, promoting healthy diets involves reducing food over-consumption, limiting meat-based protein consumption, and purchas-

ing locally produced food. This category covers solutions for influencing the demand for goods and/or services. In the land sector, demand-side management aims at reducing the demand for products with large carbon footprints and environmental impacts. The collected demand-side solutions present relatively high mitigation potential compared to most of the other natural climate solutions. This is acknowledged by the vast majority of countries, which present and describe these methods in their LTSs. Promoting healthy diets is the most impactful solution in this class, and all countries, excluding Bulgaria and Cyprus, consider it necessary to reach carbon emission targets in 2030 and 2050, even though its contribution differs substantially among countries. It represents a range of dietary changes to improve human diets, to make them healthy in terms of the nutrition delivered, and also sustainable from the economic, social, and environmental perspectives. Two-thirds of reporting countries propose a reduction of food waste in their LTS; carbon benefits that can derive from a reduction in food waste vary substantially among countries.

Table 3. Demand side natural climate solutions envisaged in the LTS.

Mitigation Classification	**Demand Side**			
Natural Climate Solution	**Food Waste Reduction**		**Healthy Diets**	
	Score	**$MtCO_2eq\ yr^{-1}$**	**Score**	**$MtCO_2eq\ yr^{-1}$**
Austria	**[++]**	1.6	**[+++++]**	4.2
Belgium	**[+++]**	2.1	**[+++++]**	5.6
Bulgaria	+++	2.1	+++++	5.6
Croatia	[++]	0.6	**[++]**	1.5
Cyprus	++	0.1	+++	0.4
Czech Republic	**[+]**	0.6	**[++]**	1.6
Denmark	**[++]**	1.3	**[+++]**	3.5
Estonia	+	0.2	**[+]**	0.5
Finland	+	1.2	**[+]**	3.3
France	**[+++]**	14.9	**[+++++]**	39.1
Germany	**[++]**	11.9	**[++++]**	31.4
Greece	++	1.7	**[+++]**	4.5
Hungary	**[+]**	0.9	**[++]**	2.5
Ireland	**[+]**	1.3	**[++]**	3.5
Italy	+++	11.3	**[+++++]**	29.7
Latvia	+	0.2	**[+]**	0.6
Lithuania	**[+]**	0.4	**[++]**	1.0
Luxembourg	**[+++]**	0.2	**[+++++]**	0.6
Malta	**[+]**	0.1	**[+++++]**	0.2
Netherlands	**[+++]**	3.4	**[+++++]**	9.1
Portugal	**[++]**	2.0	**[+++]**	5.3
Slovak Republic	**[+]**	0.4	**[++]**	1.1

Table 3. *Cont.*

Mitigation Classification	**Demand Side**			
Natural Climate Solution	**Food Waste Reduction**		**Healthy Diets**	
	Score	**$MtCO_2eq\ yr^{-1}$**	**Score**	**$MtCO_2eq\ yr^{-1}$**
Slovenia	++	0.3	**[+++]**	0.8
Spain	**[+]**	6.5	**[++]**	17.2
Sweden	+	1.9	**[++]**	5.0

Legend: The bold signs in brackets indicate that the natural climate solution is reported in the country's LTS, while signs without brackets indicate that the natural climate solution is missing in the country's LTS. The mitigation potential is expressed as follows: [+] very low or negligible, [++] low, [+++] moderate, [++++] high, and [+++++] very high. Absolute values source: Roe et al. [18].

4. Discussion

In this study, we assessed whether, in planning their long-term low greenhouse gas emission strategies (LTSs), EU countries have identified natural climate solutions that could contribute to the largest extent to the reduction of GHG emissions and enhancement of carbon removals, considering the country's potential based on the literature review and analysis by Roe et al. [18]. Over 90% of the countries are well aware of the importance of natural climate solutions; in fact, they indicate in their LTSs various measures and policies for climate change mitigation across all three mitigation categories (forests and other ecosystems, agriculture, and demand side). To reach the EU climate goals, it is important for countries to focus on early and rapid actions that maximize benefits while minimizing adverse effects [25]. This study only reports on the mitigation potential, showing which solutions can better contribute to climate change mitigation through land activities, considering the specific potential for each EU country. Based on this, it is possible to assess how some countries could improve their LTSs, accounting for their specific land mitigation potential. In fact, some of them may not fully use the potential for mitigation given by their land sector.

Some countries may need to review some of the solutions included in their LTSs. It holds especially true for carbon sequestration in agriculture and, in particular, for agroforestry. The European Commission defines agroforestry as "land use systems in which trees are grown in combination with agriculture on the same land" [26]. This natural resource management system aims to benefit the environment as well as the social and economic sustainability of the community where it is adopted. Thus, it goes well beyond mere climate change mitigation. The Rural Development Program of the Common Agricultural Policy 2014–2020 already promoted different types of agroforestry practices [27]; considering that the current Common Agricultural Policy 2021–2027 offers a major stream of funding for various sustainable practices, such as agroforestry, more EU countries should include it in their strategies, especially if it has high or very high mitigation potential [28].

Reducing emissions in agriculture is challenging: among all the IPCC emission sectors, agriculture has recorded the lowest relative emission reduction since 1990 in the EU. Most of the emissions from the agricultural sector in the EU come from livestock (CH_4 from enteric fermentation and manure management) and nutrient management (N_2O from nitrogen in cropland soil) [29]. In this study, the mitigation potential was based on estimations from Roe et al. [18], who used data from Beach et al. [30] for enteric fermentation and manure management and data from Beach et al. [30] and Griscom et al. for nutrient management. As pointed out by Beach et al. [30], the baseline used in their study did not account for the total non-rice cropland area. In fact, when comparing data on nutrient management, estimates from Beach et al. [30] are one order of magnitude lower than

those from Griscom et al. [31]. This could have contributed to the relatively low mitigation potential found for these measures.

We found that over 70% of the countries consider forest management as a component of their strategy to reduce emissions from land. In fact, forest management plays a major role in the land sector of the EU's mid-century low-carbon emission strategy [32]. A multi-purpose forest management approach allows achieving a balanced combination of different objectives in addition to climate change mitigation [33]. In this regard, it is important not to focus exclusively on the increase of biomass stock (both in forests and in harvested wood products) [34]: achieving both biodiversity and climate change mitigation goals in European temperate forests will be possible if decision makers articulate an overall vision that encompasses large spatial and temporal scales, while designing sustainable forest management plans at the extent of individual stands [35]. It is important to design and describe comprehensively, within the relevant national strategy (forest and biodiversity strategy), the vision on how to contribute to achieving the EU's biodiversity and other environmental objectives besides the GHG emissions reduction target.

The high rate of forest area gain witnessed on average throughout Europe in the last 30 years is decreasing [36]. The overall decline in the expansion rate of forests is due to a number of factors, which may hamper the achievement of the policy objectives on climate change mitigation and adaptation through increasing the forest area. This trend may be reversed, since more than 70% of the LTS reports indicate reforestation and afforestation as measures to reach the climate target. The scarcity of funding for afforestation and re-forestation activities, with which EU countries cope, may be coming to an end; the EU pledge to plant at least 3 billion additional trees by 2030 could boost afforestation and reforestation, also thanks to the financial support provided by the Common Agricultural Policy through the national Rural Development Programs [37]. However, the mitigation potential in the analyzed countries is relatively low; furthermore, when it comes to implementing reforestation and afforestation, governments have to cope with competition for land, which represents another challenge. In fact, different interests may overlap on the same parcel of land: they can be economic interests by different stakeholders (e.g., food and biomass production) or different environmental services (e.g., biodiversity and carbon sequestration) [38,39].

Reducing food waste and, in particular, dietary changes show relatively large mitigation potential in Europe among all the natural climate solution categories and have no negative impacts across the other challenges [6]. Our results highlight that all the analyzed EU countries recognize the importance of demand-side policies and measures to meet their climate target; this represents a big step forward, as demand-side measures have been less studied and promoted than supply-side measures in the past (e.g., deforestation, forest management) [40]. However, no countries describe the specific policies and measures that can be implemented to achieve them. Domestic policies could aim to influence consumer behavior towards sustainable consumption patterns, for example, through labeling, certification, and establishing economic incentives/penalties [41]. Demand-side measures take time and great effort to be implemented because they often involve behavioral, social, and lifestyle changes, which are among the most challenging aspects of any large-scale policy shift [40,42]. Besides the actual potential of this strategy in terms of climate change mitigation, we believe that tackling food waste at all stages of production, distribution, retail, and consumption is key, and the EU and all the EU countries should be committed to meeting the target 12.3 of SDG, "by 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses".

In analyzing the results of this study, attention must be paid to the fact that mitigation potential scores are not comparable across countries, as it is not an absolute measure but relative to each individual country. We based our analysis on the "technical" mitigation potential, which represents the total mitigation potential achievable with available technology, regardless of the cost. A limitation is that under certain circumstances some measures may not be plausible or desirable due to economic, social, political, or environmental constraints and tradeoffs. On the other hand, the "cost-effective" land-based mitigation potential possible up to EUR 100/tCO_2eq is an economic-based measure that provides an additional indication for policy. In fact, the cost-effective sectoral estimate is about 43% of available technical potential for the twenty-five analyzed countries. However, the EUR 100/tCO_2eq threshold (as considered by Roe et al. [18]) is far lower than other sources, and uncertainties remain regarding the CO_2 price beyond 2030. Therefore, adopting the cost-effective potential would require the development of different cost scenarios to ensure comprehensiveness and robustness. Although the technical mitigation potential is a theoretical measure that may not always be suitable when precise greenhouse gas (GHG) emission estimates are required in absolute terms, such as the calculation of emission reference levels, it remains a valuable indicator for guiding policy decisions.

In general, governments should ensure that natural climate solutions with high and very high relative mitigation potential are included and prioritized in national policies, and possibly national strategies should be revised accordingly to ensure they respond to the need to enhance mitigation across the European Union. As concrete examples, peatland restoration should be included in their LTSs by Denmark, Finland, Germany, Latvia, and the Netherlands; agroforestry by Austria, Czech Republic, Denmark, Germany, Greece, Hungary, Italy, Lithuania, Portugal, and Slovenia; and demand-side solutions by Bulgaria.

5. Conclusions

The role and the potential of natural climate solutions vary, even substantially, according to the place and time of their implementation. It clearly emerges that some countries can rely on a large mitigation potential for certain solutions, while other countries would have negligible or low benefits from the same solutions: each country has to investigate the benefits and trade-offs of the solutions considering its own national circumstances and sub-national peculiarities. Furthermore, all countries need to know the main emission sources at present to plan solutions that maximize the carbon benefits in the future and the applicable strategies to enhance removals.

This study informs policy discussions by indicating which natural climate solutions can provide the largest carbon benefits, pointing out if European countries have already planned such measures in their long-term low GHG emission strategies, and eventually proposing which policies and measures are worthy of further consideration. The analyzed EU countries rely on the contribution from the land sector to reduce GHG emissions and demonstrate an understanding of the key role of natural climate solutions: they envisage a wide set of solutions in their LTSs for achieving climate neutrality by 2050. However, our findings suggest that the potential for natural climate mitigation could be further applied. LTSs are lively documents, and the countries can update them as more effective measures are identified or in order to capture policy developments.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/land14040825/s1, File S1: Estimation of the absolute values of mitigation potential of land-based solutions from 2020 to 2050.

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of the results, and the writing; C.D.N. critically reviewed the paper and provided substantial comments on the contents and structure. All authors have read and agreed to the published version of the manuscript.

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Abbreviations

The following abbreviations are used in this manuscript:

BE-CCS	Bioenergy with carbon capture and storage
EU	European Union
LTS	Long-term strategies
LULUCF	Land-use, land-use change and forestry
GHG	Greenhouse gas
NDCs	Nationally determined contributions
LD	Linear dichroism

Appendix A

Table A1. Definition of the natural climate solutions.

Natural Climate Solution	Definition
Afforestation and reforestation	Increase carbon sequestration shifting from non-forest cover to forest cover at 30% tree cover threshold.
Reduce peatland degradation	Avoided GHG emissions (CO_2, CH_4, and N_2O) from degradation of peatlands.
Sustainable forest management	Avoided emissions and enhanced sequestration from the improvement of forest management, including reduced-impact logging, extended harvest rotations, increased post-harvest sequestration rates, and set-aside areas without logging activity.
Peatland restoration	Avoided GHG emissions (CO_2, CH_4, and N_2O) from restoration (re-wetting) of degraded peatlands.
Reduce enteric fermentation	Improve feed conversion, antibiotics, bovine somatotropin (bST), propionate precursors, antimethanogens, and intensive grazing to avoid/reduce methane emissions from livestock enteric fermentation.
Manure management	Avoided CH_4 and N_2O emissions from livestock manure management in anaerobic systems through incorporation of small-scale or large-scale anaerobic digesters.
Nutrient management	Avoided CH_4 and N_2O and changes in carbon sequestration in cropland soils associated with nitrogen application through changes in fertilizer application and management practices: split fertilization, 100% crop residue incorporation, nitrification inhibitors, and reducing nitrogen fertilizer applications by 20%.
Soil carbon croplands	Enhanced soil organic carbon sequestration by shifting from current management to no-till management with an input scenario consistent with cover cropping.

Table A1. *Cont.*

Natural Climate Solution	Definition
Soil carbon grasslands	Enhanced soil organic carbon sequestration in managed pastures, by shifting from current practices to improved sustainable management with light to moderate grazing pressure and at least one improvement. For rangelands, a shift from current management defined by land degradation to nominally managed.
Agroforestry	Carbon sequestration from adding aboveground woody carbon storage in agriculture systems (areas with <25% tree cover).
Biochar application	Enhanced carbon sequestration by amending agricultural soils with biochar, which increases the agricultural soil carbon pool by converting rapid-mineralizing carbon (crop residue biomass) to persistent carbon (charcoal) through pyrolysis.
Food waste reduction	Emissions reductions from diverted agricultural production (excluding land-use change) from reduced food loss and wastage from all stages of production, distribution, retail, and consumption through the implementation of measures such as improved storage and transport systems, generation of public awareness, and changing consumer behaviors.
Healthy diets	Emissions reductions from diverted agricultural production (excluding land-use change) from the adoption of sustainable healthy diets: (a) maintain a 2250 calorie per day nutritional regime; (b) converge to healthy daily protein requirement, limiting meat-based protein consumption to 57 g/day; and (c) purchase locally produced food when available.

References

1. EEA. National Emissions Reported to the UNFCCC and to the EU Greenhouse Gas Monitoring Mechanism. Available online: https://www.eea.europa.eu/data-and-maps/data/national-emissions-reported-to-the-unfccc-and-to-the-eu-greenhouse-gas-monitoring-mechanism-18 (accessed on 7 August 2022).
2. Bombelli, A.; Di Paola, A.; Chiriacò, M.V.; Perugini, L.; Castaldi, S.; Valentini, R. Climate Change, Sustainable Agriculture and Food Systems: The World After the Paris Agreement. In *Achieving the Sustainable Development Goals Through Sustainable Food Systems*; Valentini, R., Sievenpiper, J.L., Antonelli, M., Dembska, K., Eds.; Springer International Publishing: Cham, Switzerland, 2019; pp. 25–34, ISBN 978-3-030-23968-8.
3. European Commission. *EU Reference Scenario 2020: Energy, Transport and GHG Emissions: Trends to 2050*; Publications Office of the European Union: Luxembourg, 2021.
4. Griscom, B.W.; Adams, J.; Ellis, P.W.; Houghton, R.A.; Lomax, G.; Miteva, D.A.; Schlesinger, W.H.; Shoch, D.; Siikamäki, J.V.; Smith, P. Natural Climate Solutions. *Proc. Natl. Acad. Sci. USA* **2017**, *114*, 11645–11650. [CrossRef] [PubMed]
5. Schulte, I.; Eggers, J.; Nielsen, J.Ø.; Fuss, S. What Influences the Implementation of Natural Climate Solutions? A Systematic Map and Review of the Evidence. *Environ. Res. Lett.* **2022**, *17*, 013002. [CrossRef]
6. Smith, P.; Campbell, D.; Cherubini, F.; Grassi, G.; Lwasa, S.; McElwee, P.; Saigusa, N.; Soussana, J.-F.; Nkem, J.; Calvin, K.; et al. Interlinkages between Desertification, Land Degradation, Food Security and Greenhouse Gas Fluxes: Synergies, Trade-Offs and Integrated Response Options. In *Climate Change and Land: An IPCC Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse Gas Fluxes in Terrestrial Ecosystems*; IPCC: Geneva, Switzerland, 2019; p. 122.
7. Frank, S.; Gusti, M.; Havlík, P.; Lauri, P.; DiFulvio, F.; Forsell, N.; Hasegawa, T.; Krisztin, T.; Palazzo, A.; Valin, H. Land-Based Climate Change Mitigation Potentials within the Agenda for Sustainable Development. *Environ. Res. Lett.* **2021**, *16*, 024006. [CrossRef]
8. European Union. *Long-Term Low Greenhouse Gas Emission Development Strategy of the European Union and Its Member States Submission by Croatia and the European Commission on Behalf of the European Union and Its Member States*; European Union: Zagreb, Croatia, 2020.
9. UNFCCC. Adoption of the Paris Agreement. In Proceedings of the Conference of the Parties Twenty-First Session Paris, Paris, France, 30 November–11 December 2015.
10. European Union. *Regulation (EU) 2018/1999 of the European Parliament and of the Council of 11 December 2018 on the Governance of the Energy Union and Climate Action*; Publications Office of the European Union: Luxembourg, 2018.
11. Costa, C.; Wollenberg, E.; Benitez, M.; Newman, R.; Gardner, N.; Bellone, F. Roadmap for Achieving Net-Zero Emissions in Global Food Systems by 2050. *Sci. Rep.* **2022**, *12*, 15064. [CrossRef]
12. Walker, W.S.; Gorelik, S.R.; Cook-Patton, S.C.; Baccini, A.; Farina, M.K.; Solvik, K.K.; Ellis, P.W.; Sanderman, J.; Houghton, R.A.; Leavitt, S.M.; et al. The Global Potential for Increased Storage of Carbon on Land. *Proc. Natl. Acad. Sci. USA* **2022**, *119*, e2111312119. [CrossRef]

13. Yigini, Y.; Panagos, P. Assessment of Soil Organic Carbon Stocks under Future Climate and Land Cover Changes in Europe. *Sci. Total Environ.* **2016**, *557–558*, 838–850. [CrossRef]
14. Chapman, M.; Walker, W.S.; Cook-Patton, S.C.; Ellis, P.W.; Farina, M.; Griscom, B.W.; Baccini, A. Large Climate Mitigation Potential from Adding Trees to Agricultural Lands. *Glob. Change Biol.* **2020**, *26*, 4357–4365. [CrossRef]
15. Baumgarten, A.; Haslmayr, H.-P.; Schwarz, M.; Huber, S.; Weiss, P.; Obersteiner, E.; Aust, G.; Englisch, M.; Horvath, D.; Leitgeb, E.; et al. Organic Soil Carbon in Austria—Status Quo and Foreseeable Trends. *Geoderma* **2021**, *402*, 115214. [CrossRef]
16. Pellerin, S.; Bamière, L.; Angers, D.; Béline, F.; Benoit, M.; Butault, J.-P.; Chenu, C.; Colnenne-David, C.; De Cara, S.; Delame, N.; et al. Identifying Cost-Competitive Greenhouse Gas Mitigation Potential of French Agriculture. *Environ. Sci. Policy* **2017**, *77*, 130–139. [CrossRef]
17. Chiti, T.; Blasi, E.; Pellis, G.; Perugini, L.; Chiriacò, M.V.; Valentini, R. Soil Organic Carbon Pool's Contribution to Climate Change Mitigation on Marginal Land of a Mediterranean Montane Area in Italy. *J. Environ. Manag.* **2018**, *218*, 593–601. [CrossRef]
18. Roe, S.; Streck, C.; Beach, R.; Busch, J.; Chapman, M.; Daioglou, V.; Deppermann, A.; Doelman, J.; Emmet-Booth, J.; Engelmann, J.; et al. Land-based Measures to Mitigate Climate Change: Potential and Feasibility by Country. *Glob. Change Biol.* **2021**, *27*, 6025–6058. [CrossRef] [PubMed]
19. IPCC. *Climate Change 2014: Mitigation of Climate Change: Working Group III Contribution to the IPCC Fifth Assessment Report*, 1st ed.; Cambridge University Press: Cambridge, UK, 2015; ISBN 978-1-107-05821-7.
20. United Nations Environment Programme. *The Emissions Gap Report 2017: A UN Environment Synthesis Report*; The Emissions Gap Report: Nairobi, Kenya, 2017; ISBN 978-92-1-047969-1.
21. Roe, S.; Streck, C.; Obersteiner, M.; Frank, S.; Griscom, B.; Drouet, L.; Fricko, O.; Gusti, M.; Harris, N.; Hasegawa, T.; et al. Contribution of the Land Sector to a 1.5 °C World. *Nat. Clim. Change* **2019**, *9*, 817–828. [CrossRef]
22. Daigneault, A.; Favero, A. Global Forest Management, Carbon Sequestration and Bioenergy Supply under Alternative Shared Socioeconomic Pathways. *Land Use Policy* **2021**, *103*, 105302. [CrossRef]
23. European Commission. National Long-Term Strategies. Available online: https://ec.europa.eu/info/energy-climate-change-environment/implementation-eu-countries/energy-and-climate-governance-and-reporting/national-long-term-strategies_en (accessed on 1 December 2022).
24. UNFCCC. Long-Term Strategies Portal. Available online: https://unfccc.int/process/the-paris-agreement/long-term-strategies (accessed on 1 December 2022).
25. Hasegawa, T.; Fujimori, S.; Frank, S.; Humpenöder, F.; Bertram, C.; Després, J.; Drouet, L.; Emmerling, J.; Gusti, M.; Harmsen, M.; et al. Land-Based Implications of Early Climate Actions without Global Net-Negative Emissions. *Nat. Sustain.* **2021**, *4*, 1052–1059. [CrossRef]
26. European Commission. *Regulation 1305/2013 of the European Parliament and of the Council of 17 December 2013 on Support for Rural Development by the European Agricultural Fund for Rural Development (EAFRD) and Repealing Council Regulation 1698/2005*; European Commission: Brussels, Belgium, 2013.
27. Mosquera-Losada, M.R.; Rodríguez-Rigueiro, F.J.; Santiago-Freijanes, J.J.; Rigueiro-Rodríguez, A.; Silva-Losada, P.; Pantera, A.; Fernández-Lorenzo, J.L.; González-Hernández, M.P.; Romero-Franco, R.; Aldrey-Vázquez, J.A.; et al. European Agroforestry Policy Promotion in Arable Mediterranean Areas. *Land Use Policy* **2022**, *120*, 106274. [CrossRef]
28. European Commission. *A Farm to Fork Strategy for a Fair, Healthy and Environmentally-Friendly Food System. COM(2020) 381 Final*; European Commission: Brussels, Belgium, 2020.
29. EEA. Available online: https://www.eea.europa.eu/en/analysis/maps-and-charts/eu-agricultural-emissions-by-source-2 (accessed on 28 February 2025).
30. Beach, R.H.; Creason, J.; Ohrel, S.B.; Ragnauth, S.; Ogle, S.; Li, C.; Ingraham, P.; Salas, W. Global Mitigation Potential and Costs of Reducing Agricultural Non-CO_2 Greenhouse Gas Emissions through 2030. *J. Integr. Environ. Sci.* **2015**, *12*, 87–105. [CrossRef]
31. Griscom, B.W.; Busch, J.; Cook-Patton, S.C.; Ellis, P.W.; Funk, J.; Leavitt, S.M.; Lomax, G.; Turner, W.R.; Chapman, M.; Engelmann, J.; et al. National Mitigation Potential from Natural Climate Solutions in the Tropics. *Phil. Trans. R. Soc. B* **2020**, *375*, 20190126. [CrossRef]
32. Di Lallo, G.; Chiriacò, M.V.; Tarasova, E.; Köhl, M.; Perugini, L. The Land Sector in the Low Carbon Emission Strategies in the European Union: Role and Future Expectations. *Climate Policy* **2023**, *24*, 586–600. [CrossRef]
33. Gutsch, M.; Lasch-Born, P.; Kollas, C.; Suckow, F.; Reyer, C.P.O. Balancing Trade-Offs between Ecosystem Services in Germany's Forests under Climate Change. *Environ. Res. Lett.* **2018**, *13*, 045012. [CrossRef]
34. Schwaiger, F.; Poschenrieder, W.; Biber, P.; Pretzsch, H. Ecosystem Service Trade-Offs for Adaptive Forest Management. *Ecosyst. Serv.* **2019**, *39*, 100993. [CrossRef]
35. Sabatini, F.M.; de Andrade, R.B.; Paillet, Y.; Ódor, P.; Bouget, C.; Campagnaro, T.; Gosselin, F.; Janssen, P.; Mattioli, W.; Nascimbene, J.; et al. Trade-offs between Carbon Stocks and Biodiversity in European Temperate Forests. *Glob. Change Biol.* **2019**, *25*, 536–548. [CrossRef] [PubMed]
36. Forest Europe. *State of Europe's Forests 2020*; Forest Europe: Bratislava, Slovakia, 2020.

37. European Commission. *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions on the New EU Forest Strategy for 2030*; European Commission: Brussels, Belgium, 2021.
38. Biber, P.; Felton, A.; Nieuwenhuis, M.; Lindbladh, M.; Black, K.; Bahýl', J.; Bingöl, Ö.; Borges, J.G.; Botequim, B.; Brukas, V.; et al. Forest Biodiversity, Carbon Sequestration, and Wood Production: Modeling Synergies and Trade-Offs for Ten Forest Landscapes Across Europe. *Front. Ecol. Evol.* **2020**, *8*, 547696. [CrossRef]
39. Kurowska, K.; Kryszk, H.; Marks-Bielska, R.; Mika, M.; Leń, P. Conversion of Agricultural and Forest Land to Other Purposes in the Context of Land Protection: Evidence from Polish Experience. *Land Use Policy* **2020**, *95*, 104614. [CrossRef]
40. Smith, P.; Haberl, H.; Popp, A.; Erb, K.; Lauk, C.; Harper, R.; Tubiello, F.N.; de Siqueira Pinto, A.; Jafari, M.; Sohi, S.; et al. How Much Land-Based Greenhouse Gas Mitigation Can Be Achieved without Compromising Food Security and Environmental Goals? *Glob. Change Biol.* **2013**, *19*, 2285–2302. [CrossRef]
41. Verkerk, P.J.; Delacote, P.; Hurmekoski, E.; Kunttu, J.; Matthews, R.; Mäkipää, R.; Mosley, F.; Perugini, L.; Reyer, C.P.O.; Roe, S.; et al. *Forest-Based Climate Change Mitigation and Adaptation in Europe*; From Science to Policy; European Forest Institute: Joensuu, Finland, 2022.
42. de Ruiter, H.; Kastner, T.; Nonhebel, S. European Dietary Patterns and Their Associated Land Use: Variation between and within Countries. *Food Policy* **2014**, *44*, 158–166. [CrossRef]

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