LIFE
Climate Change Mitigation

LAYMAN'S REPORT

A novel approach for accounting and monitoring carbon sequestration of tree crops and their potential as carbon sink areas

REPORTING PERIOD
16/07/2015 – 30/10/2020

(LIFE14 CCM/GR/ 000635)

LIFE CLIMATREE

General information

The LIFE CLIMATREE project "A novel approach for accounting and monitoring carbon sequestration of tree crops and their potential as carbon sink areas" (LIFE14 CCM/GR/000635) is co-funded by the EU Environmental Funding Programme LIFE Climate Change Mitigation.

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30.10.2020

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1,931,447 €
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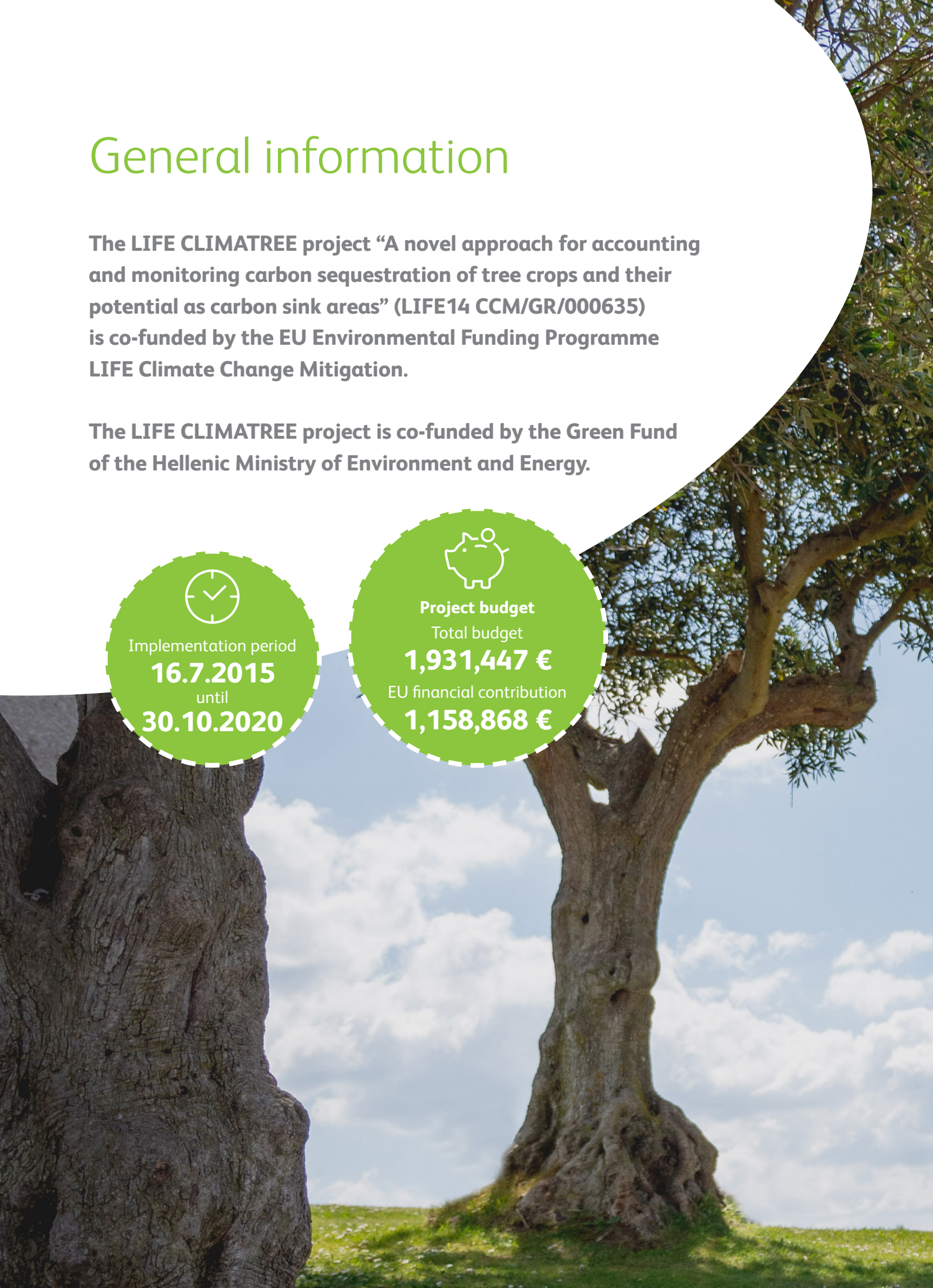

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The LIFE CLIMATREE project

LIFE CLIMATREE aims at evaluating and demonstrating climate change mitigation potentials of tree crops' cultivations. This requires comprehensive and robust investigation of the link between orchards and atmospheric CO_2 . This link is the target of LIFE CLIMATREE, attempting a holistic approach which takes into account what actually occurs within the farm. The annual change in CO_2 related biomass, the CO_2 storage in soil as well as the CO_2 emissions due to the applied cultivation practices are all systematically evaluated. In this context, the biological cycle of the trees is examined in combination with a Life Cycle Assessment of the currently applied as well as of alternative "green" agricultural practices. The mitigation rich cultivation practices are, then, identified and their CO_2 mitigation potentials are demonstrated.

This is an essential contribution to design coupled agricultural – climate policies. Such policies can be facilitated by the carbon farming schemes as defined within the new CAP. Furthermore, voluntary CO_2 markets and ecolabeling schemes can be also undertaken to exploit the mitigation potentials of orchards. To support such initiatives, LIFE CLIMATREE assigns economic values to the CO_2 sequestration by tree crop farms, considering that it is an essential ecosystem service provided by farmers. Finally, the benefits of sustainable tree cultivation are identified to demonstrate the total contribution of "green" cultivation practices. LIFE CLIMATREE defines the significance of the mitigation potentials of tree cultivation, which can significantly contribute to tackle climate change.

Estimating the CO_2 balance of tree cultivations

The estimation of the actual CO_2 balance of tree cultivations is a necessity for identifying the mitigation potential of tree cultivations. This is partially addressed by GHGs Inventories, within the LULUCF sector.

GHGs inventories incorporates two characteristics inhabiting the exploitation of mitigation potentials:

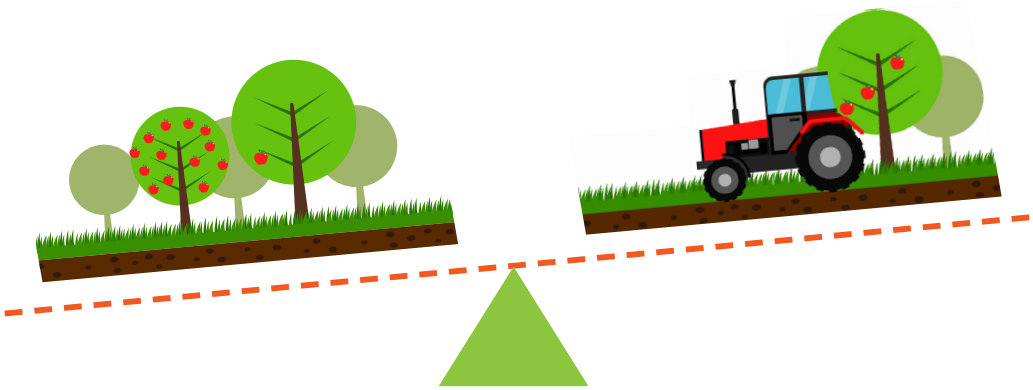
- GHGs inventories involve high uncertainty, at least in the Southern European countries, where tree cultivations occupy a relative high percentage of land use; estimates are largely based on default coef cients resulting in rough predictions.
- GHG inventories serve accounting purposes, consider CO_2 emissions induced by the cultivation practices (tractors use, energy for irrigation, fertilization etc.) as part of the Energy sector; these emissions are not ref ected in LULUCF inventories where tree crops are reported.

To address these deficits, LIFE CLIMATREE developed a novel methodology investigating for this purpose the existing know-how of the GHG Inventories and taking into account the Life Cycle Assessment principles.

Algorithm (CO_2RCA) & Tool (CO_2RCCT)

Within the LIFE CLIMATREE project, a specialized algorithm was designed and developed [CO_2 Removal Capacity Algorithm - CO_2RCA] aiming at the efficient and accurate calculation of the tree crops' capacity to remove CO_2 from atmosphere.

CO_2RCA



THE ALGORITHM CO_2RCA WAS DESIGNED TO CALCULATE THE BALANCE BETWEEN	the mass of CO_2 which is removed from atmosphere by tree crops to produce new biomass, and	the mass of CO_2 which is emitted to atmosphere by the applied agricultural practices.
CO_2RCA TAKES INTO ACCOUNT	the biological cycle of the tree	the practices applied for its cultivation, maintenance, protection and harvesting.

It is underlined that CO_2RCA calculates the carbon balance which is strictly related to atmosphere's CO_2 (CO_2 related carbon).

CO_2
Removal from the atmosphere for the development of tree's new biomass

CO_2
Storage into the soil beneath and around the tree

CO_2
Gain as a result of the application of "green" agricultural practices

CO_2
Emissions to the atmosphere due to the applied cultivation practices

CO_2RCA consists of a backbone set of equations, which are divided in 4 sections

Based on the CO_2RCA, a detailed e-tool [CO_2 Removal Capacity Calculation Tool - CO_2RCCT] was designed and developed to calculate tree crops' CO_2 Removal Capacity. The operation of the CO_2RCCT is supported by an extended back-end database, which includes appropriate data and coefficients.

CO_2RCCT was developed in 2 versions: the scientific, open-source version in excel format (.xlsx) and the web-based, public use version. Both are available at the project's website [www.lifeclimatree.eu].

CO_2RCCT was developed at a pilot scale incorporating 5 tree species:

- Orange [Citrus sinensis]
- Apple [Malus domestica]
- Peach [Prunus persica]
- Almond [Amygdalus communis or Prunus dulcis]
- Olive [Olea europaea]

in 3 countries: Greece | Italy | Spain.

The tool is operational in 4 languages: English | Greek | Italian | Spanish.

Indicative Results extracted by using the CO_2RCCT

	TREE CROP	CO_2 ANNUALLY REMOVED FROM ATMOSPHERE	CO_2 EMISSIONS/ REMOVAL RATIO	CO_2 ANNUAL REMOVAL CAPACITY
SPAIN	**olive**	**17,433,350** tn CO_2/year	**0.21315**	**13,717,511** tn CO_2/year
GREECE	**peach**	**406,127** tn CO_2/year	**0.31051**	**280,022** tn CO_2/year
ITALY	**orange**	**812,169** tn CO_2/year	**0.33019**	**544,000** tn CO_2/year

Regarding the specific 5 tree species, in Greece, Italy and Spain every year 28,994,370 tn of CO_2 is removed from atmosphere, 96.4% of which is used to create the tree's new wood biomass, while the 3.6% is incorporated into the soil beneath them.

A series of "green" alternative agricultural practices were examined by using the CO_2RCCT:

- use of cover crops
- use of Leguminosae cover crops
- application of mulching
- application of fertilizers via fertigation
- application of insects monitoring and/or mass trapping
- valorization of prunings as solid fuel instead of diesel
- use of Renewable Energy Sources,

and their impact on tree crops' "climate" performance was analyzed in depth.

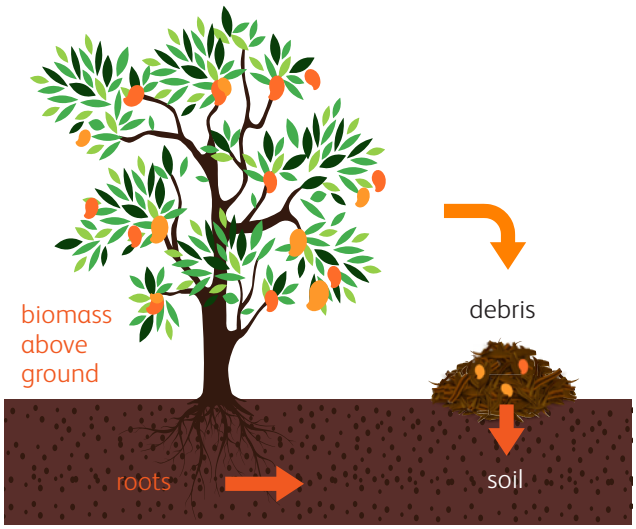
By applying a combination of "green" alternative agricultural practices a total reduction of approximately 80% is estimated that can be achieved regarding the current CO_2 emissions, leading in this way to an estimated total CO_2 Annual Removal Capacity of approximately 24,500,000 tn for the 5 tree species, in Greece, Italy and Spain.

Specifically concerning Greece, the 5 examined tree crops are illustrated, based on the results of the CO_2RCCT, by the following figures regarding the CO_2 Annual Removal Capacity (ARC) and its constituting parameters:

GREECE		orange	apple	peach	almond	olive
ARC	CO_2 ANNUAL REMOVAL CAPACITY	218,437 tn CO_2/year	9,768 tn CO_2/year	280,022 tn CO_2/year	70,437 tn CO_2/year	3,047,921 tn CO_2/year
AR_{BW}	CO_2 ANNUAL REMOVAL DUE TO THE PRODUCTION OF WOOD BIOMASS	300,878 tn CO_2/year	58,443 tn CO_2/year	403,408 tn CO_2/year	101,011 tn CO_2/year	4,549,120 tn CO_2/year
AS_S	CO_2 ANNUAL STORAGE IN SOIL AS CARBON OF THE FALLEN BIOMASS	7,224 tn CO_2/year	2,069 tn CO_2/year	2,719 tn CO_2/year	2,305 tn CO_2/year	54,879 tn CO_2/year
AE_F	CO_2 ANNUAL EMISSIONS DUE TO THE USE OF FERTILIZERS	37,063 tn CO_2/year	15,213 tn CO_2/year	32,746 tn CO_2/year	9,047 tn CO_2/year	635,916 tn CO_2/year
AE_P	CO_2 ANNUAL EMISSIONS DUE TO THE USE OF PESTICIDES	25,353 tn CO_2/year	5,981 tn CO_2/year	32,739 tn CO_2/year	11,609 tn CO_2/year	492,126 tn CO_2/year
$AE_{FF\&E}$	CO_2 ANNUAL EMISSIONS DUE TO THE USE OF FOSSIL FUELS & ELECTRICITY	27,248 tn CO_2/year	29,550 tn CO_2/year	60,620 tn CO_2/year	12,223 tn CO_2/year	428,037 tn CO_2/year
ARC_{AREA}	CO_2 ANNUAL REMOVAL CAPACITY PER UNIT OF CULTIVATED AREA	6.44625 tn CO_2/year	0.87465 tn CO_2/year	7.12835 tn CO_2/year	5.29610 tn CO_2/year	3.73945 tn CO_2/year
$ARC_{PRODUCT}$	CO_2 ANNUAL REMOVAL CAPACITY PER UNIT OF HARVESTED FRUITS	0.27844 tn CO_2 hectare/year	0.03866 tn CO_2 hectare/year	0.45389 tn CO_2 hectare/year	2.29570 tn CO_2 hectare/year	0.89183 tn CO_2 hectare/year
ARC_{TREE}	CO_2 ANNUAL REMOVAL CAPACITY PER TREE UNIT	0.01446 tn CO_2 of yield/year	0.00118 tn CO_2 of yield/year	0.01623 tn CO_2 of yield/year	0.01899 tn CO_2 of yield/year	0.02157 tn CO_2 of yield/year
TAE/TAR	CO_2 TOTAL ANNUAL EMISSIONS / CO_2 TOTAL ANNUAL REMOVALS	0.29102 tn CO_2 tree/year	0.83857 tn CO_2 tree/year	0.31051 tn CO_2 tree/year	0.31824 tn CO_2 tree/year	0.33798 tn CO_2 tree/year

The dynamic model

LIFE CLIMATREE created a dynamic model in order to investigate the long run-trends of the CO_2 balance of tree cultivations. The model permits the evaluation of carbon changes in the three major pools (biomass, dead organic matter, soil) under dif erent conditions including climate change scenarios and cultivation practices. The model can facilitate needs of the National GHGs Inventories. The long run trends indicate that soil carbon pool can play a significant mitigation role while cultivation practices result in substantial dif erentiated CO_2 impacts on all carbon pools. Cultivation practices matter and their impacts have been evaluated and ranked.



Economic benefits

CO_2 sequestration emerges as a significant ecosystem service and the actors that create such a service could be rewarded with the economic value of the service. LIFE CLIMATREE attempted the economic valuation of the CO_2 sequestration by using novel methods. The olive cultivations are the playground for this study because of the broad use of olive oil by citizens. Olive cultivation occupies a significant land use in the Mediterranean: around 9% of the cultivated land in Spain and Italy and 20% in Greece. The study estimated a value around 1,270 Euros per hectare of olive cultivation adopting cultivation practices maximizing CO_2 sequestration. This is a significant value which can be used to underline the development of incentives to induce farmers to explore mitigation potentials.

Sustainable agriculture and rural development. The social dimension

The realization of **mitigation potentials**, once accompanied with the relevant payments to farmers, can enhance sustainability on rural areas. Employment in the agricultural sector can be enriched and linked to long run activities such as tree cultivations in environmentally and climatic friendly way. Farmers can thus be an important climate, environmental and economic stakeholder with a lasting contribution. Coupling agricultural and climate objectives can result in development and social cohesion.

Economic benefits induced by carbon storage in olive trees

VALUE PER HECTARE ADOPTING BEST MITIGATION PRACTICES	**1970** €/ha	**1163** €/ha	**1270** €/ha
ADDITIONAL ANNUAL CARBON SEQUESTRATION INDUCED BY BEST PRACTICES	**7.92** million tn	**1.12** million tn	**0.78** million tn
ADDITIONAL VALUE OLIVE OIL CERTIFIELD FOR MITIGATION RICH PRACTICES	**1.79** €/liter	**1.91** €/liter	**1.59** €/liter
ANNUAL AGGREGATE ECONOMIC VALUES OF ADDITIONAL CO_2 ABSORPTION IN OLIVE TREES	**9.263** million €	**2.166** million €	**995** million €

Emerging potentials from calculating the tree crops' CO_2 Removal Capacity

A series of rising potentials from using the tree crops' CO_2RCA and CO_2RCCT appear to be significantly promising regarding the expected impacts on the climate, the sustainable agricultural development and the economy.

The quantified results regarding the tree crops' CO_2 Annual Removal Capacity as well as its constituting parameters, can provide the necessary data:

- to the farmers, as well as to the consulting agronomists, towards the improvement of the "climate" performance of their tree crop farms through the adoption of best/ "green" agricultural practices.
- to the policy/decision makers towards the improvement of the relevant agricultural climate change indexes through the ef ective planning, organization and promotion of the appropriate required policies, strategies and measures (e.g., financial incentives, "green" subsidies, supporting infrastructure, etc.) to enhance the development of the agricultural sector in a sustainable and simultaneously viable way.
- to the financial institutions to develop "green" banking products for the agricultural sector that will be based on a CO_2 reduction incentive concept (e.g., lower "green" interest rate) by taking into account the "climate" performance of the specific tree crop farm for which the farmer requests financing.
- to a voluntary carbon of -setting market through which the farmers themselves will be able to financially exploit the CO_2 credits of their own tree crop farms.

The above potential uses of the CO_2RCA and the CO_2RCCT can result to a series of significant advantages:

- Financial support to the European Union's agricultural sector.
- Development of financial incentives (e.g., "green" subsidies, "green" loans, etc.) for the farmers towards the adoption of "green" agricultural practices, which can lead to less CO_2 emissions and consequently to increased CO_2 Annual Removal Capacity of their orchards.
- Avoidance of currency export to third, non-EU countries for purchasing CO_2 credits in the case of the voluntary carbon of -setting market.
- Development of a new market of services within EU that will provide:
  - consultation to the farmers for "greening" the applied agricultural practices
  - calculation of the CO_2 Annual Removal Capacity of the orchards
  - certification of the calculated CO_2 credits
  - brokering of the certified CO_2 credits.

Incentives and policy frameworks

LIFE CLIMATREE traces and delineates frameworks of incentives to promote the mitigation potentials. The new CAP can incorporate a system of incentives under frameworks entitled as eco-schemes and especially carbon farming. Carbon farming schemes aim at exploiting the mitigation potentials of farms in Europe. LIFE CLIMATREE has created a systematic and operational know-how to identify and evaluate the mitigation potentials of orchards. This know-how can directly feed the design of carbon farming incentives with certification methods and robust estimates of the economic incentives. In addition, the LIFE CLIMATREE's know-how can support the design of private initiatives promoting and enhancing mitigation potentials. Ecolabeling schemes and CO2 voluntary markets can facilitate the mitigation prospects and induce farmers to apply the best management practices.

Overall, LIFE CLIMATREE creates the necessary knowledge for close-to-market initiatives exploring mitigation potentials. This knowledge has been communicated to decision makers and stakeholders and seems to inspire actual actions. The perfect timing defined by the design of the new CAP, as well as with the new stringent climate targets of EU, creates the best setting for action.

Coupled agricultural-climate policies can now be a reality with their benefits enhancing the sustainability of rural areas. A nature-based mitigation has been demonstrated with its co-benefits to stand important for the environment, economy and society. Let us explore the mitigation potentials of trees. They cannot be any more an issue of "how" and "if" but an issue of "when".

Publicity & Dissemination

The Dissemination strategy of LIFE CLIMATREE focused on two groups of relevant stakeholders:

- Decision and policy makers at the European and National level in relation to climate and agricultural policies,
- Farmers and stakeholders from the sectors of agriculture and crop cultivations.

Overall, the project's dissemination Activities reached a high peak in the last year, making use of its extension until October,31 2020. Both categories of stakeholders have been approached, systematically informed, and finally inf uenced. Decision makers at the national and European level as well as farmers and their unions have participated in the dissemination activities.

Networking

An extensive network with other projects, public organizations, farmer's associations as well as private companies has been established during the LIFE CLIMATREE implementation. This network was established in order to facilitate the LIFE CLIMATREE successful implementation, to exchange information regarding cultivation practices and to communicate similar ef orts.

Overall Result

Tree crops are proved to be of significant importance for the regulation of the climate, acting as a Climate Change mitigation measure.

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