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NACAO

SITUATIONAL ANALYSIS

on natured-based Carbon Offsets

CATALOGUE OF GOOD PRACTICES & MAPPING OF CARBON SINKS

Andalusia (Spain)
2023

This Situational Study has been prepared by the General Directorate for Environmental Sustainability and Climate Change (DGSACC) at the Regional Ministry of Sustainability, Environment, and Blue Economy (CSMAEA) on behalf of Andalusia region in the framework of Interreg Europe programme project Nature-based Carbon Offsets (NACAO). The Nature-based Carbon Offsets (NACAO) project receives financial support from the European Union (Interreg Europe/ERDF). This publication reflects the author's views only and the Interreg Europe programme authorities are not liable for any use that may be made of the information contained therein.

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1.Introduction

Climate change is one of the greatest challenges requiring urgent policy action. We pollute a lot. We have known that for a long time. What is new is that we are increasingly putting up resources: firstly, reducing emissions, individually and collectively; and, secondly, offsetting them by investing in clean projects.

The compensation of GHG emissions is, in general, a topic underdeveloped by the public administration and, when developed, very limited and traditional measures are entered into force.

In this sense, NACAO (Nature-based Carbon Offsets) project aims at being an accelerator for regional governments with competencies on climate change throughout Europe actively approaching the offsetting of carbon emissions, in this case by developing nature-based solutions and policies contributing to the offsetting of emissions through them.

During the project, regional governments with competencies on environment and climate change from the Northern, Southern, Eastern and Western of Europe will share green and blue carbon solutions and police in force aiming at the preservation, restoration and improvement of natural sites acting as carbon sinks, such as forests, wetlands and other ecosystems, that compensate GHG emissions. Also, their experiences on carbon credits and emissions markets related to nature-based solutions.

The ultimate aim is for the partners to increase their knowledge and capacity to implement in their regions green and blue carbon initiatives and polices learned during the cooperation, regions thus contributing to the mitigation and adaptation to climate change.

The project brings together 6 partners from 6 countries (Spain, Italy, Poland, France, Finland and Germany) to improve their policy instruments addressed so that they develop the compensation of GHG emissions through the use of nature-based interventions.

Object and scope of Situational Studies

The aim is gathering all the good practices and experiences (successful and unsuccessful) developed in the field that will be shared as well as mapping the green and blue carbon sinks in the regions where the lessons learnt during the cooperation could be applied.

2. Regional context

The Law 8/2018, of 8th October, on measures against climate change and for the transition towards a new energy model in Andalusia, establishes the Andalusian Emissions Offset System (SACE) registry as a voluntary instrument for the reduction of Greenhouse Gas (GHG) emissions and, if applicable, for compensation through offset or self-compensation projects. This is all in consideration of the objectives set by the European Union and the Government of Spain to achieve an orderly transformation of our economy towards a low-carbon and climate-resilient economy.

In article 37 of this Law, a **carbon absorption project** is defined as one that aims to ***increase the carbon sink capacity*** on both publicly and privately owned lands. Thus, projects that contribute to carbon sequestration, such as afforestation, reforestation, restoration and conservation of existing forested areas (Green or Forestry Carbon), coastal ecosystem projects, projects in Mediterranean woodland and dehesa areas, wetland conservation or restoration projects, seagrass meadow projects (Blue Carbon), and similar nature conservation or restoration efforts, as well as projects focused on conserving or increasing soil organic matter content within the realms of forestry or agriculture, can be classified as absorption projects (*Figure 1*).

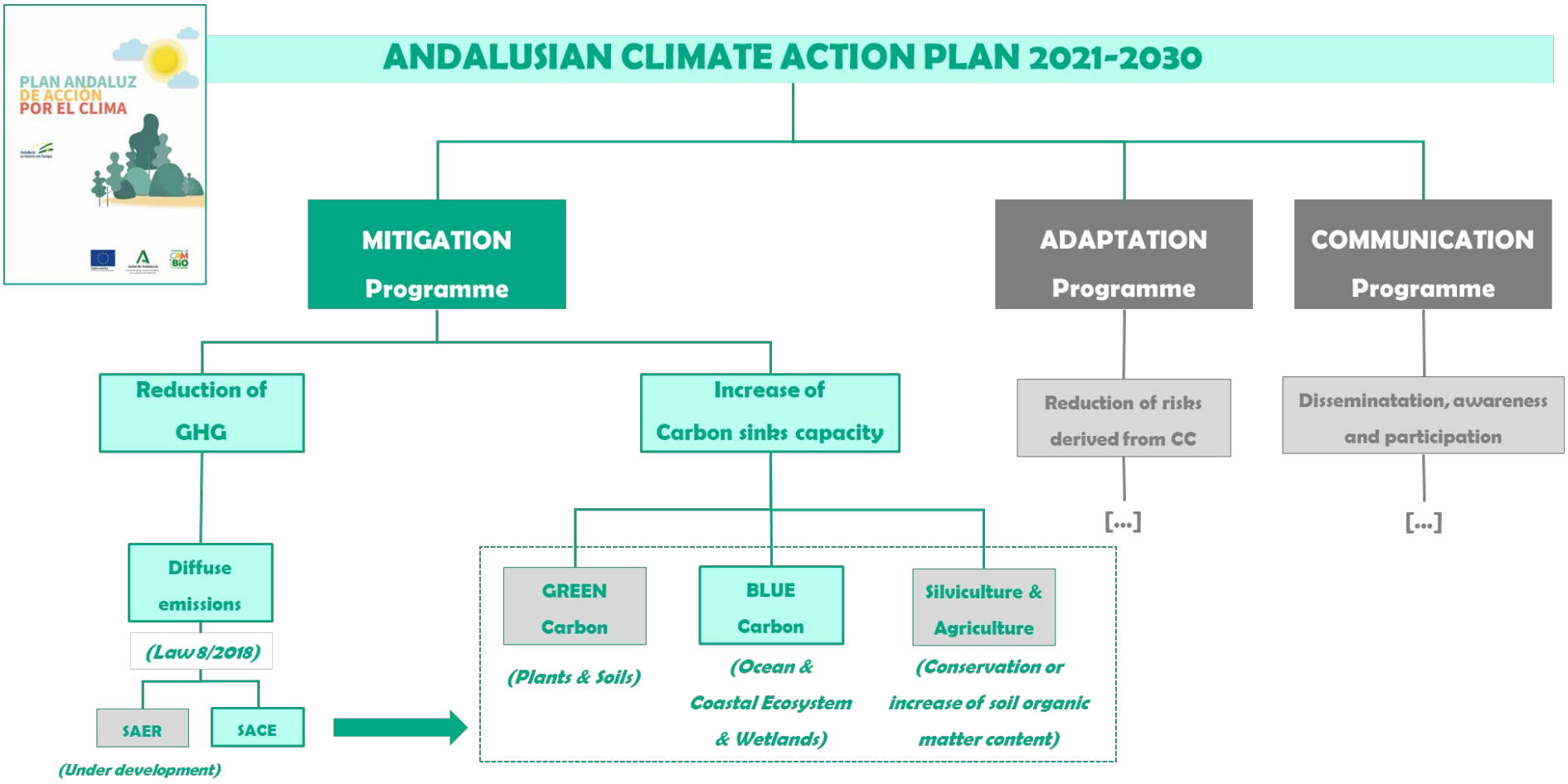


Figure 1.- Types of Carbon absorption or offsetting projects

Under this mechanism, organizations voluntarily register their carbon footprints, commitments to GHG reduction, emission absorption projects, and associated emission compensation plans in the **Andalusian Emissions Offset System (SACE) registry**. Consequently, when absorption projects are successfully implemented, they result in a quantified number of offset units that are certified in the name of their holders (Figure 2*)*. These units can then be used for a one-time emission offset.

ANDALUSIAN EMISSIONS OFFSET SYSTEM (SACE)

Voluntary registration created by Law 8/2018 through which companies contribute to the fight against Climate Change

Calculating

Reducing

Offsetting

1) **Emissions report**: self-assessment of their emissions using the tool provided by SACE;

1) **Reduction Plan**: definition of Strategy for emissions reduction;
2) **Implementation of the Plan**: carrying out the planned activities; y

1) **Offsetting**: compensating emissions that cannot be reduced through offsetting or self-offsetting projects.

Companies may offset part of their emissions through the absorption generated in **carbon sequestration projects**, both forestry and marine, that are included in the **Catalogue of Sequestration Projects**

Sistema Andaluz de Compensación de Emisiones (SACE) - Portal Cambio Climático de Andalucía - Cambio Climático (juntadeandalucia.es)

Figure 2.- Andalusian Emissions Offset System registry (SACE registry)

Therefore, through absorption projects, it becomes possible for interested organizations to offset their carbon footprint. As a preliminary step, it's important to promote and raise awareness among organizations about the benefits of registering their carbon footprint in the SACE registry. The **Andalusian Climate Change Office (OACC)** (*Figure 3*) collaborates closely with the Spanish Office for Climate Change (OECC), which operates under the Ministry for Ecological Transition and Demographic Challenge (MITERD), to ensure accurate accounting of Absorption Units (UDAs), avoid duplicate registration, and ensure interoperability between the SACE Registry and the Carbon Footprint, Compensation, and Carbon Dioxide Absorption Projects Registry established by Royal Decree 163/2014, of 14th March.

The purpose of the OACC is to support and promote mitigation, adaptation, and communication policies related to climate change in Andalusia (*Figur).*

ORGANIZATIONAL CHART

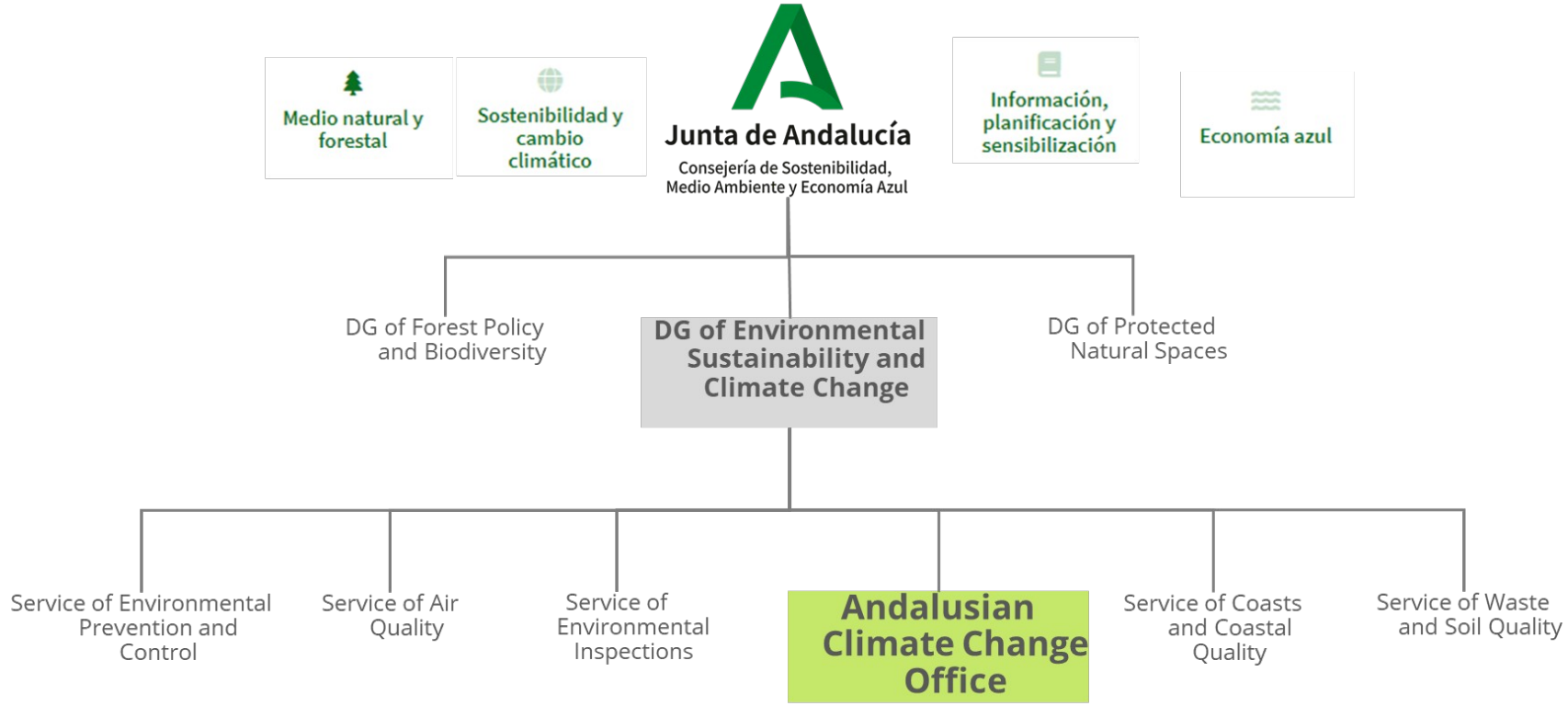


Figure 3.- Organizational chart of the Andalusian Climate Change Office (OACC)

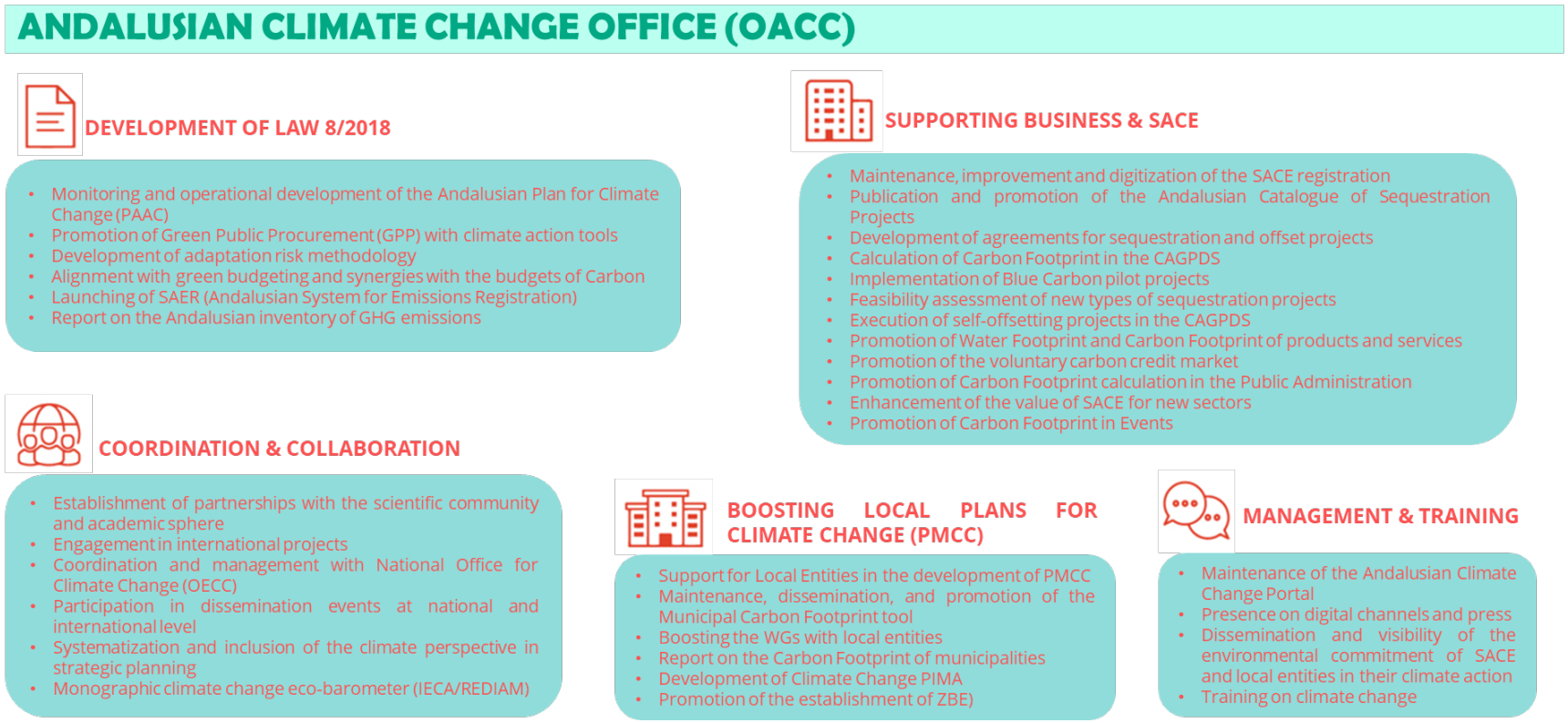


Figure 4.- Functions of the Andalusian Climate Change Office (OACC)

3. Regulatory and Policy framework for Climate Change

In October 2018, the Andalusian Parliament passed **Law 8/2018 on Measures against Climate Change and for the Transition towards a New Energy Model in Andalusia**. The enforcement of this law marked a turning point in Andalusia, elevating all climate change initiatives up to that point to the highest legislative level. Since then, the Andalusian Government has been working on regulatory developments in accordance with the mandates of the said law. The **Andalusian Climate Action Plan (PAAC) 2021-2030** serves as the overarching planning instrument for the autonomous community's efforts to combat climate change. It was approved by the Regional Government as a Regional Decree 234/2021, of 13rd of October.

Its mission is to integrate climate change into regional and local planning, aligning them with the plans of the Spanish government, the European Green Deal, and the Paris Agreement, contributing to achieving the Sustainable Development Goals outlined in the United Nations' 2030 Agenda.

The PAAC establishes 6 strategic objectives for 2030, 12 sectoral objectives, and over 137 lines of action distributed across three programs: Mitigation and Energy Transition, Adaptation, and Communication/Participation (*Figure 5*). These will be further developed in operational phases by 2022, 2026, and 2030:

1. The **Mitigation Programme** aims to establish the strategies and necessary actions to achieve the emissions reduction target, while also coordinating, monitoring, and promoting policies, plans, and initiatives that contribute to such reduction and the transition towards a new energy model:
    - Achieve a 39 to 41% reduction in diffuse GHG emissions in Andalusia by 2030 compared to 2005, broken down by sectors: Transport and mobility (30 to 43%); Industry (25 to 35%); Buildings and housing (37 to 48%); Commerce, tourism, and Public Administrations (16 to 31%); Agriculture, livestock, aquaculture, and fishing (8 to 24%); Waste (25 to 38%); and Energy (0 to 15%);
    - Reduce the trend in primary energy consumption by at least 39.5% by 2030, excluding non-energy uses; and
    - Contribute at least 42% of gross final energy consumption from renewable energy sources by 2030.
2. The **Adaptation Programme** aims to guide and establish the scheduling of climate change adaptation actions for Andalusian society, the local business and production sector, the Andalusian Government Administration, and local entities, based on a manageable risk assessment aligned with a common scenario:
    - Reduce the risk of climate change impacts by minimizing their effects in various sectors: water resources; flood prevention; agriculture, livestock, aquaculture, fishing, and forestry; urban planning and land use; and tourism.
3. The **Communication and Participation Programme** aims to promote actions related to information, education, and fostering shared responsibility for active

societal engagement in the fight against climate change. It also seeks to encourage and enhance citizen participation in the development of policies in this domain:

- Support the Emission Mitigation and Energy Transition Programme to achieve the goals of GHG emissions reduction and energy matters;
- Support the Adaptation Programme to achieve the objective of reducing the risk of climate change impacts; and
- Encourage behavioral changes in society necessary for climate change mitigation, adaptation, effect reduction, and early awareness.

The PACC has been the first Regional Instrument for Climate Change developed and approved in Spain, in line with the National Law 7/2021, of 20th of May, on Climate change and Energy Transition, and the National Integrated Plan of Energy and Climate (PNIEC). Additionally, for the development of the PAAC, other legal instruments and concurrent planning were analysed as a means to ensure its alignment with the existing legal framework in the field of Climate Change at international, European, national and even regional level (Figure 6).

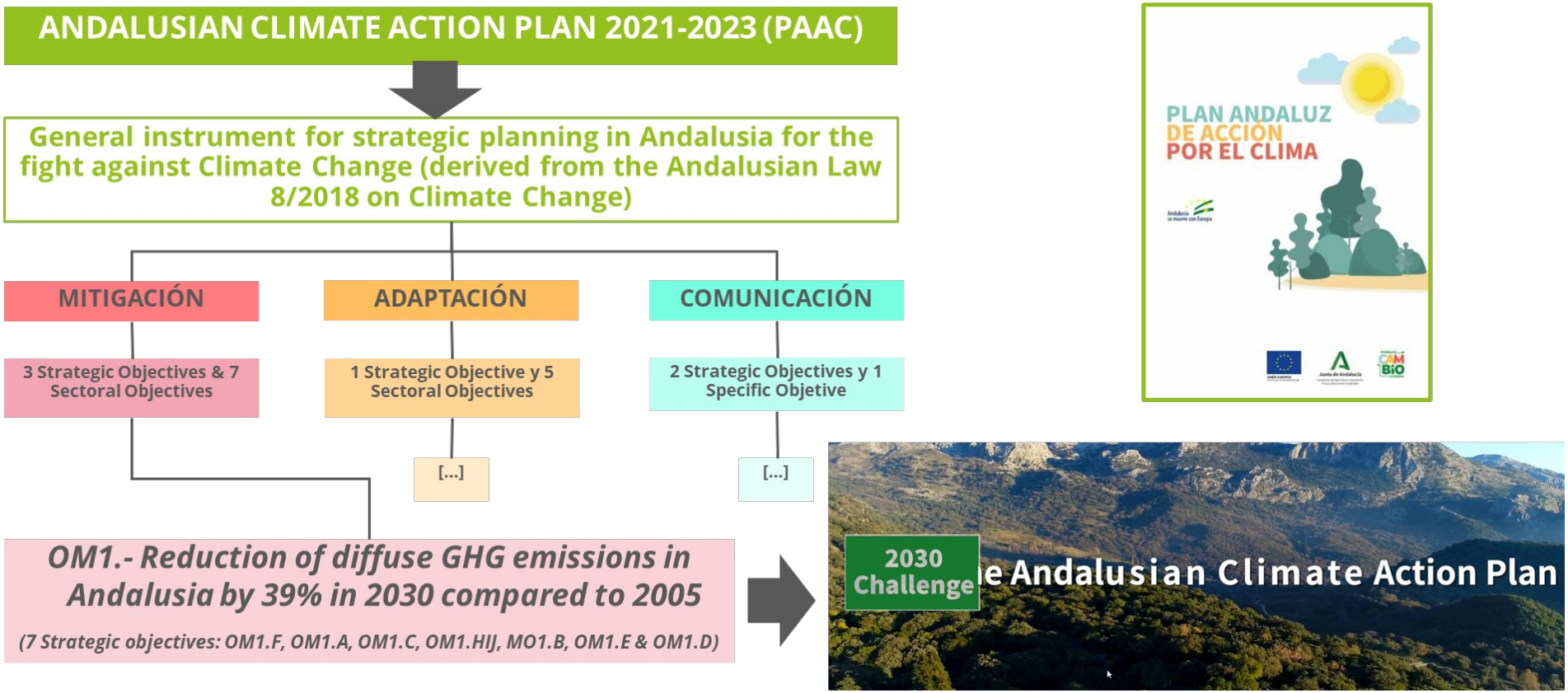


Figure 5.- Strategic areas and specific objectives of the PACC

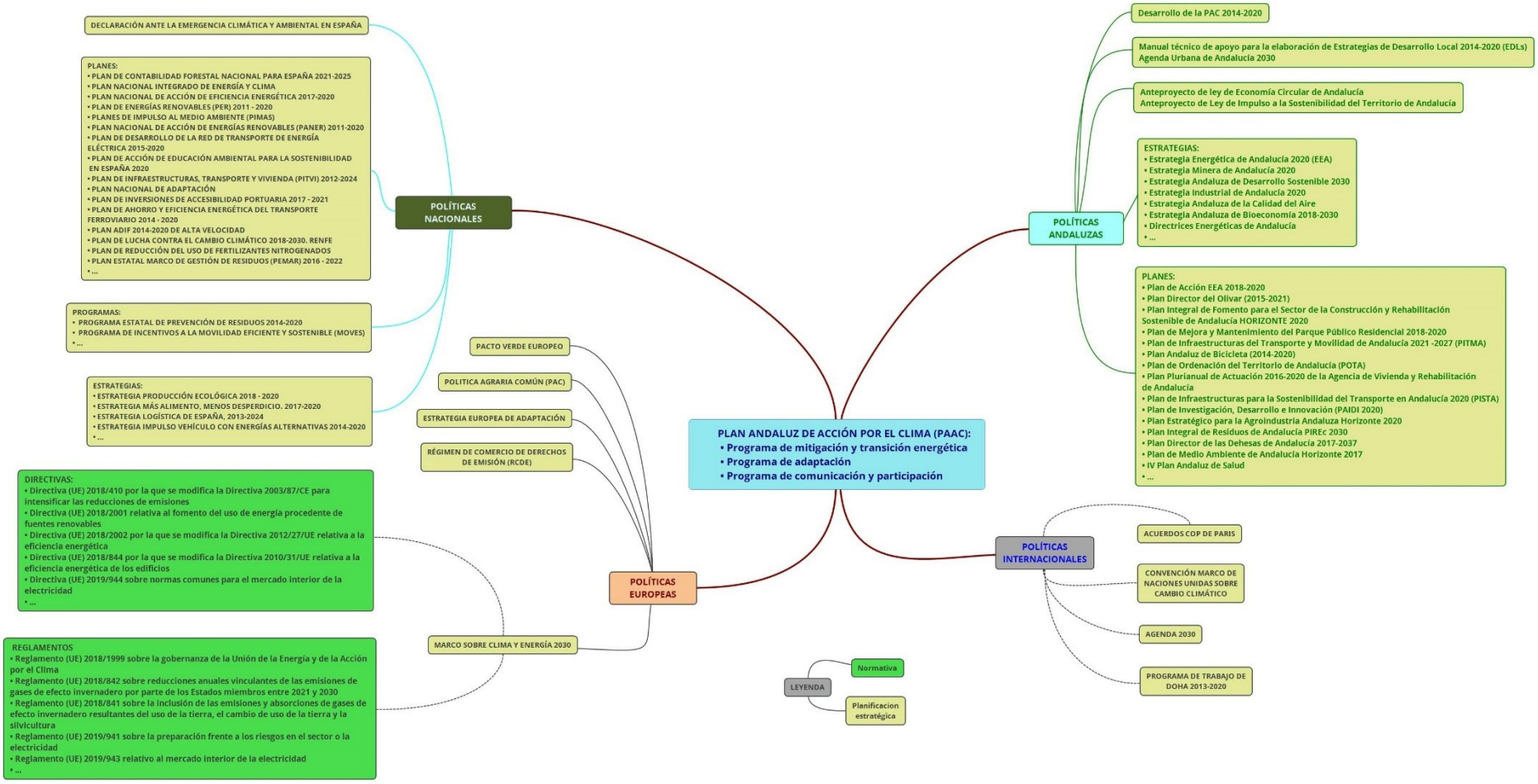


Figure 6.- Legal framework and concurrent planning analysed for the development of the PACC

(Source: Andalusian Climate Action Plan 2021-2030)

4. Catalogue of Good Practices on nature-based Carbon Offsets

In recent years, there has been an exponential increase in the number of organizations that, voluntarily and as part of their Corporate Social Responsibility schemes (CSR), calculate their carbon footprint and develop reduction plans. More and more organizations are also seeking to offset emissions that cannot be reduced through their plans by implementing absorption projects.

In response to this scenario, the CSMAEA has taken a proactive approach to address the demands of organizations and has initiated a set of measures to promote absorption projects, making their implementation a reality in Andalusia. For this purpose, the Andalusian Emissions Compensation System (SACE) was established, which is a voluntary scheme created by Law 8/2018, providing the business sector with the opportunity and means to actively participate in the fight against climate change.

Emission reduction targets can be partially or wholly achieved through emissions compensation, which will be realized through the issuance of absorption units (UDAs) generated by the execution of compensation or self-compensation projects.

Furthermore, the article 51 of the Law 8/2018 regulates the Registry of the Andalusian Emissions Compensation System (Registry SACE), establishing the data related to individuals or legal entities owning the activities to be recorded therein.

The evolution of this Registry serves as an indicator of the significant interest generated in this area in recent times. More and more organizations are choosing to actively engage in the fight against Climate Change, as confirmed in the 2022-2023 comparison, showing an upward trend in the number of registered footprints and new organizations enrolled (*Figure 7*).

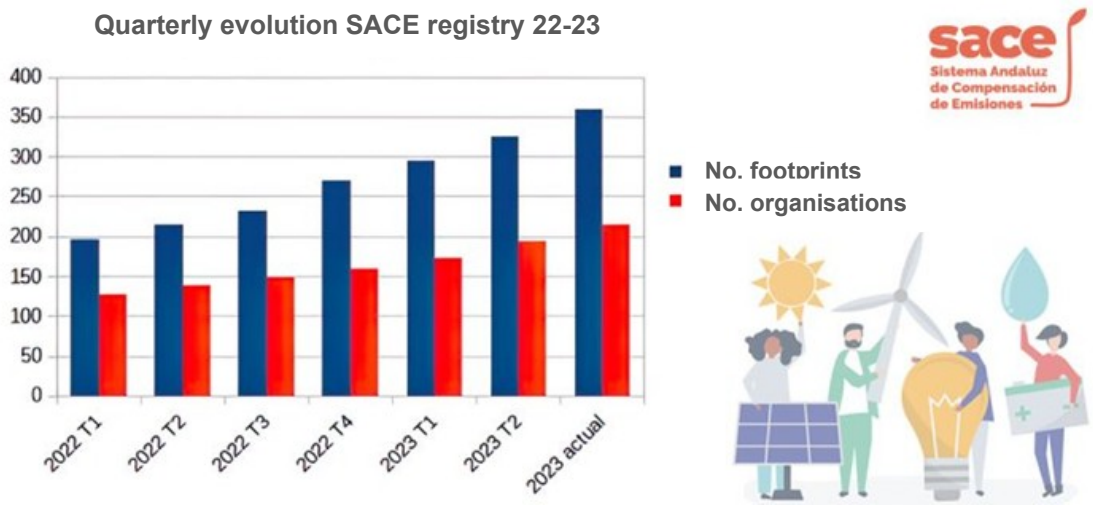


Figure 7.- Quarterly evolution of SACE 2022-2023

(Source: SACE registry)

The recorded growth is directly linked to organizations' interest in conducting their activities in an environmentally responsible way. Previously, DGSACC conducted an

analysis that allowed the identification of needs in the current situation upon which to base the measures to be implemented. The needs that became apparent following the study included, among others:

- Establishing robust methodologies for quantifying carbon captured by projects;
- Providing certification standards endorsed by the public administration to ensure safety;
- Making public land locations available to interested organizations for the implementation of such projects;
- Formulating new models for public-private collaboration in this field;
- Streamlining the regulatory framework to enable voluntary carbon markets;
- Developing tools for organizations to aid them in calculating their GHG emissions and conducting mitigation planning;
- Administrative simplification to facilitate organizations' voluntary efforts in combating Climate Change;
- Promoting awareness and sensitization among citizens and organizations to encourage such actions;
- Setting an exemplary role for the Public Administration by calculating, reducing, and offsetting its own emissions;
- Expanding governance schemes among different administrations;
- Etc.

The implementation of different measures (methodological, procedural, legal, communication, etc.) by CSMAEA has supported the increasing demand from organizations to contribute to the fight against climate change through the calculation, reduction, and offsetting of their GHG emissions. The set of measures implemented in Andalusia under the SACE framework are as follows and will be made available to other European regions that wish to take a step further in the fight against Climate Change (Table 1).

Table 1.- Overview of the Good Practices on nature-based Carbon Offsets in Andalusia (Spain)

ID	Title	Type[1]	Brief description	Source of Carbon Offsets[2]	Promoting institution level[3]	Status
1	Andalusian Carbon Standard for the Certification of Blue Carbon credits	Technical	Approval and publication of the Standard for Certification of Blue Carbon credits, other supporting documents (protocols, calculators, templates, ...) and Catalogue of projects to implement Blue Carbon absorption projects in Andalusia	Blue Carbon	Regional	Successful
2	Catalogue of Blue Carbon absorption pilot projects	Technical	Implementation of 2 pilot projects on restauration/conservation of seagrass meadows in Bahía de Cádiz y Cabo de Gata to test and validate the Standard Certification of Blue Carbon credits	Blue Carbon	Regional	Successful
3	Consolidated legal framework for Climate Change in Andalusia	Regulatory framework	Consolidated legal framework for the registration of the carbon footprint, offsetting and CO_2 sequestration projects: Andalusian Law 18/2018 and Andalusian Climate Action Plan 2021-2030 (PACC)	Green & Blue Carbon	Regional	Successful
4	Andalusian System for Emission Offsetting (SACE)	Regulatory framework	Voluntary instrument for the reduction of GHG and for compensation, if applicable, through offset projects or self-compensation (regulated by Article 50 of Law 18/2018)	Green & Blue Carbon	Regional	Successful
5	Coordination of Andalusian System for Emission Offsetting (SACE) with the National Registry	Administrative	Simplification of the administrative procedure for the dual registration of the Carbon Footprint at regional (SACE) and national level (Registry of carbon footprint, offsetting and CO_2 sequestration projects): meetings, methodologies to be similar and validated by both, inter administrative procedure to act as a "single window", registration of absorption projects in national registry, but execution at regional level to avoid double accounting	Green & Blue Carbon	National & Regional	Successful

[1] Technical, administrative, financial, promotion & participation, regulatory framework, collaboration, etc.
[2] Green carbon (projects based on carbon storage on plants & soils), blue carbon (projects based on carbon storage on ocean, coastal & wetlands), other (projects based on sustainable practices on agriculture, silviculture & building sectors)
[3] National, regional and/or local

ID	Title	Type	Brief description	Source of Carbon Offsets	Promoting institution level	Status
6	Catalogue for Offsetting projects in public land for Andalusia	Collaboration	Development of a Catalogue of offsetting projects that can be implemented on public land In Andalusia: 1) Selection of specific projects on regional public land for the implementation of absorption projects and their use in compensation; 2) Eligible areas: areas affected by fires and non-forested forest areas since 1989; and 3) Creation of an access procedure to the Catalogue for private entities	Green & Blue Carbon	Regional	On-going
7	Public-private collaboration agreements	Collaboration	In response to the increasing demand from private organizations to undertake offset projects on public lands: 1) Drafting of standard agreements for each identified interested party; 2) Processing of the catalogue to be reviewed by the Legal Department, making it available for standardized use across the organization; and 3) Simplification and streamlining of the signing process with all organizations fitting within the categories outlined in the catalogue	Green & Blue Carbon	Regional	Successful
8	Protocol for the calculation of the Carbon Footprint in events	Technical	Protocol for events' organizer companies to make their events sustainable, calculate their Carbon Footprint and, after analysis, implement improvements in upcoming events to reduce emissions. Additionally, the protocol offers the option of tree planting as a means of offsetting a portion of their emissions	Green Carbon	Regional	Successful
9	Carbon Footprint registration of Regional Ministry of Sustainability, Environment and Blue Economy	Technical	As an exemplary initiative, for the 4th consecutive year, Regional Ministry calculates emissions resulting from its own activities, earning the Calculate + Reduce (effective plan) certification. Regional Ministry is currently in progress of implementing its own absorption projects for emissions compensation (in analysing phase: registration of forest projects or some of the Blue Carbon pilot projects)	Green & Blue Carbon	Regional	Successful
10	Inventory of GHG emissions for Andalusia	Technical	Self-measurement of the annual evolution of diffuse GHG emissions and the carbon sink capacity in the Andalusian region, in line with the OM1, strategic objective of mitigation in PAAC: 39% reduction in GHG emissions in Andalusia by 2030 compared to 2005	Green & Blue Carbon	Regional	Successful

ID	Title	Type	Brief description	Source of Carbon Offsets	Promoting institution level	Status
11	Portal Andaluz de Cambio Climático as a tool for awareness and dissemination	Promotion & Participation	A web tool that is created for raising awareness and disseminating information to both interested organizations and citizens. Contents are also shared on social media platforms. An email account is made available for inquiries from interested parties	Green & Blue Carbon	Regional	Successful
12	Flexibilization of the regulatory framework for the voluntary carbon credit market	Regulatory framework	Since the voluntary carbon credit market is a market where the Administration doesn't intervene, it is understood that the role of the Ministry in this case is to facilitate its development by loosening the regulatory framework and developing tools to enable the creation of the voluntary market: 1) Amendments to the duration of specific public-private collaboration agreements for the implementation of offset projects; 2) Extension of land typologies for the development of offset projects; and 3) Inclusion of the consideration of absorption projects in regional forestry regulation as a means to enhance Andalusia's carbon sink capacity	Green & Blue Carbon	Regional	On-going

5. Mapping of Carbon sinks

CSMAEA has conducted an in-depth study on the ecosystems of Andalusia to address and deepen our understanding of the value these ecosystems provide for human well-being based on the ecosystem services they generate. This has multiple implications from various perspectives.

In the case of Andalusia, the importance of conducting such assessments is, if anything, even more critical, as a significant portion of the region's strategic economic activities are closely tied to sectors that exhibit a high dependency on ecosystems and biodiversity. Their relevance is further heightened in the current context of global change.

This **Ecosystem Services Study of Andalusia**[4] (hereinafter, the reference study) consists of, among other components, an Evaluation' Report & Atlas of Ecosystem Services in Andalusia. As part of this study, the capture and storage of CO_2 by ecosystems throughout Andalusia have been analysed, following a categorization that includes a primary classification (with sub-levels for more detailed information) and their locations based on the mapping also developed by CSMAEA. The capture and storage of CO_2 by plants provide a greenhouse gas emissions mitigation service, as atmospheric CO_2 is removed and fixed into the plant structure through photosynthesis, improving conditions in the face of climate change.

The mapping of Carbon sinks included in this Situational Study of Andalusia has been prepared by DGSACC within the framework of the Interreg Europe NACAO project based on the information and data contained in the reference study. It provides a snapshot of the current state of Andalusia's ecosystems in preparation for future carbon absorption projects, serving as a fundamental tool to increase the region's carbon sinks capacity.

It should be noted that the scope of the Carbon sinks included in this Situational Study is detailed in sections 5.1 and 5.2. These sections exclusively present the results of CO_2 capture and storage by terrestrial vegetation, marine phanerogams (seagrass) and marshes ecosystems, covering the most significant spectrum for both green and blue carbon.

Subsequently, based on the conclusions derived from the reference study, this Situational Study extracts the most important and representative ecosystem types in Andalusia from the point of view of carbon sequestration, compiling and mapping them in Table 3. This table serves as an inventory of those habitats or areas existing in the region where it would be of interest to implement nature-based solutions as carbon absorption or sequestration projects for emission offset or compensation.

Below, a summarized presentation of the key results from the reference study regarding carbon captured by terrestrial vegetation (section 5.1) and by marine phanerogams (seagrasses) and marshes ecosystems (section 5.2) is provided, along

[4] Full Spanish version available in: https://portalrediam.cica.es/descargas?path=%2F10_SISTEMAS_PRODUCTIVOS%2F12_SERVICIOS_ECOSISTEMICOS%2FServiciosEcosistemicos_2022%2FDocumentos

with the conclusions drawn from them and their specific locations on the map of Andalusia, based on the zoning of the obtained results.

5.1 Carbon capture and storage (carbon sequestration) by terrestrial plants

Assessment methodology

For the assessment of this service, a biophysical approximation methodology has been used in the reference study, specifically a methodology based on the use of carbon density data (indirect measurements).

Information sources

- Information from the RECAMAN project for carbon stock data (density values, tC/ha) in the live forest biomass reservoir (BV) and MFE50 tile-based mapping;
- Information from reference literature for carbon stock data (density values, tC/ha) in live agricultural biomass reservoirs and soil reservoirs (SOC) and dead matter (MM) for forest, agricultural and grassland ecosystems; and
- Ecosystem mapping of Andalusia available in REDIAM (2019).

Results

Regarding the total carbon stock results (tC), the justification for these should be done by appropriately combining the carbon density values and the surface area occupied by each ecosystem.

The total carbon storage value (tC) for Andalusian ecosystems according to the N1 and N2 level classification[5] is shown in the following Table 2:

[5] N1 y N2: Level 1 and Level 2 of ecosystems corresponding to the Ecosystem Mapping of Andalusia (2019)

Table 2.- Carbon storage (tC) for Andalusian Ecosystems (level 1 & level 2)

(Source: prepared by DGSACC based on the Ecosystem Services Study of Andalusia)

Ecos. N1	Description	C Total Stock (tC)	Ecos. N2	Description	C Total Sstorage (tC)
1	**Forests**[6]	**196.403.848,40**	**11**	**Wooded Grasslands**	**88.511.215,65**
			12	Mediterranean Sclerophyllous Forests	43.238.916,74
			13	Mediterranean Sclerophyllous Forests	2.972.128,72
			14	Coniferous Forests	8.035.243,64
			15	Forest Crops & other Tree Plantations	53.646.343,65
2	Scrubland[7]	90.602.717,75	21	High Mountain Scrubland	2.764.252,83
			22	Wet Scrubland	36.713.089,96
			23	Arid Scrubland	15.159.617,53
			24	Sclerophyllous Scrubland	35.965.757,43
3	Grassland[8]	21.127.594,84	31	High Mountain Grasslands	598.204,90

[6] Forests: ecosystems formed by trees of different species with a minimum ground cover of 25% (with the exception of dehesas) and other plants such as shrubs and herbaceous species.

[7] Scrubland: ecosystems dominated by a diverse vegetation of shrubs and various types of undergrowth, with a wide range of growth forms, from almost ground level to treelike.

[8] Grassland: natural or semi-natural herbaceous ecosystems, highly diverse, occupying large areas or prevailing in scattered areas under or among other formations.

Ecos. N1	Description	C Total Stock (tC)	Ecos. N2	Description	C Total Sstorage (tC)
			32	Herbaceous Vegetation, Reeds & Wet Meadows	9.924.069,87
			33	Arid &Semi-arid Esparto Grasslands & Hills	2.862.757,92
			34	Other Mediterranean Grasslands	7.742.562,15
4	Marine, Coastal & Inland Dune Ecosystems[9]	2.933.919,12	42	Dunes with vegetation	200.686,52
			43	Beaches & Cliffs	2.733.232,60
5	Continental Wetland Ecosystems[10]	9.733.207,76	52	Riverbanks & Watercourses	9.733.207,76
7	**Agricultural Ecosystems[11]**	**122.883.343,41**	71	Agricultural Mosaics of Ecological Value	11.058,17
			72	**Woody Crops**	**76.912.976,48**
			73	Herbaceous Crops	45.959.308,75
Total		443.684.631,28			443.684.631,28

[9] Marine, coastal & inland dune ecosystems: ecosystems influenced by the sea.
[10] Continental Wetland Ecosystems: freshwater ecosystems, without marine influence, encompassing both flowing and stagnant waters, as well as ecosystems characterized by high humidity. The salinity range of the waters varies from zero (freshwater) to saline.
[11] Agricultural Ecosystems: ecosystems in areas designated for crops or cultivation of land to obtain plant products for human or animal use.

In total, the **Andalusian Ecosystems provide a climate regulation service value through carbon storage (total stock) of 443.684.631tC**.

Andalusian forests (1) are the ecosystems that capture the highest amount of carbon (Table 2). Additionally, they maintain the highest densities of accumulated carbon (average value of 88,8 tC/ha), as observed in Figure 8, and they cover 29% of the analysed surface area.

Within the forests, the results obtained for Wooded Grasslands (11) are equally predictable, considering their density and the area they occupy in Andalusia, with 78,8 tC/ha and 14%, respectively. On the other hand, Forest Crops & other Tree Plantations (15), although they only cover 7,1% of the considered area, maintain significant carbon densities, averaging 93,5tC/ha.

Agricultural ecosystems (7) are the second most carbon-rich type of ecosystems in Andalusia. The influence of the land's surface area on the calculation of accumulated carbon stock is more evident in this type of ecosystems, widely distributed in Andalusia, covering more than 44% of the considered land surface.

Within the agricultural ecosystems, Woody Crops (72) with a cumulative carbon density value of 39,4tC/ha, despite covering 24.6% of the land area, logically have the highest accumulated carbon in Andalusia.

Finally, the results obtained in ecosystems with the lowest carbon stock must also be justified in terms of their land area (Table 2). This is the case for ecological value agricultural mosaics (71), occupying only 0.005% of the land area, and Inland Dune Ecosystems (42), covering 0.39% of the area considered in the analysis.

The detailed values of carbon densities per hectare (tC/ha), focused on forests and agricultural ecosystems, which are ecosystems' terrestrial vegetation with the highest carbon capture, are shown in the following Figure 8.

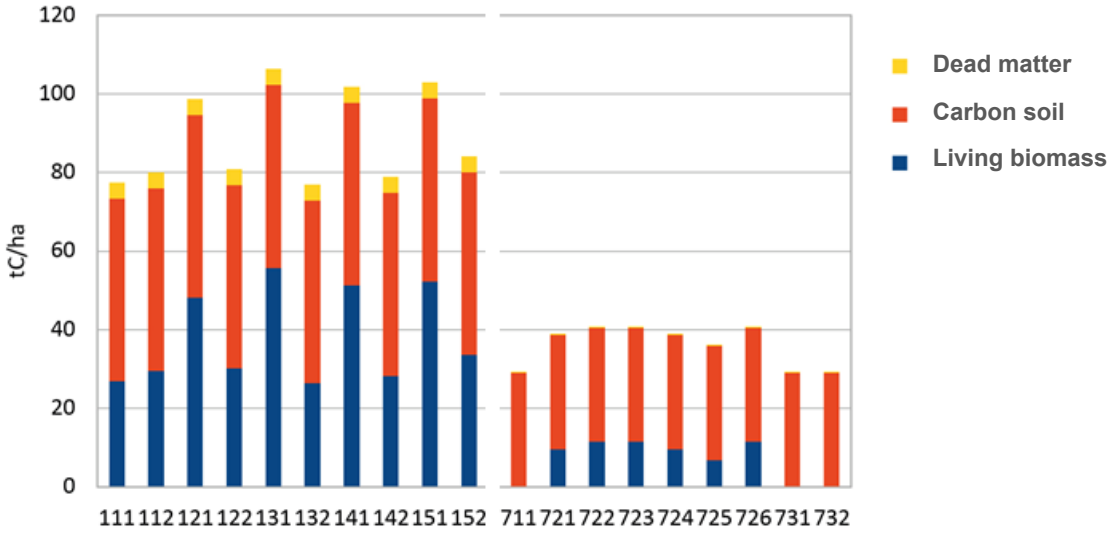


Figure 8.- Carbon storage (tC/ha) for Andalusian forests & agricultural ecosystems, according to the classification' level N3[12]

(Source: adapted by DGSACC based on the Ecosystem Services Study of Andalusia)

Dense deciduous forests (131) were the ecosystems that accumulated the most carbon per hectare among all the ecosystems considered, with a total carbon density value of 106,4tC/ha.

A similar service' valuation has been observed for dense forest crops (151), dense coniferous forests (141), and dense sclerophyllous Mediterranean forests (121), with biophysical density values around 100tC/ha (103, 102 and 99 tC/ha, respectively).

On the opposite end, and within the agricultural ecosystems, non-rice herbaceous crops (731) and rice fields (732) had a total accumulated carbon that did not exceed 30tC/ha. However, it's important to note that these data should be interpreted appropriately because the total carbon value obtained in these ecosystems exclusively corresponds to the soil and dead organic matter reservoir, as there is no information available for the live biomass reservoir.

Regarding actual values, these have only been calculated for the portion corresponding to the live biomass of forested lands (data on carbon stock in live biomass from the RECAMAN project). Notable values are observed in the carbon stock in certain areas of the Cazorla, Segura and Las Villas Natural Parks, as well as in Castril, Alcornocales, Grazalema, Sierra de las Nieves, and Sierra Bermeja, in the Montes de Málaga, in the pine forests of Doñana, its surroundings, and the western coastal area of Huelva and in specific sectors of Sierra Morena (dense replanted pine forests). All of these areas correspond to dense and mature forest formations dominated by pine trees, cork oaks, holm oaks, and fir trees.

[12] (111) Oak and other deciduous woodlands; (112) Other wooded pastures; (121) Dense sclerophyllous Mediterranean forests; (122) Sparse sclerophyllous Mediterranean forests; (131) Dense deciduous forests; (132) Sparse deciduous forests; (151) Dense forest crops and other tree plantations; (141) Dense coniferous forests; (142) Sparse coniferous forests; (151) Dense forest crops and other tree plantations; (152) Sparse forest crops and other tree plantations; (711) Ecological value agricultural mosaics; (721) Olive groves; (722) Citrus; (723) Tropical crops; (724) Nut orchards; (725) Vineyards; (726) Other woody crops; (731) Non-rice herbaceous crops; (732) Rice fields.

Conclusions

Forests (1) are the ecosystems that accumulate the most carbon in Andalusia, with a stock of 196.403.848,40tC, followed by **agricultural ecosystems (7)** with a value of 122.883.343,41tC.

These results are predictable given the accumulated carbon density and the land area occupied by these ecosystems in Andalusia as a whole: Forests (1) with 88,8tC/ha (average value) and 29% of the land area; and agricultural ecosystems (2) with 36 C/ha (average value) and covering over 44% of the land area.

Within forests (1), Wooded Grasslands (11) stood out with 88,5MtC, followed by Forest Crops & other Tree Plantations (15) with 53,6MtC, and sclerophyllous Mediterranean forests (12) with 43,2MtC (Table 1). However, dense deciduous forests (131) were the ecosystems that provided the highest value of the climate regulation service in terms of tC/ha of all the considered ecosystems, with a total carbon density value of 106,4tC/ha. Equivalent values were obtained for dense forest crops (151), dense coniferous forests (141), and dense sclerophyllous Mediterranean forests (121), with biophysical density values around 100tC/ha (Figure 8).

Among agricultural ecosystems (7), the highest carbon accumulations were found in Woody Crops (72) with 76,9MtC. The influence of the land area on the calculation of accumulated carbon stock is more evident in agricultural ecosystems, which are widely distributed in Andalusia (covering over 44% of the land area). Thus, woody crops with a value of accumulated carbon density of 39,4tC/ha, but with a land area of 24,6ha, logically have the highest accumulated carbon in Andalusia within this category.

Therefore, from the perspective and relevance of carbon storage, **forests and agricultural ecosystems** are ideal ecosystems for the development of carbon **sequestration projects** to offset GHG emissions in the region of Andalusia, serving as a financing formula for the conservation and/or restoration of these types of ecosystems. Additionally, it is worth noting that agricultural ecosystems are a significant part of the strategic economic activities for our region as they are linked to the primary sector (agriculture).

5.2 Carbon capture and storage (carbon sequestration) by marine phanerogams and marshes ecosystems

Assessment methodology

For the assessment of this service, a biophysical approximation methodology has been used, specifically a methodology based on the use of CO_2 density data (indirect measurements). For the stock in marshes and estuaries, the average stock value for these ecosystems has been calculated. In the case of seagrass, the real value has been calculated as a preliminary step to the calculation of the reference value.

Information sources

- Carbon stock data (density values, tCO_2/ha) for seagrass ecosystems and total carbon stock (tCO_2/ha) for marshes/salt marshes/estuaries ecosystems were sourced from the following references:
  - Carbon stocks and fluxes associated to andalusian seagrasses: variability and effects of meadow degradation and recolonization. Miguel Ángel Mateo Mínguez Elena Díaz-Almela Nerea Piñeiro-Juncal Carmen Leiva Dueñas Santiago Giralt Romeu Candela Marco Méndez. 2019. LIFE BLUE NATURA; and
  - Carbon stocks and fluxes associated to andalusian saltmarshes. Elena Díaz-Almela, Nerea Piñeiro-Juncal, Candela Marco-Méndez, Santiago Giralt, Carmen Leiva-Dueñas, Miguel Ángel Mateo (Coordinator). 2019. LIFE BLUE NATURA.
- Integrated mapping of seagrass ecosystems in Andalusia. Sustainable Management Programme for the Marine Environment (Programa de gestión sostenible del medio marino). Consejería de Agricultura, Pesca y Desarollo Sostenible. 2020.
- Mapping of Tidal Marshes in Bay of Cádiz and Odiel Marshes was sourced from the project LIFE BLUE NATURA. 2019; and
- Ecosystem mapping of Andalusia. 2019. Regional Environmental Information Network (REDIAM). Junta de Andalucía.

Results

The results obtained regarding carbon storage for Andalusian marine ecosystems ($tC0_2$) are shown in Figure 9:

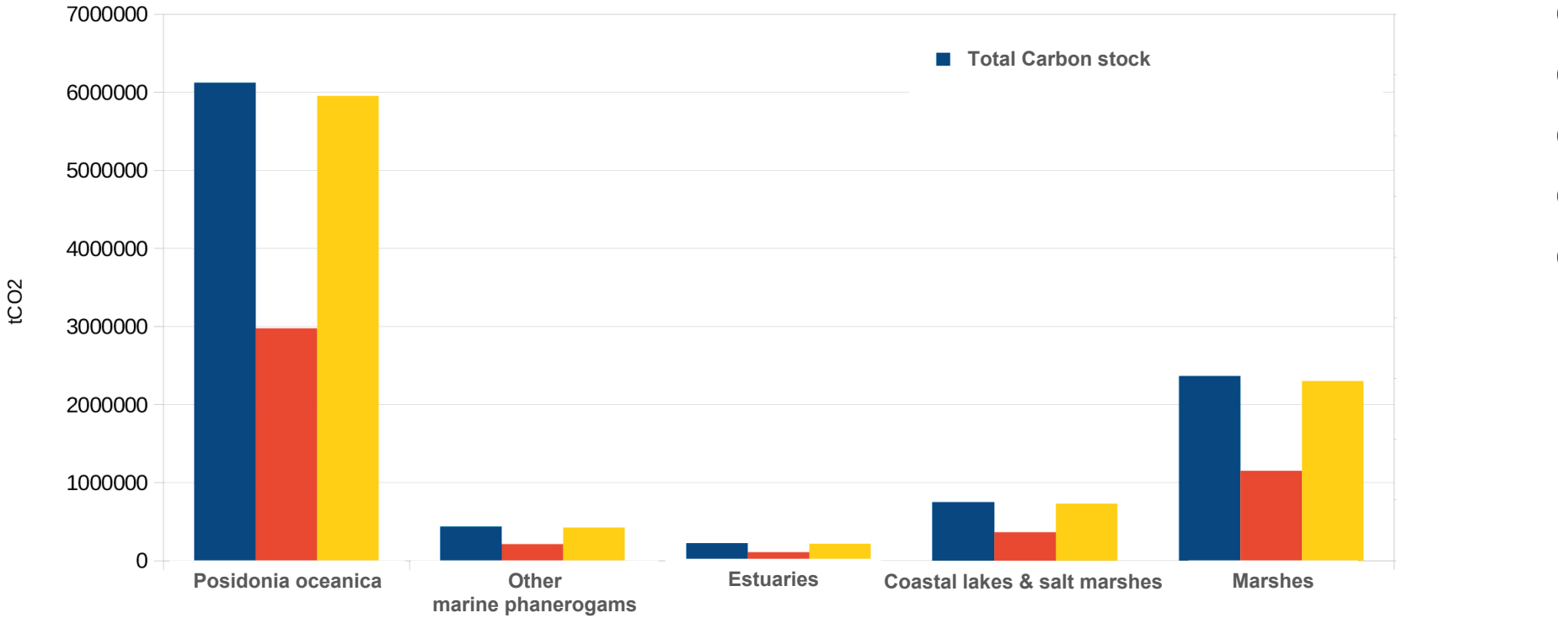


Figure 9.- Carbon storage ($tC0_2$) for Andalusian marine ecosystems

(Source: adapted by DGSACC based on the Ecosystem Services Study of Andalusia)

Posidonia oceanica seagrass meadows were the ecosystems that accumulated the most carbon per hectare among all the considered ecosystems, with a total carbon density value of 862,9t CO_2/ha. In 2nd place, among the marine and/or marine-influenced ecosystems, we find the **tidal marshes**, with density values around 337,8tCO_2/ha.

Regarding the *geographical distribution*, as shown in the results of the of Ecosystem Services Study of Andalusia, the values achieved by Posidonia oceanica seagrass meadows stand out along the entire coastline of Almería, particularly in Cabo de Gata-Níjar Natural Park, in the eastern part of the Poniente region, and in the border area of the Levante of Almería with the region of Murcia. Equally noteworthy are the values found in other specific areas such as Castell de Ferro, Nerja, or Calahonda, in Marbella.

In contrast, ecosystems formed by other marine phanerogams had a total accumulated carbon that did not exceed 94tCO_2/ha (Figure 11). Coastal lagoons and salt marsh ecosystems, as well as estuaries, occupied an intermediate position with values that did not exceed 165 and 257tCO_2/ha, respectively (Figure 10).

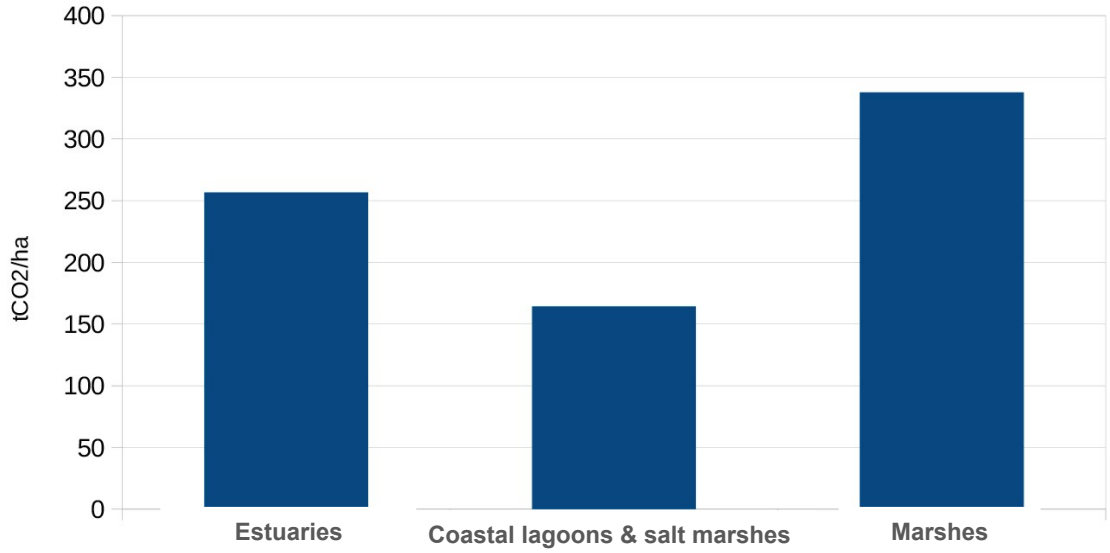


Figure 10.- Carbon storage (tC0$_2$/ha) for estuaries, coastal lagoons, salt marshes and marshes

(Source: adapted by DGSACC based on the Ecosystem Services Study of Andalusia)

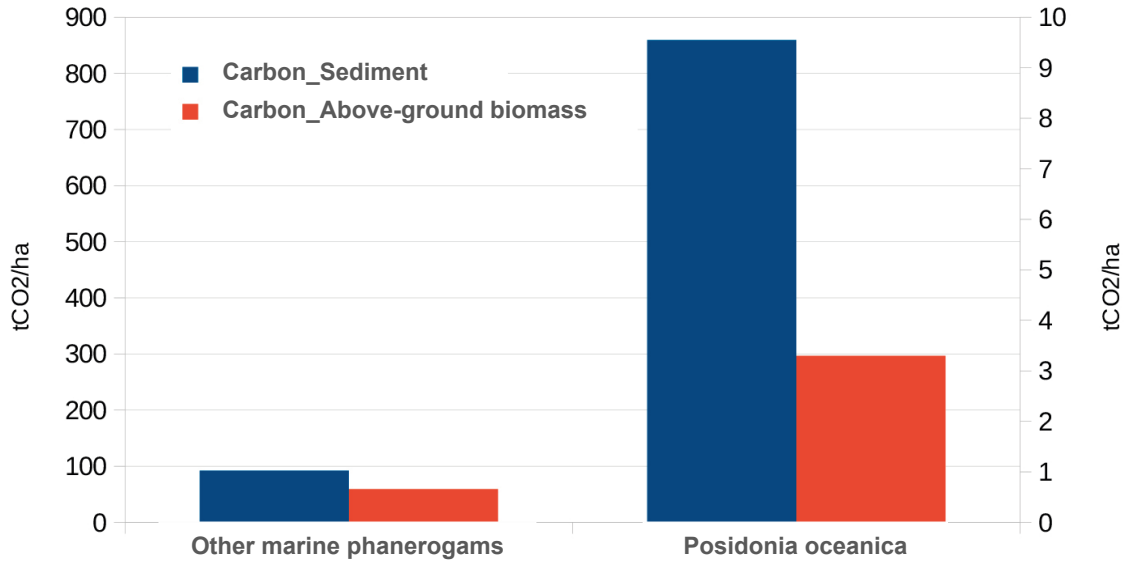


Figure 11.- Carbon storage ($tC0_2$/ha) for other marine phanerogams & Posidonia

(Source: adapted by DGSACC based on the Ecosystem Services Study of Andalusia)

Conclusions

Seagrass meadows of Posidonia oceanica are the marine ecosystems that accumulate the most carbon in Andalusia, with a stock of 6.123.506tCO_2, followed by **salt marsh ecosystems** with a value of 2.366.664tCO_2.

These results are predictable given the accumulated carbon density and the land area occupied by these ecosystems in the entirety of Andalusia: Posidonia oceanica seagrass meadows with 862,9t CO_2/ha (average value) and covering 29% of the land area, and marshes with 337,8tCO_2/ha (average value) and covering 28,9% of the land area.

Posidonia oceanica seagrass meadows are the ecosystems that provide the highest value of the climate regulation service in terms of blue carbon accumulated per hectare among all the considered ecosystems. The sediment carbon reservoir accounted for over 99% of the total accumulated carbon.

From the perspective and relevance of carbon storage, **Posidonia oceanica seagrass meadows and tidal marshes** are ideal ecosystems for the development of blue carbon sequestration projects under the **Andalusian Carbon Standard for the Certification of Blue Carbon Credits**. The development of this standard has been innovative in Andalusia and has allowed the creation of methodologies to estimate the tons of carbon that will be captured by these sequestration projects before their implementation. Thus, the implementation of blue carbon projects to offset GHG emissions is established as a financing formula for the conservation/restoration of these crucial habitats in Andalusia.

Finally, the Table 3 below provides, for each of the carbon sinks analysed in this Situational Study, the results of CO_2 capture and storage by terrestrial vegetation (forests and agricultural ecosystems) and by seagrasses and marshes ecosystems,

along with their main characteristics and their **location** on the map of Andalusia based on mapping developed by CSMAEA.

Table 3.- Mapping on Carbon Sinks in Andalusia (Spain)

(Source: prepared by DGMASCC based on the Report of Ecosystem Services in Andalusia)

ID	Ecos. N2	Type of aera	Location	Type of project	Source of Carbon	Main characteristics of the Carbon sinks	Status	Tn CO_2 captured or emitted by sink
1	11	Wooded Grasslands	Annexes from 1 to 6	Forest	Green Carbon	Wooded areas dominated by grassland, including grazed formations	In explotation	88.511.215,65
2	12	Mediterranean Sclerophyllous Forests		Forest	Green Carbon	Wooded formations of tree species with small, hard, and leathery leaves adapted to the Mediterranean dry climate	In explotation	43.238.916,74
3	13	Mediterranean Sclerophyllous Forests		Forest	Green Carbon	Wooded formations of tree species that shed their leaves annually	In explotation	2.972.128,72
4	14	Coniferous Forests		Forest	Green Carbon	Wooded formations of coniferous trees (gymnosperms with straight trunks and needle-like or scale-like evergreen leaves)	In explotation	8.035.243,64
5	15	Forest Crops & other Tree Plantations		Forest	Green Carbon	Wooded plantation areas, whether they have a short or long growth cycle or are reforested, where the planting framework is still visible, regardless of whether they are within or outside their distribution area	In explotation	53.646.343,65

ID	Ecos. N2	Type of aera	Location	Type of project	Source of Carbon	Main characteristics of the Carbon sinks	Status	Tn CO_2 captured or emitted by sink
6	71	Agricultural Mosaics of Ecological Value		Agriculture	Sustainable practices on agriculture	Areas primarily used for agriculture, alternating with natural vegetation zones	Without explotation	11.058,17
7	72	Woody Crops		Agriculture	Sustainable practices on agriculture	Land designated for the cultivation of woody (tree or shrub) fruit species for consumption	Without explotation	76.912.976,48
8	73	Herbaceous Crops		Agriculture	Sustainable practices on agriculture	Land designated for the cultivation of herbaceous plant species for utilization	Without explotation	45.959.308,75
9	-	Posidonia oceanic seagrass meadows	Annexes from 7 to 14	Coastal areas	Blue Carbon	Endemic species of the Mediterranean Sea among marine angiosperms and are not found in any other sea worldwide. They can be found from the sea surface to depths of 30-40 meters, depending on water transparency	In explotation	6.123.506,00
10	-	Other marine phanerogams		Coastal areas	Blue Carbon	Group of plants included in the so-called higher or vascular plants, meaning they produce flowers, fruits and seeds, and develop underwater in the sea	Without explotation	556.792,00
11	-	Estuaries		Coastal areas	Blue Carbon	Ecosystems that form with the mixture of freshwater from rivers and saltwater from the sea, meaning they occur when river water flows into the sea, and thus, they are mixed ecosystems	Without explotation	225.000,00

ID	Ecos. N2	Type of aera	Location	Type of project	Source of Carbon	Main characteristics of the Carbon sinks	Status	Tn CO_2 captured or emitted by sink
12	-	Coastal lagoons / Salt marshes		Marshes	Blue Carbon	Open spaces of shallow brackish coastal waters with variable salinity and water volume, which may be entirely or partially separated from the sea by sandbanks, gravel, or, less frequently, rocks. Salinity can vary from brackish to hypersaline	Without explotation	700.000,00
13	-	Tidal Marshes		Marshes	Blue Carbon	Coastal ecosystem in the upper coastal intertidal zone between land and open saltwater or brackish water that is regularly flooded by tides. It is dominated by dense stands of salt-tolerant plants such as herbs, grasses, or low shrubs	In explotation	2.300.000,00

6. Conclusions

Recognizing the threat that climate change plays in our society, the Andalusian Regional Government has decided to take a proactive and leadership role at the regional level as a way for the region to contribute to the challenges of reducing GHG emissions and adapting to climate change, as set forth by international agreements. The roadmap encompasses a series of measures to be implemented by various areas of the Andalusian Regional Government.

For this reason, the fight against climate change, the implementation of measures to adapt to its effects, and the reduction of emissions have been, are, and will continue to be essential actions for the Andalusian Regional Government.

In 2018, the Andalusian Parliament approved **Law 8/2018**, of 8th October, on Measures to Address Climate Change and the Transition to a New Energy Model in Andalusia. The entry into force of this law marked a turning point in Andalusia, elevating to the highest legislative level all initiatives related to climate change up to that point. Since then, the Andalusian Regional Government has worked to develop the regulatory aspects of the law's mandates, with the **Andalusian Climate Action Plan 2021-2030 (PAAC)** being the general planning instrument for Andalusia region for combatting climate change.

With the approval of the PAAC in 2021, Andalusia became the 1st Spanish region to adopt planning in line with the National Law on Climate Change (Law 7/2021, of 20th May, on Climate Change and Energy Transition).

The PAAC is the planning tool for all climate change policies to be implemented by the Andalusian Regional Government in the next decade. Its mission is to integrate climate change into regional and local planning while aligning them with the plans of the Spanish Government, European Green Deal and Paris Agreement, contributing to the achievement of the Sustainable Development Goals set by the United Nations' 2030 Agenda.

The Law 8/2018 establishes the **Andalusian Emissions Offset System (SACE) registry** as a voluntary instrument for the reduction of GGH emissions and, if applicable, for the compensation.

Since then, the Andalusian Regional Government has launched various projects in response to the fight against climate change. In the context of voluntary GHG emissions offsetting, noteworthy initiatives and actions related to administrative simplification and flexibility of the regulatory and legal framework, expanding governance schemes, creating formulas for public-private collaboration, establishing safe certification standards, providing organizations with tools to assist in their voluntary climate change planning, launching awareness and dissemination actions, etc.

These and other **Good Practices** that have contributed the most to driving the development of GHG emissions offset projects in Andalusia are outlined in Table 1 of this Situational Study and will be made available to other European regions through the participation of DGSACC as the lead partner in the **Interreg Europe NACAO project**.

It should also be noted the participation of CSMAEA as a partner in the LIFE BLUE NATURA project with the aim of characterizing and mapping these habitats, calculating carbon stocks and flows within them and creating instruments (standards and offset projects) that allow the inclusion of tidal marsh and seagrass meadow conservation and restoration projects in the voluntary carbon market. Within the framework of this project, the **Andalusian Carbon Standard for the certification of blue carbon credits** was developed, ensuring maximum replicability on the international stage. This standard sets the requirements for verification, certification and auditing, as well as the criteria for a project to be considered a blue carbon sequestration initiative.

With this Standard for the ertification of blue carbon credits, Andalusia became the 1st region in Spain to approve a methodology for offsetting CO_2 emissions through blue carbon generation, also pioneering in Europe.

More recently, and in line with the CO_2 capture and storage capacity of ecosystems in Andalusia, it is worth mentioning the **Ecosystem Services Study of Andalusia** conducted by CSMAEA, which has been used as a reference for the carbon sink mapping of Andalusia included in Table 3 of this Situational Study.

An in-depth analysis of this Ecosystem Services Study of Andalusia leads to the conclusion that, on the one hand, **forests and agricultural ecosystems**, and on the other hand, **ecosystems composed of Posidonia oceanica seagrass meadows and tidal marshes ecosystems**, are ideal terrestrial and marine habitats for implementing carbon sequestration projects due to their (1) high carbon capture capacity, (2) extensive coverage in Andalusia, and (3) significance as a substantial part of the region's strategic economic activities.

The justification for these should be done by appropriately combining the carbon density values and the surface area occupied by each ecosystem.

Posidonia oceanica seagrass meadows were the ecosystems that accumulated the most carbon per hectare among all the considered ecosystems, with a total carbon density value of 862,9t CO_2/ha. In 2nd place the **tidal marshes**, with density values around 337,8tCO_2/ha. In the case of **Andalusian forests** the average value is 88,8 tC/ha covering the 29% of the analysed surface area while **Agricultural ecosystems** widely distributed, covering more than 44% of the considered land surface, with an average value of 36 tC/ha.

As a result, the implementation of these types of offsetting GHG emissions projects becomes a financing formula for the conservation and/or restoration of these vital habitats in Andalusia.

To continue promoting these types of actions that ensure the proper conservation and/or restoration of Andalusia's habitats, it is considered strategic by the DGSACC to continue developing carbon quantification methodologies for such projects in forests, agricultural ecosystems and coastal areas.

Currently, methodologies have been developed in Andalusia for Green and Blue Carbon, although methodologies for carbon farming practices are still in development.

The methodologies developed for Green Carbon include the restoration of burned areas and afforestation. The next strategic step for the Andalusian Regional Government could be the **development of sustainable forest management or pest control methodologies**, given the importance of forests in our region.

In the case of Blue Carbon, it is also considered strategic to **delve deeper into methodologies for such habitats, focusing on, for example, salt flats**, whilst Andalusia has over 1.100 kilometres of coastline. Its coastline is a significant part of the region's strategic economic activities, being linked to both the primary sector and the tertiary sector (tourism). Therefore, the promotion of carbon sequestration projects as a financing method for the conservation/restoration of these habitats would contribute to the growth of the region's blue economy.

The development and consolidation of these methodologies is included in the planning of DGSACC and it will be carried out through the Andalusian Climate Change Office (OACC).

CSMAEA aims to continue promoting GHG emissions offset projects across both the public and private sectors. These projects serve to combat climate change, preserve Andalusian biodiversity and stimulate economic development in the areas where they are implemented.

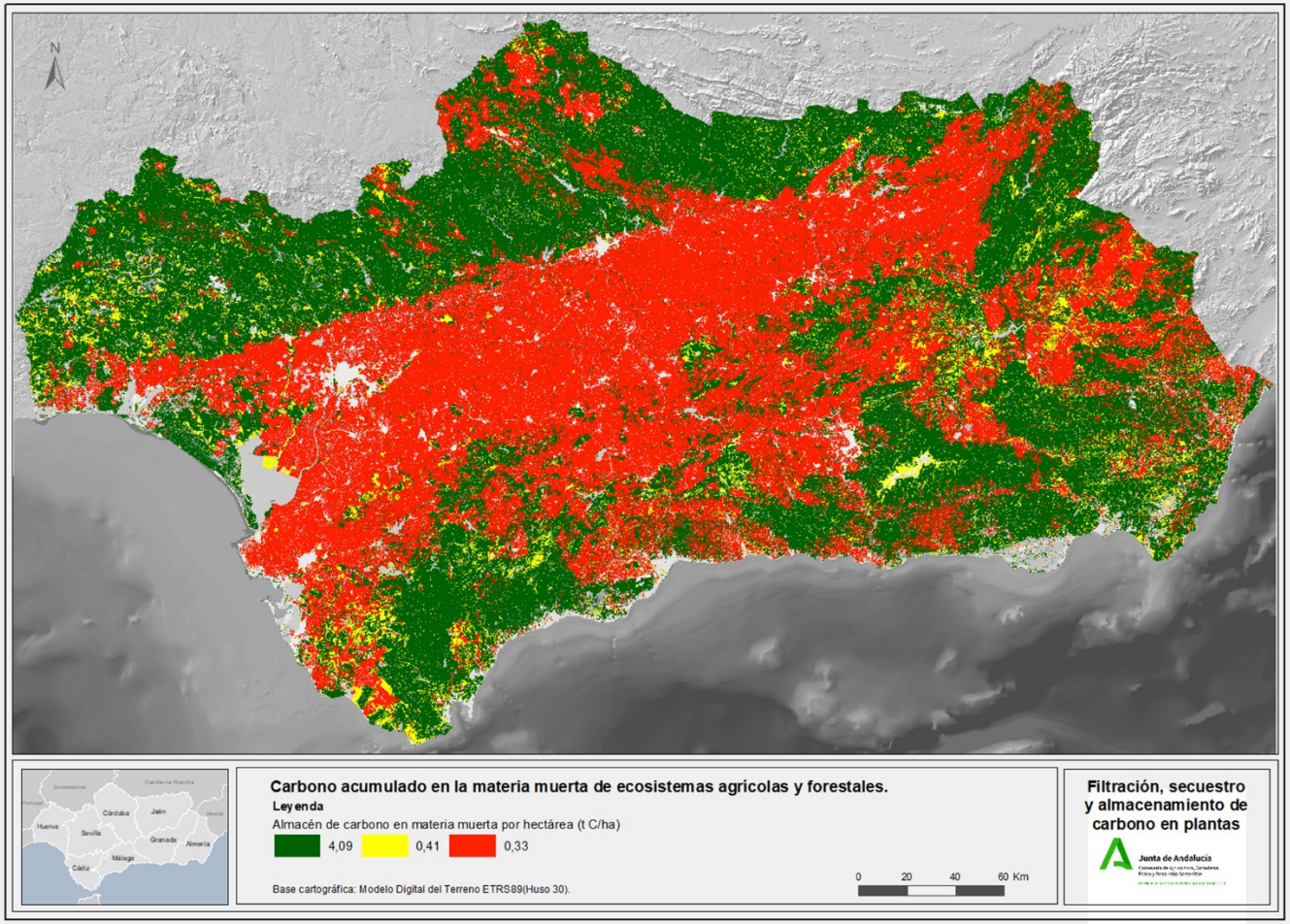
7. Bibliographic references

- Law 8/2018, of 8th October, on measures against climate change and for the transition towards a new energy model in Andalusia
- Decree 234/2021, 13th October, approving the Andalusian Climate Action Plan 2021-2030 (PAAC)
- Law 7/2021, of 20th May, on Climate Change and Energy Transition
- Andalusian portal for Climate Change
- Andalusian Carbon Standard for the certification of blue carbon credit
- Ecosystem Services Study in Andalusia
- RECAMAN project
- LIFE BLUE NATURA project
- Carbon stocks and fluxes associated to andalusian seagrasses: variability and effects of meadow degradation and recolonization. Miguel Ángel Mateo Mínguez Elena Díaz-Almela Nerea Piñeiro-Juncal Carmen Leiva Dueñas Santiago Giralt Romeu Candela Marco Méndez. 2019
- Carbon stocks and fluxes associated to andalusian saltmarshes. Elena Díaz-Almela, Nerea Piñeiro-Juncal, Candela Marco-Méndez, Santiago Giralt, Carmen Leiva-Dueñas, Miguel Ángel Mateo (Coordinator). 2019

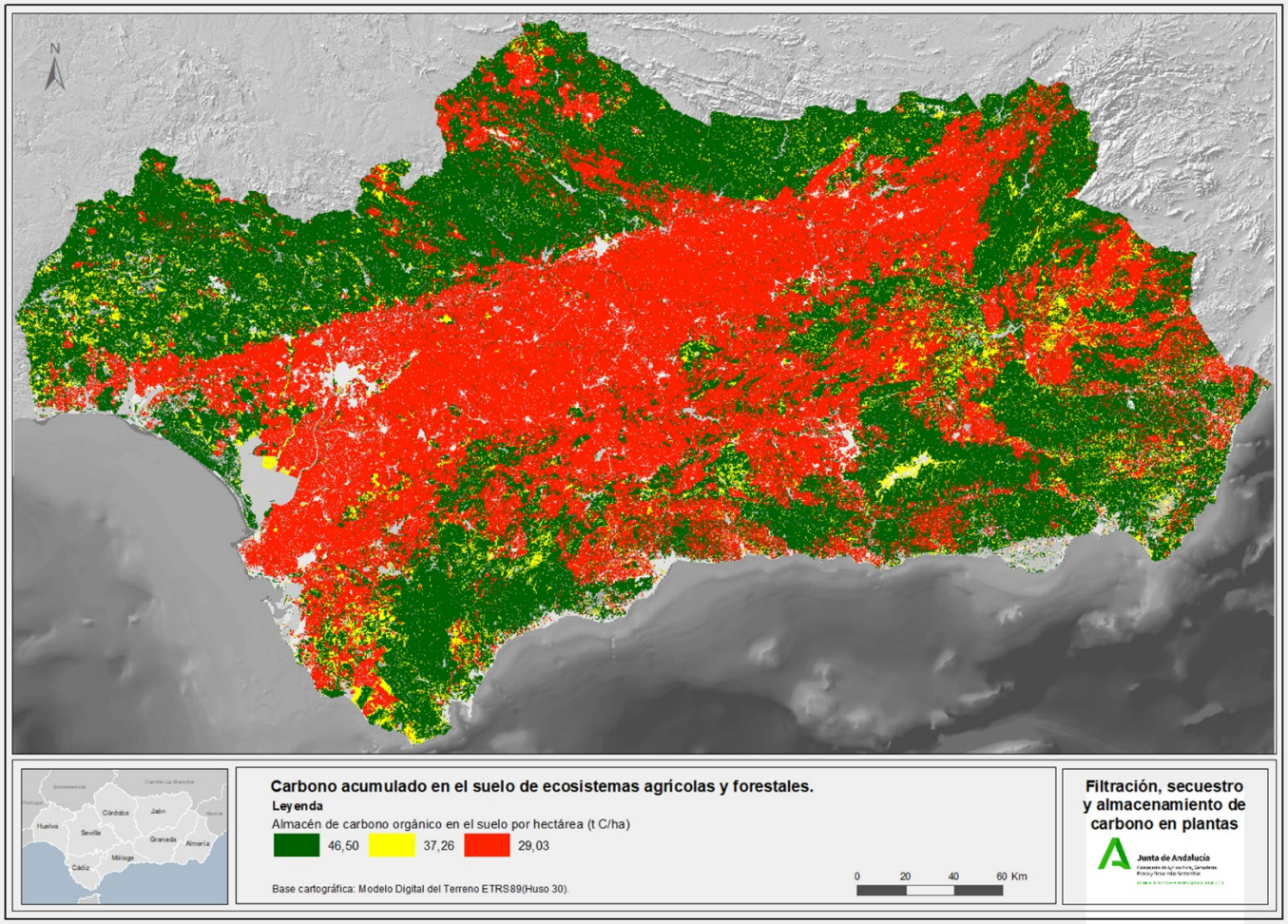
- Integrated mapping of seagrass ecosystems in Andalusia. Sustainable Management Programme for the Marine Environment (Programa de gestión sostenible del medio marino). Consejería de Agricultura, Pesca y Desarollo Sostenible. 2020
- Mapping of Tidal Marshes in Bay of Cádiz and Odiel Marshes was sourced from the project LIFE BLUE NATURA. 2019
- Ecosystem mapping of Andalusia. Regional Environmental Information Network (REDIAM). Junta de Andalucía. 2019

8. Annexes

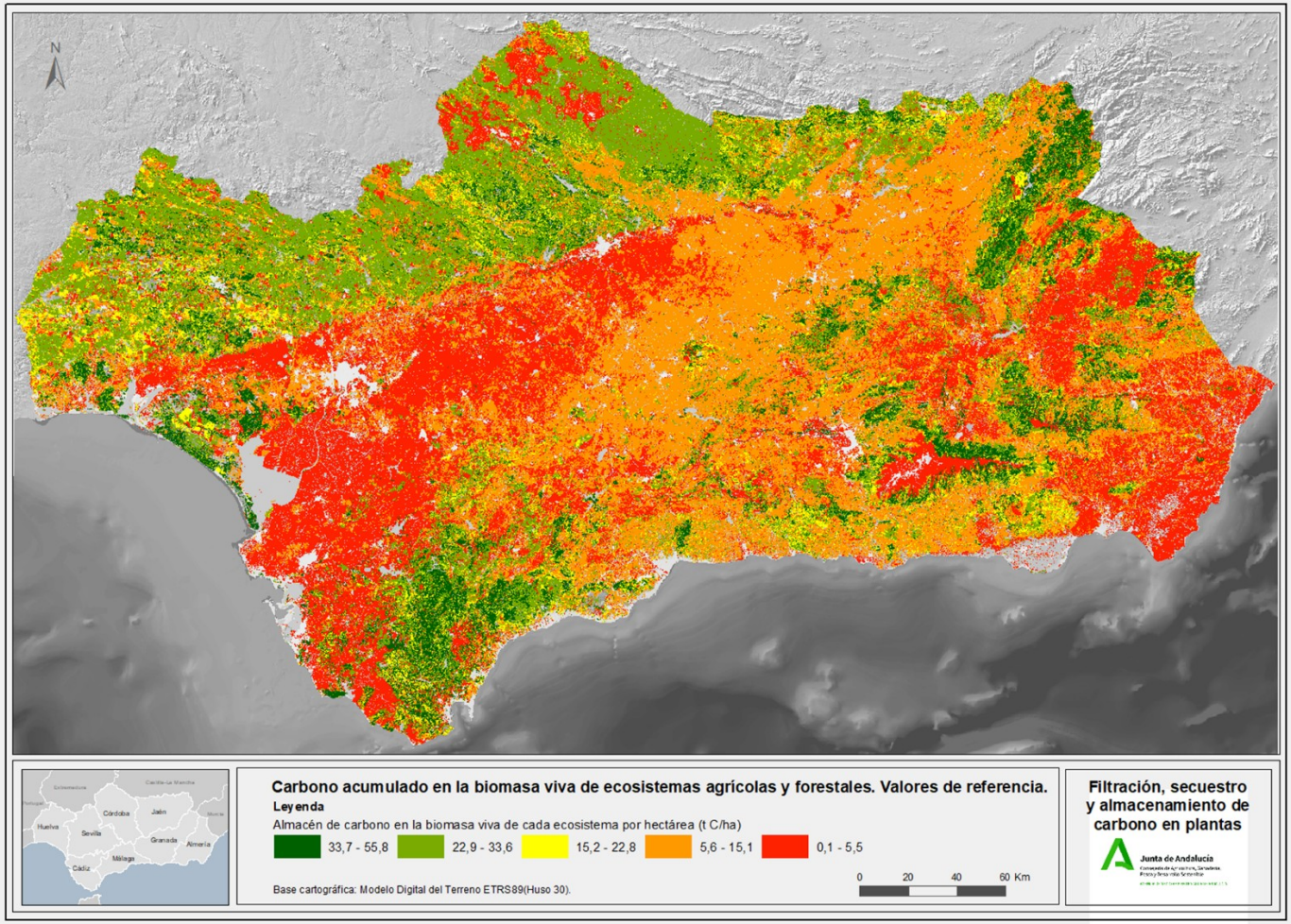
Annex 1. Carbon stock accumulated in dead organic matter in Agricultural & Forest ecosystems



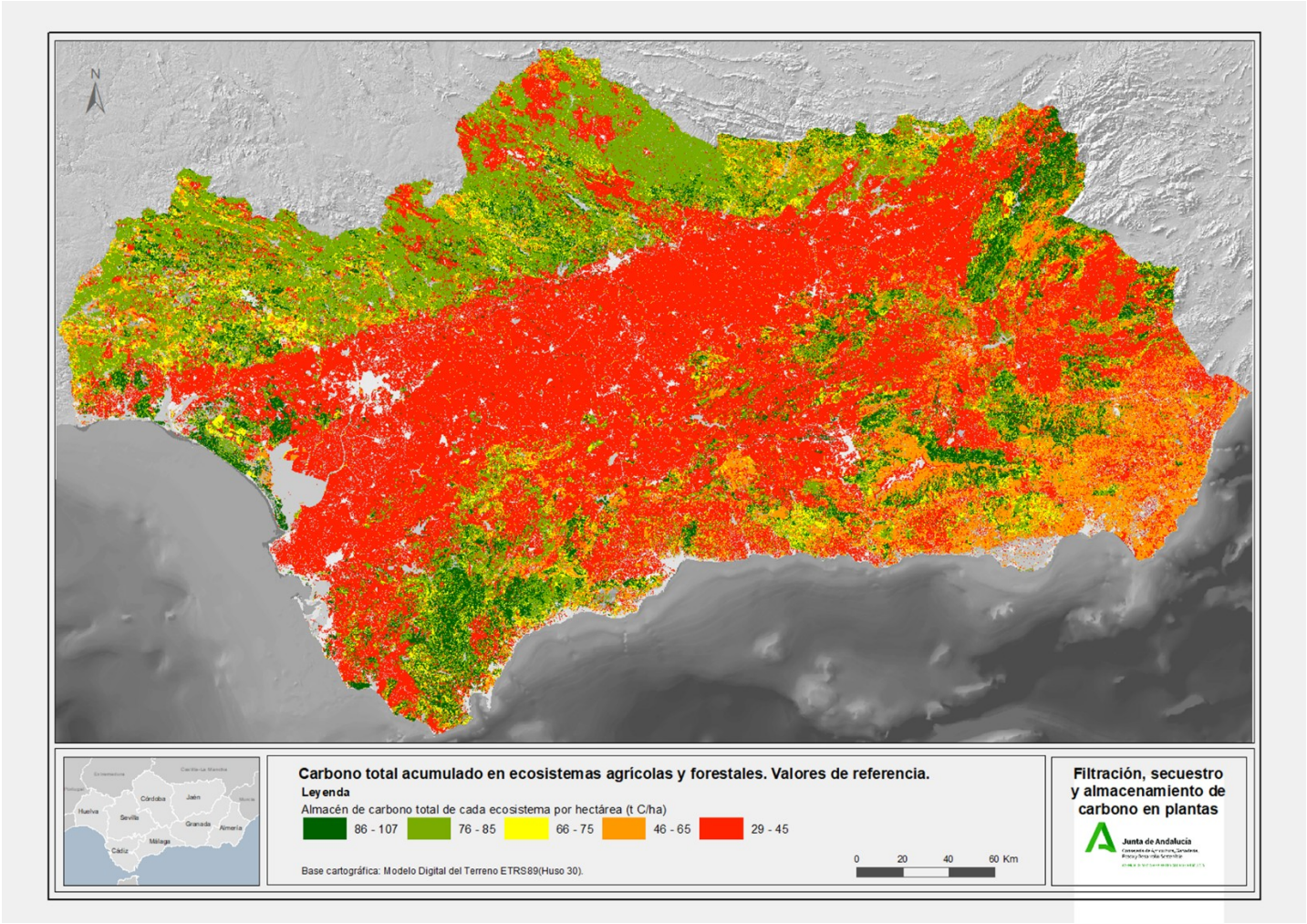
Annex 2. Carbon stock accumulated in soil in Agricultural & Forest ecosystems



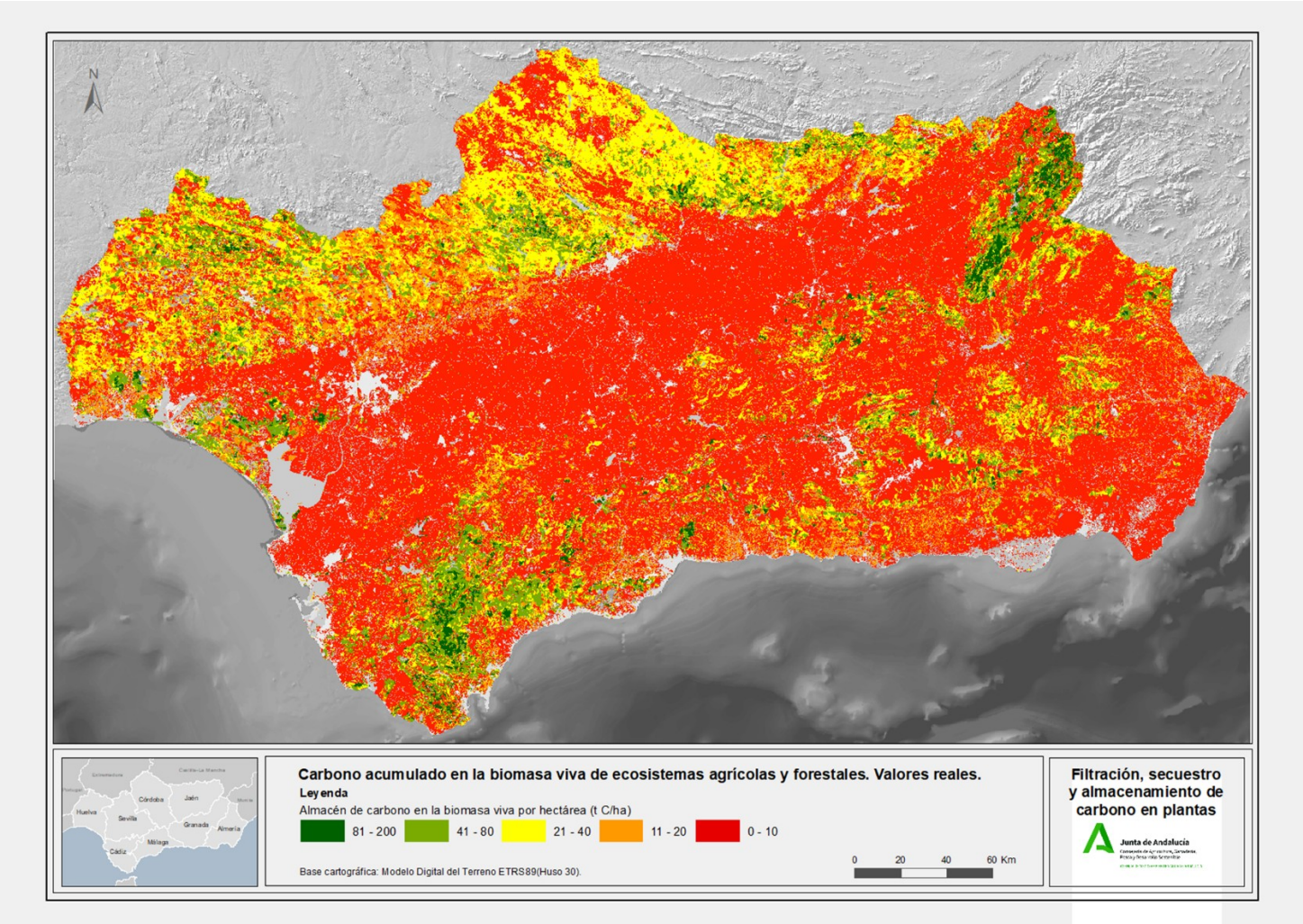
Annex 3. Carbon stock accumulated in living biomass in Agricultural & Forest ecosystems. Reference values



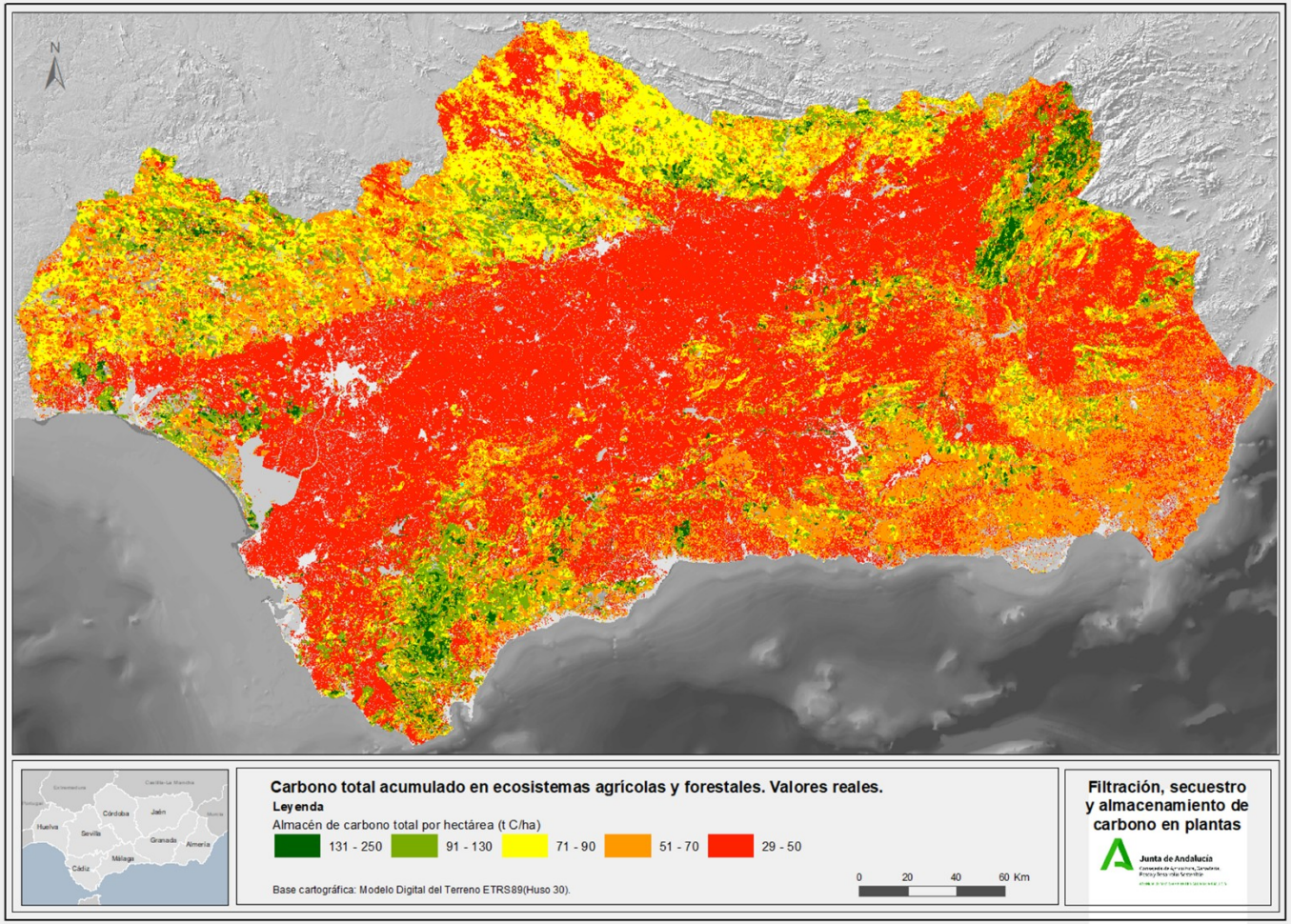
Annex 4. Total Carbon stock accumulated in Agricultural & Forest ecosystems. Reference values



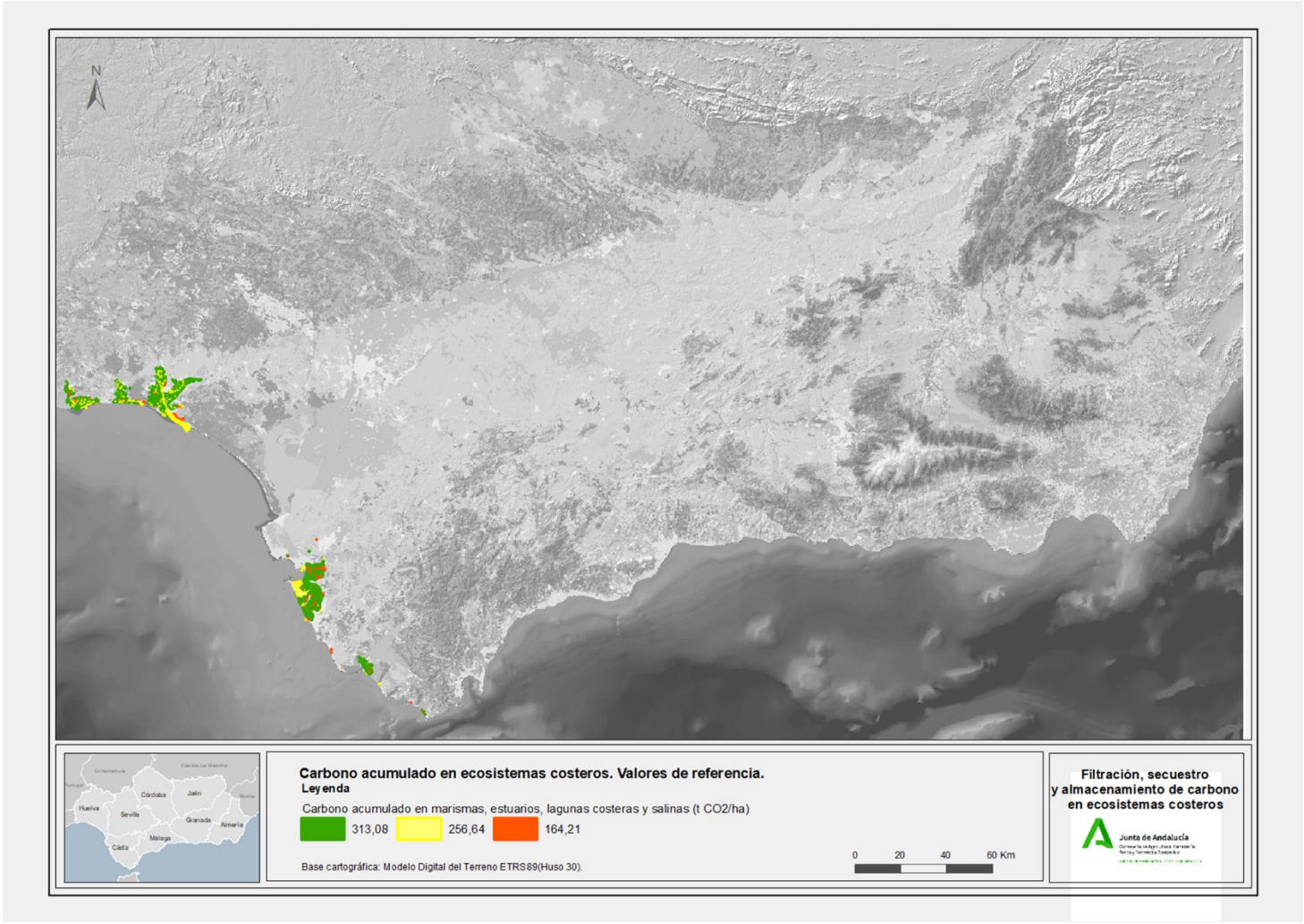
Annex 5. Carbon stock accumulated in living biomass in Agricultural & Forest ecosystems. Real values



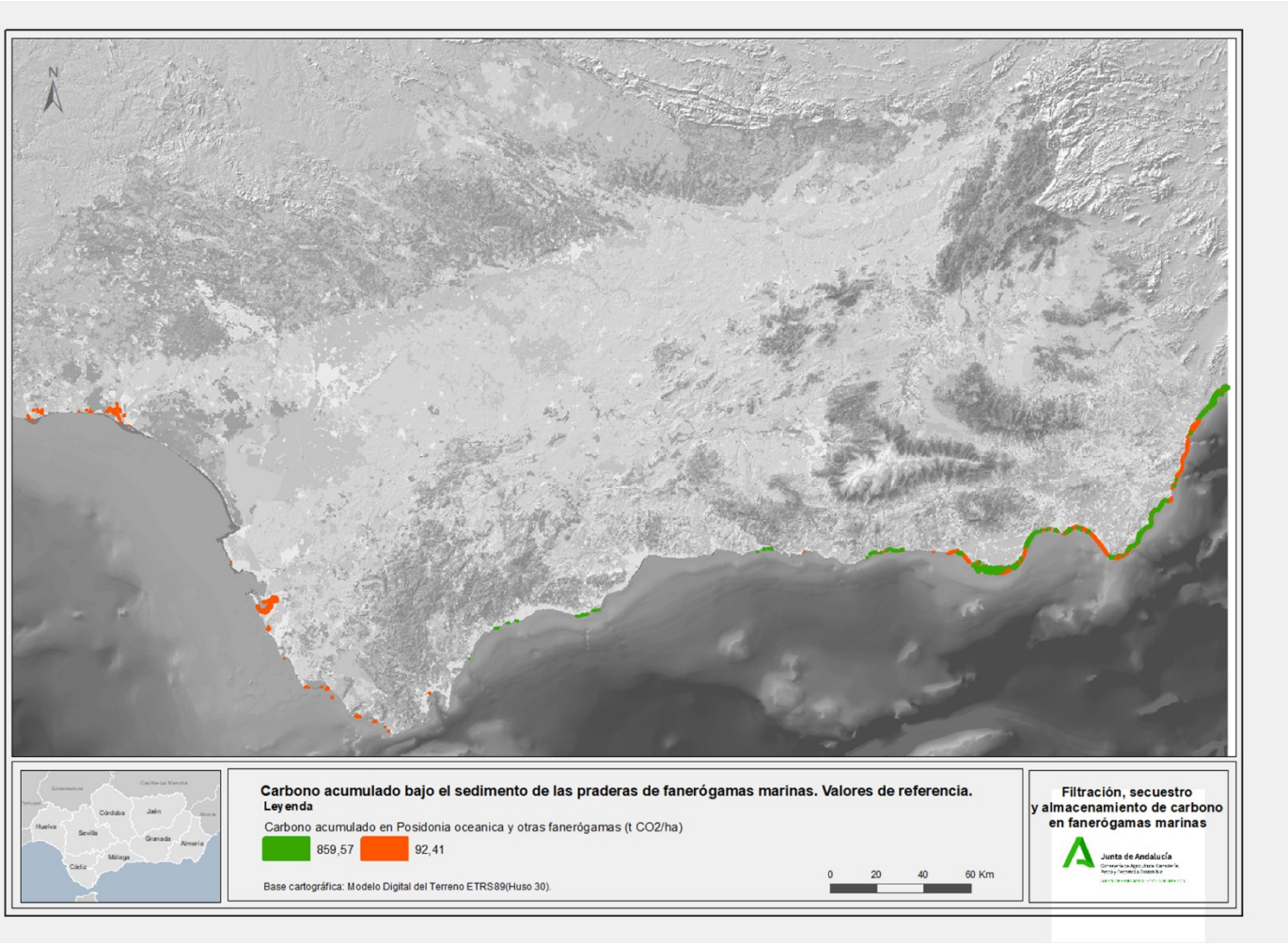
Annex 6. Carbon stock accumulated in Agricultural & Forest ecosystems. Real values



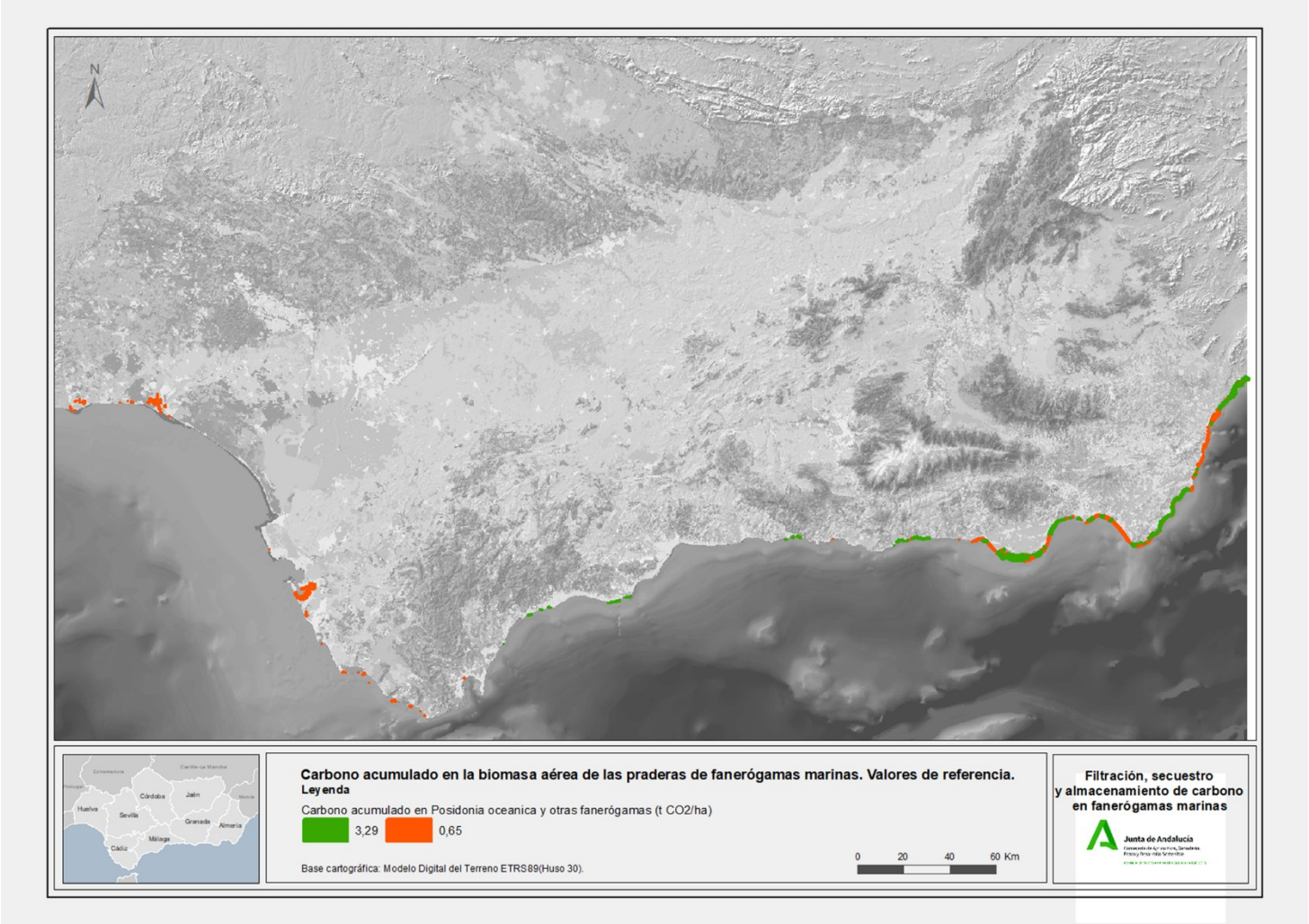
Annex 7.- Total Carbon stock accumulated in Coastal Ecosystems. Reference values



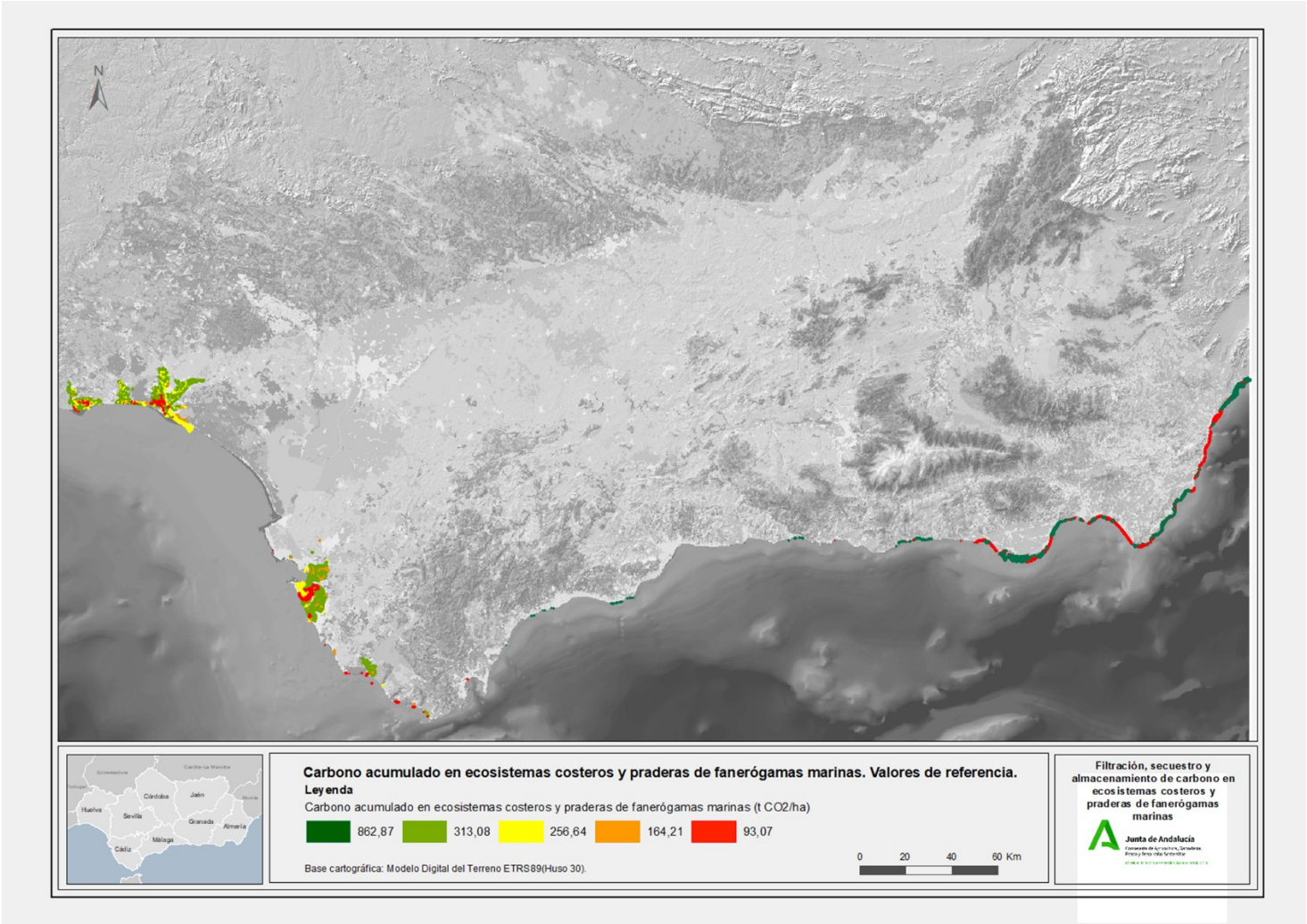
Annex 8. Carbon stock accumulated below sediment in Seagrass meadows. Reference values



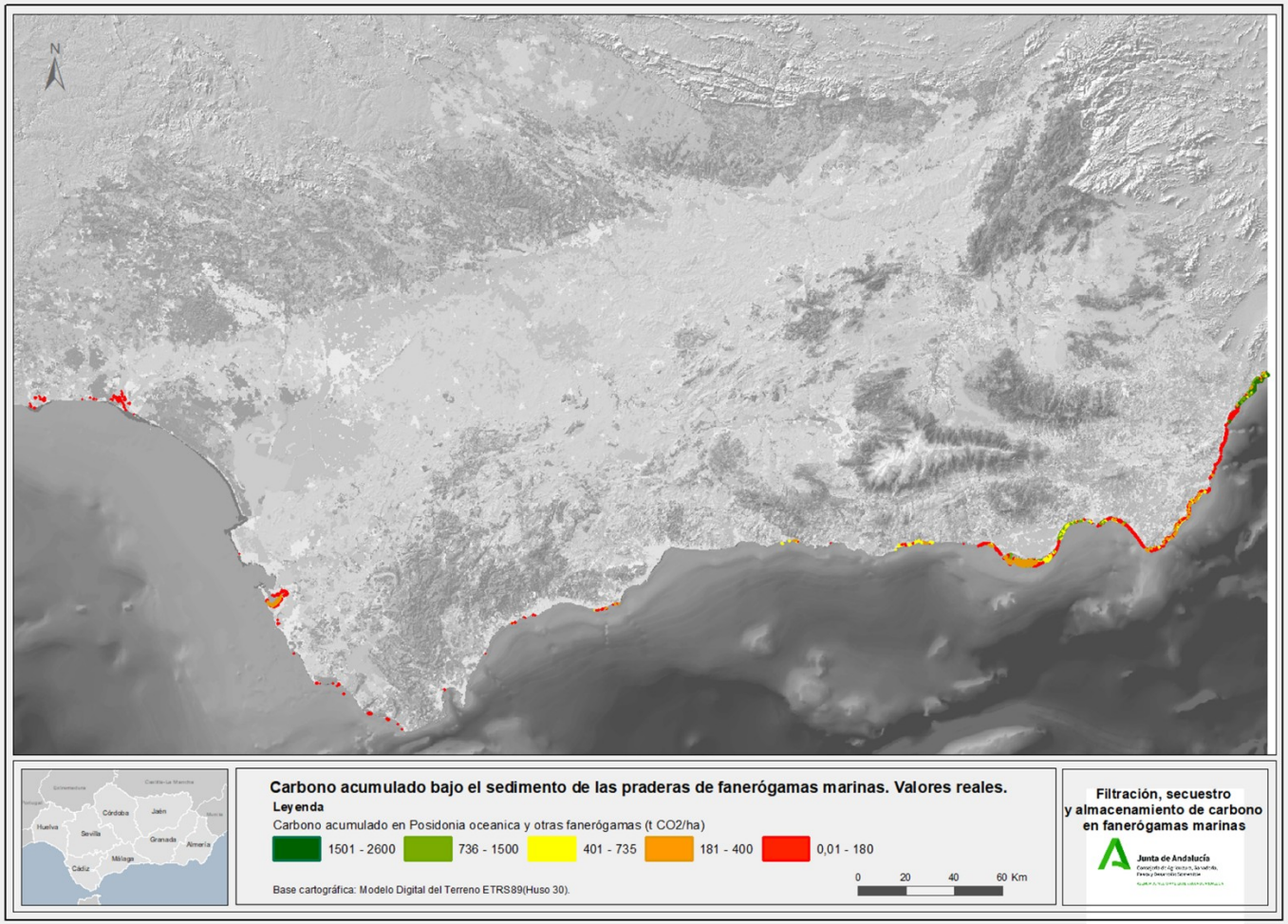
Annex 9. Carbon stock accumulated in above-ground biomass in Seagrass meadows. Reference values



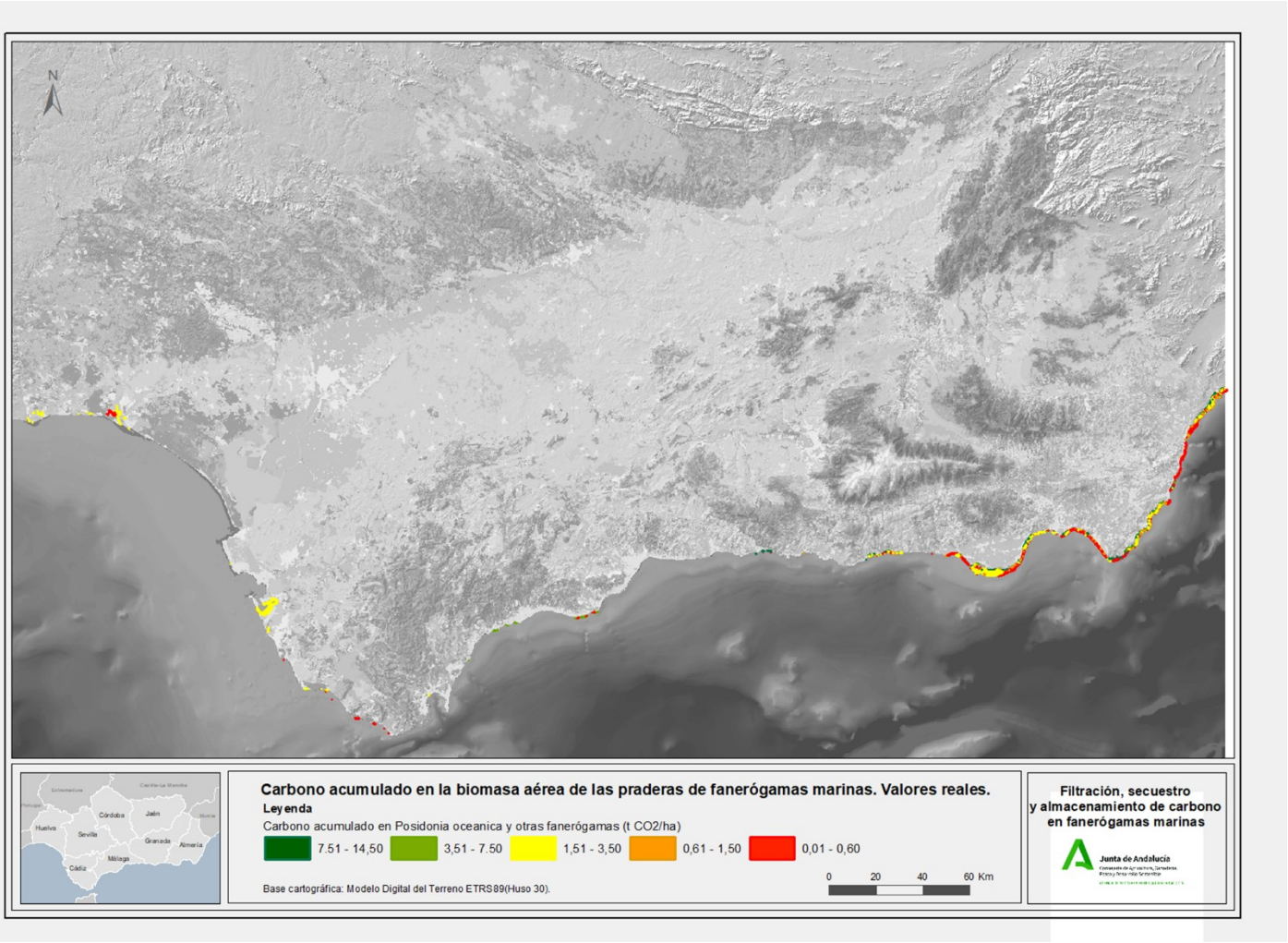
Annex 10. Total Carbon stock accumulated in Coastal Ecosystems & Seagrass meadows. Reference values



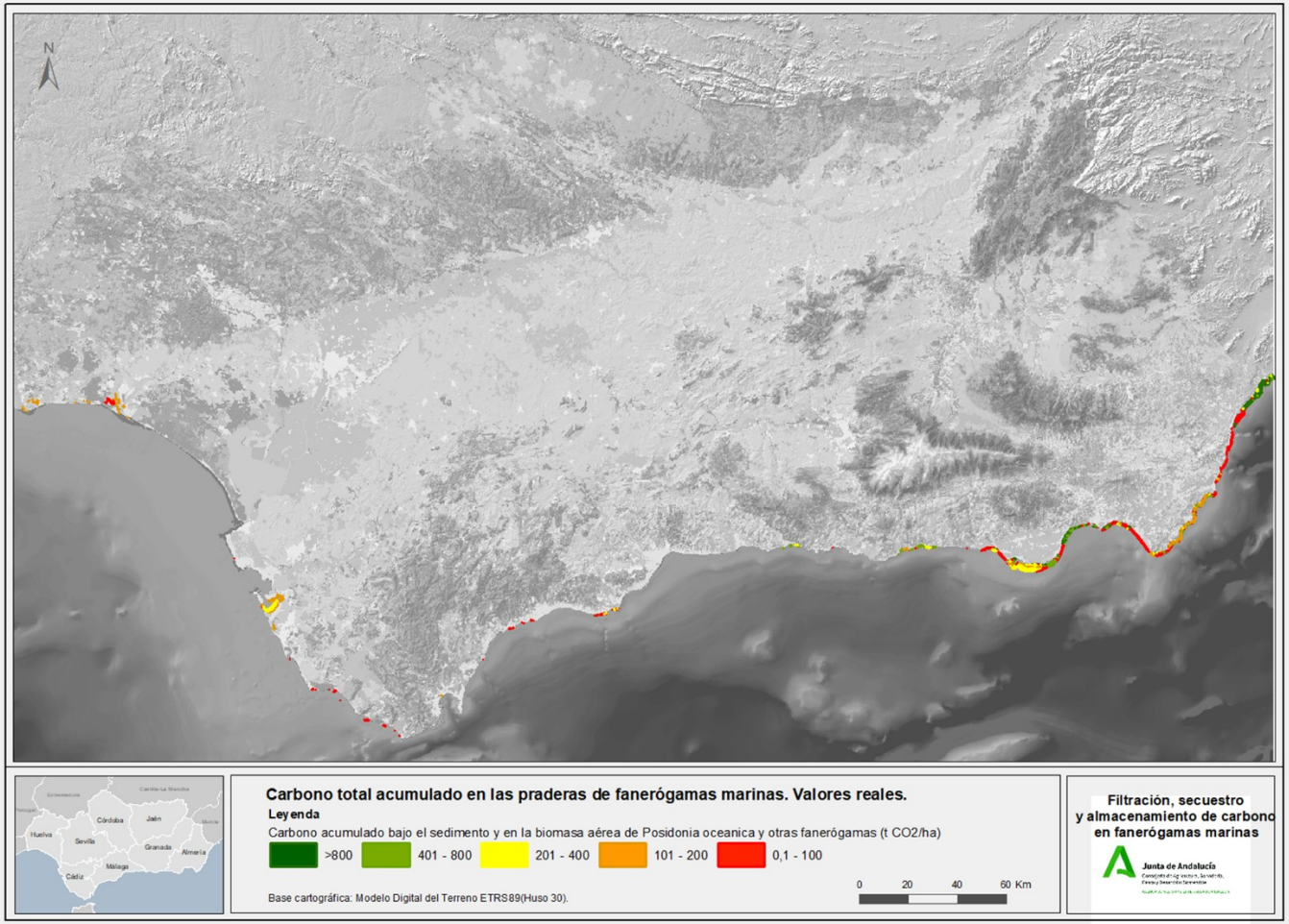
Annex 11. Carbon stock accumulated below sediment in Seagrass meadows. Real values



Annex 12. Carbon stock accumulated in above-ground biomass in Seagrass meadows. Real values



Annex 13. Carbon stock accumulated in Seagrass meadows. Real values



Annex 14. Total Carbon stock accumulated in Seagrass meadows. Reference values