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D 1.3.1 - CO2 Pacman datasets and tool

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Abbrevations

CF	Carbon Footprint
GHG(s)	Greenhouse Gas(ses)
SDG	Sustainable development Goal
NGO	Non-governmental organisation
IPCC	Intergovernmental Panel on Climate Change
IMF	International Monetary Fund

Executive summary

This key deliverable D1.3.1 focuses on data collection and scenario preparation for the three islands involved in the CO2 PACMAN project. The document aims to describe the methodology and provide a foundation for Activity 1.4: Preparing scenarios for climate neutrality of target Islands and developing the CO2 PACMAN tool. This tool relies on the aggregated data about the islands that must be trustworthy, accurate, and mutually complementary. Additionally, this deliverable also serves as a reference for future replication activities, enabling users and members from all relevant parties to access the methods for data collection, categories introduced and used, as well as the number and quantity of data. This document can be helpful in replicating CO2 PACMAN work in their own island communities.

1. Introduction

The primary goal of the CO2 PACMAN project is to provide guidance towards climate neutrality for the Mediterranean islands. To achieve this goal, a comprehensive set of project activities has been developed using a multifaceted approach. First, to calculate the baseline emissions of the three pilot islands by compiling the respective greenhouse gas inventories. Second, to develop the CO2 PACMAN tool (explained further in Deliverable 1.4) and define and calculate different decarbonisation strategies and policies to reach climate neutrality. Gaining an initial, in-depth understanding of life and environment conditions on the Mediterranean islands is a crucial first step before developing tools and activities.

Generating a baseline assessment is essential for any scenario development or modeling activities, since it replicates reality, enables validation with the available information, and reduces ambiguities and uncertainties. Furthermore, using the most recent and accurate data sources improves the modelling work and results. It provides credibility to the developed scenarios and results, which is essential for publishing, especially when providing assessment tools for policymakers shaping future decisions.

This document describes the data collection methodology for the three islands, introduces relevant categories and data sources, and provides the required transparency behind the development of project activities. It also supports the methodology's replicability by clearly detailing the required data and the sources to be consulted to establish a participatory decarbonization process for islands.

2. Data Collection and Sources

Data collection in island settings often faces several obstacles, including limited institutional capacity, fragmented data ownership, inconsistent monitoring practices, and logistical difficulties due to small municipalities or remote locations. Additionally, data may be scarce, outdated, or gathered using methodologies that are not comparable across regions or timeframes. These challenges can undermine the ability to establish baselines, track progress, or conduct cross-island comparisons.

To comprehensively address the state of decarbonization in the Mediterranean islands, CO2 PACMAN has established methodology D1.1.1, which is based on international rules and standards, and involves local communities and policymakers to ease the process. The devised methodology addresses all relevant factors, the present issues, potential uncertainties, as well as the identified strengths and opportunities for synergistic actions. This methodology enables the consistent and transparent collection of data necessary for calculating the GHG balance baseline across all pilot islands, ensuring coherence and facilitating replication in other Mediterranean islands and beyond.

To address these issues, key considerations that must be accounted for during the data collection process were identified:

- The definition of critical data for the project activities: avoiding time and effort in providing irrelevant data.
- Temporal and spatial resolution: Balancing data granularity with feasibility and consistency.
- Local relevance and cultural context: Ensuring data reflects the socio-environmental realities of island communities.
- Data quality and reliability: Evaluating the credibility and accuracy of sources.
- Institutional coordination: Engaging with local governments, NGOs, and community stakeholders to access and validate data.

Addressing these factors enables the establishment of a robust methodological foundation for sustainable development assessments on islands.

2.1 Data sources

Centralized data collection relevant for the CO2 PACMAN activities is not available, neither for the individual island nor integrated for islands across the Mediterranean. While primary data collection is essential for capturing local specificity, it is expensive, time-consuming, and impractical for all required information.

Despite these challenges and the absence of previously established centralized data storage, the data required to calculate the GHG balance baseline for the three pilot islands was successfully collected through the organized CO2 PACMAN activities. This was done by implementing the methodology outlined in D1.1.1 and intensive stakeholder involvement during the Rooting Labs for all islands.

Secondary data includes existing information sourced from official records, research publications, and third-party databases, such as government reports, statistical censuses, environmental statistics, and economic reports. These sources play a crucial role in providing baseline information, supporting trend analysis, and aligning with the methodologies for data analysis. However, additional effort and consideration are needed to harmonize data for the use in the IPCC methodology and level the baseline across all three islands, since the present sources are not monolithic. They are provided by different countries, governments, and local administrations without a unified methodology. Only by harmonizing these diverse data sources using the IPCC methodology can a level playing field be set up.

Interaction with Local Stakeholders – CO2 PACMAN Rooting Labs

In the context of primary data use, input from local stakeholders is vital. While official sources provide structure and comparability, they may overlook nuances that are only visible at the community level. Engaging with local stakeholders adds depth, legitimacy, and contextual accuracy to data interpretation. With this in mind, the project activities were developed to include the first round of Living Labs, establishing contact with the relevant local stakeholders. Some project activities included the general island population, but the primary focus was on strengthening the connection with local entities from the categories described above, which significantly improved access to the needed data.

Official Government Sources

National government agencies and regional/local administrations are the most authoritative secondary data sources. They provide structured and often legally mandated datasets that serve as the backbone for sustainability metrics.

***Table 1**. Overview of the official governmental sources*

Source	Data Provided	Advantages	Disadvantages
National Statistical Offices	- Census data - Household surveys - Economic indicators - Labor statistics - Social development metrics	- Official - Accurate - Large-scale data	- Time gaps between surveys - Inconsistent timing across regions - Lacks granularity, spatial specificity, and fine categories for islands
Environmental Protection Agencies or Ministries	- Air and water quality - Biodiversity, land use - Emissions	- Regularly updated; aligned with international obligations	- Data is often aggregated at the national/regional level; limited island-specific data unless the island is large (e.g., Crete)
Ministries of Energy, Agriculture, and Infrastructure	- Energy consumption/production - Agriculture, land/resource use - Transport, utilities	- Comprehensive sectoral data	- Time gaps between surveys - Low granularity - Often not island-specific
Meteorological and Hydrological Services	- Long-term climate and weather data	- Crucial for climate change assessment and resilience planning	- Not explicitly listed, but may share similar spatial resolution limitations as above

These sources are typically structured, regularly updated, and adhere to national, European and international quality standards, making them a reliable foundation for sustainability assessments.

Public service providers

Public service providers vary in their legal statuses within the country and across the islands in focus, so the data that they manage also differs in quality and availability. For public entities, the regulations might be stricter on data accessibility. Still, for companies that provide public services, the guidelines might not be restrictive enough to ensure the wide availability of the required data. This is often the case with transportation (ferry) companies, water and electricity providers, although the experiences may vary from case to case. Good connections and relations with the officials can prove beneficial in obtaining the data sources in these situations.

Regional Data Repositories and Documents

Local and regional administrations have proven to be the best sources of relevant data for the islands since they are positioned at the intersection of the top-down governmental and international approach and their municipalities' actual lives and conditions. Additionally, local and regional administrations are bound by the national regulations to follow the implementation of the laws, which often implies the development of regional and local strategies, plans, and documents. Local governments are part of local life and are usually more involved in developing their communities. With the development and broader acceptance of European projects and funding mechanisms, local governments have accelerated their work on sustainability topics and introduced sustainability planning to align with European and national sustainability targets. This trend has significantly improved the availability of statistics and local action plans containing sustainability related data, making regional governments and their documents a crucial data source for the modelling and scenario analysis inputs. Additionally, the increase of digitalization is present at the governmental and local levels, significantly improving data access and availability.

International, Academic and Non-Governmental Sources

Data from international organizations and regional institutions is essential for comparative analysis and integration with global benchmarks. Entities such as the United Nations, European Union, World Bank, and IMF (International Monetary Fund) regularly provide macroeconomic data indicators and development information. Some offer comprehensive datasets covering a range of sustainability-related indicators, using generally accepted methodologies, and are especially relevant to the project's topic. Still, similar to the national census, the data comes with a limited spatial resolution.

Academic institutions, think tanks, and NGOs frequently produce high-quality research reports and project specific datasets, especially in areas such as ecosystem health, community resilience, and traditional knowledge. Although these datasets are often localized and project-specific, they provide depth and contextual understanding that complements official statistics.

NGOs and Civil Society Organizations: Local action groups can be particularly active in areas like conservation, sustainable livelihoods, agricultural and marine topics, where they may operate community-based monitoring programs or collect data through project evaluations. These data sources are extremely valuable as they provide in-depth insights into specific areas from the local community level. An added benefit is that their publications are often publicly available and accessible to the general public. On the other hand, potential downsides can be seen in the limited scope of analysing the topics, and the lack of a comprehensive overview.

2.2 Data harmonization across islands

Harmonizing data sources is critical for ensuring comparability and coherence across different islands and sustainability themes. This involves standardizing definitions, aligning measurement techniques with international frameworks (such as the IPCC Guidelines and UN SDG indicators), and employing interoperable data formats. Where possible, leveraging existing global and regional datasets should complement locally generated data to capture the full spectrum of sustainability challenges and achievements.

The project partners organized meetings and coordination activities on data harmonization across the islands. This ensured that the differences in population and island size were accounted for. Additionally, the importance of specific sectors on each island was reflected on the methodology (for example, agriculture on one island might not be as relevant or involve the same products as on other islands). Finally, although small, some historical and climate differences have been accounted for this way.

These considerations have been integrated into the data collection methodology to account for all the abovementioned obstacles.

3. Data repository

The collected data and the calculated results for all three islands are combined and published in the online data repository accessible to the general public. The users can freely access and use the data through the dedicated website, organized according to the FAIR principles and designed to ensure that data is Findable, Accessible, Interoperable, and Reusable. Under FAIR principles, each dataset includes a description of the data's content, origin, and format, indexed to support human and machine discovery. Data is made accessible through an open, standardized communication protocol that does not require authentication and authorization. To ensure interoperability, the data uses SI units for the appropriate indicators, and the calculation method is clearly described within the IPCC methodology used.

By reaching out to the most significant possible number of people and stakeholders, the intent is to create interest and foster real-life utilization of the data. The aim is to ensure the sustainability of the activities and the long-term storage of the gathered data after the project's implementation. Solutions for this will be sought through spin-off activities or the Green Living Areas mission collaboration.

The data repository can be accessed on the following link:
https://www.co2pacman.eu/data-repository.

4. Energy transition and landscape data

Renewable Energy Sources (RES) have lower energy density compared to the fossil fuels (installable power capacity per unit of surface, e.g. MW/ha). Therefore two main topics have to be taken into account. Firstly, to reach energy targets using Renewable Energy Technologies (RET) large aereas of land are required. Furthermore, landscape changes must be assessed, selected, planned and designed even if the footprint of RET is temporary, because the majority of plants can be uninstalled excluding hydropower installations.

In this deliverable we report on the role of landscape planning and design in energy transition management with regard to the Landscape Approach proposed in the preview Deliverable 1.1.1. A first main topic is about the typology of data required to support such an approach.

A landscape approach to planning and design is multi-level and adopts relational scales, from the regional to the local and site levels. The formulation of scenarios involving all the spatial levels is an essential instrument in order to face uncertainties and focus on specific landscape layers that can be influenced by RET. The involvement of stakeholders in participatory processes is relevant to deal with landscape changes according to the Council of Europe Landscape Convention[1]. However, the contribution of a landscape planning and design approach to the energy transition should be also seen in a regional context in order to align with existing regulatory frameworks.

The increasing complexity of market and social flows due to globalization requires that local contexts are understood within wider socio-economic systems—and this is especially true for islands. For example, the benefits derived from ecosystem services may be distributed across regions or even at a global scale.

The following table presents a basic requirement of the data set necessary to apply a landscape based approach for the energy transition in the CO2 PACMAN pilot islands. The data set is framed with reference to the Landscape Approach as in the D.1.1.1.

Due to the time required to obtain the data for the landscape analysis, this version of the deliverable does not present Landscape Scenarios of Energy Transition. Landscape assessment, planning and designing of activities are going to provide original data useful for proposing scenarios during the second round of Living Labs "The Island I would like".

A first category of dataset refers to landscape screening and suitability diagnostics for energy transition activities. These aim to identify and highlight the Landscape Capability to generate renewable energy with regard to Corine Land Cover Classes (Landscape Approach Steps 1, 2, 3 in D.1.1.1). A second category of dataset refers to the implementation of sample site design (Landscape Approach Step 4, D.1.1.1).

Table 2. *Landscape data collection and use*

Country	Level	Data type	Data topic	Data availability	Data Sources and reference spatial scale	Data uses
PRELIMINARY MULTI-CRITERIA SURVEY | D.1.1.1 Landscape Approach Steps 1-3						
IT HR GR	EU	Web Mapping Service (WMS) vector	Land cover and use	open access via the Copernicus Land Monitoring Service[2]	Corine land cover combines satellite observations with local and national auxiliary data, ensuring a consistent and harmonized classification of land cover and land use Europe wide.	The land use data are used to produce a preliminary expert based survey on the capability of land use and land cover classes to host RET to generate RE and at what density (kW installed capacity/ha) to not cause crucial trade-offs with other ecosystem services. Through a Spatial Multi-Criteria analysis (SMCA) data on land use and land cover, raster polygons are overlaid first with the digital elevation model to set clusters of land slopes more or less suitable to host RET. Then the data are crossed with those of solar and wind potential data to assess the effective solar and wind potential of the most capable land use and land cover classes to host RET. The solar energy potential data enter the SMCA to express the capability of the land use and land cover classes to
IT HR GR	Global	WMS raster and	Solar energy potential	Open access via Global Wind Atlas of	The datum is based on three different models: solar radiation model, Air	

		poster maps		WMS layers and poster maps showing the solar renewable energy source potential[3]	temperature model, PV power simulation model, to provide accurate estimates of solar energy potential worldwide.	generate renewable energy. Then in step 4 data are used to orient the selection of site design sampling where effectively the energy potential is higher due to geo-morphological factors.
IT HR GR	Globa l	WMS raster	Global Wind Atlas	Open access via Global Wind Atlas of WMS layers and poster maps showing the wind renewable energy source potential[4]	The datum is based on historical climate data and geographical information, combined with advanced atmospheric models, to provide reliable estimates of wind energy potential worldwide	The wind energy potential data enter the SMCA to express the capability of the land use and land cover classes to generate renewable energy. Then in step 4 data are used to orient the selection of site design sampling where effectively the energy potential is higher due to geo-morphological factors.
IT HR GR	EU	WMS raster	Digital Elevation model	Open access via the Copernicus Land Monitoring Service[2]	The datum is based on measured and interpolated data on the elevation on the sea level of determined point to represent the general topography of a region Europe wide	The digital elevation model data enter the SMCA to determine the slope influencing RET installation - e.g. slope < 11% for agri-PV structures – e.g. slope <25% for wind turbines
IT HR GR	EU	WMS raster	Digital Terrain Model	Open access via the Copernicus Land Monitoring	The datum is based on measured and interpolated data on the elevation on the sea level of determined point to represent the general topography of a	The digital terrain model data enter the SMCA to determine the slope influencing RET installation - e.g. slope < 11% for agri-PV structures – e.g. slope <25% for wind turbines

				Service[2]	region including anthropogenic landforms Europe wide	
IT HR GR	EU	WMS vector	Natura 2000	Open access via official website of the European Environment Agency (EEA)[5]	The map is based on polygons representing the areas established to conserve Europe's most valuable and threatened habitats and species Europe wide.	Natura 2000 sites are not compatible with RET installations and excluded from SMCA.
IT HR GR	NUTS 2	WMS raster	Soil quality	Open or Regulated access via the Regional portal	The data report the geo-morphology, the nature and current and the quality of soils, and is based on regional studies and strategies for soils protection and enhancement	The data on soil quality enter the SMCA to determine what land use and land cover polygons are characterized by lower soil quality and therefore more capable to generate RE while, depending on the RET, contributing to soil quality enhancement (e.g. agri-PV system can be combined with soil quality enhancement practices)[6].
IT HR GR	NUTS 2	WMS raster	Hydro-climatic balance	Download requested or completed through Regional partners or regional geoportals	The data report at regional level the balance between the amount of input of rainfall precipitation and the output of evapotranspiration of crops or natural vegetation and runoff	The data on hydro-climatic balance enter the SMCA only in relation to the adoption of agrivoltaic systems which mitigate the gap in between precipitation and evapotranspiration thanks to the shading effect on crops.
GR	NUTS 2	WMS vector	Biodiversit y	Open or Regulated access via the Regional	The data present points or polygons where high diversity of animals and plant species has been detected through field work.	The data on biodiversity are used in the site design implementation to understand the site biodiversity and include biodiversity enhancement in the

				portal		objectives
SAMPLE SITE DESIGN | D 1.1 Step 4						
HR	Natio nal	WMS raster	State Base map	Open access via national portal (only for Croatia)	The map represents the physical structure of the landscape with cadastral data at national level.	The data are used to draw the original map on the landscape semiology
IT	NUTS 2	WMS raster	Technical regional map	Open or Regulated access via the Regional portals	The map represents the physical structure of the landscape is a type of topographic map usually produced by regions to represent their territory. They are called "technical" maps because they represent the elements without modifying their size and position, but showing their projection[7]. Objects such as buildings and roads are therefore represented with the true shape of their perimeter seen from above, and not replacing them with conventional symbols. They are suitable as a basis for various types of thematic maps.	The data are used to draw the original map on the landscape semiology
IT HR GR	EU	WMS vector	Natural habitat	Open access via the European	The data cover all types of habitat from natural to artificial, from terrestrial to freshwater and marine. Data are	The data are used to gain information related to the presence of recognized habitats in the site design

				Environmental Agency[5]	obtained from the combination of remote sensing, expert panels and fieldwork	implementation in order to safeguard and implement existing habitats or recover them in the site design implementation.
IT HR GR	NUTS 2	WMS vector	Water courses and bodies	Open or Regulated access via the Regional portals	The data from regional basin management plans represent the spatial distribution of water bodies and the risk of flooding	The data are used in the site design implementation to evaluate the interaction in between RET and water bodies (e.g. in case of floating PVs or to conduit the rainfall water collected by PVs into water network
IT HR GR	NUTS 2	WMS raster	Soil quality	Open or Regulated access via the Regional portal	The data report the geo-morphology, the nature and current and the quality of soils, and is based on regional studies and strategies for soils protection and enhancement	The data are used in the site design implementation to include soil quality enhancement in the objectives
GR	NUTS 2	WMS vector	Biodiversity	Open or Regulated access via the Regional portal	The data present points or polygons where high diversity of animals and plant species has been detected through field work.	The data are used in the site design implementation to understand the site biodiversity and include biodiversity enhancement in the objectives
IT HR GR	LOCAL	Computer Aided Design and geographic information	Landscape semiology	Original data	The map represents the set of landscape signs produced by anthropic and natural dynamics[8, 9]. The signs are carriers of different meanings that the community attributes to them. Landscape semiology is in continuous evolution.	The data of anthropic and natural semiology is functional to frame and align RET, in particular for PVs on field and agri-PV in the set of landscape signs.

		System ShapeFile (GIS SHP) vector				

5. GHG inventory

5.1 IPCC methodology

The methodology proposed by the Intergovernmental Panel on Climate Change (IPCC) was adopted to calculate the emission inventories of the three CO2 PACMAN pilot islands. This methodology refers explicitly to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories[10], updated where applicable with the 2019[11]. This approach ensures consistency, transparency, and comparability with international standards for greenhouse gas accounting.

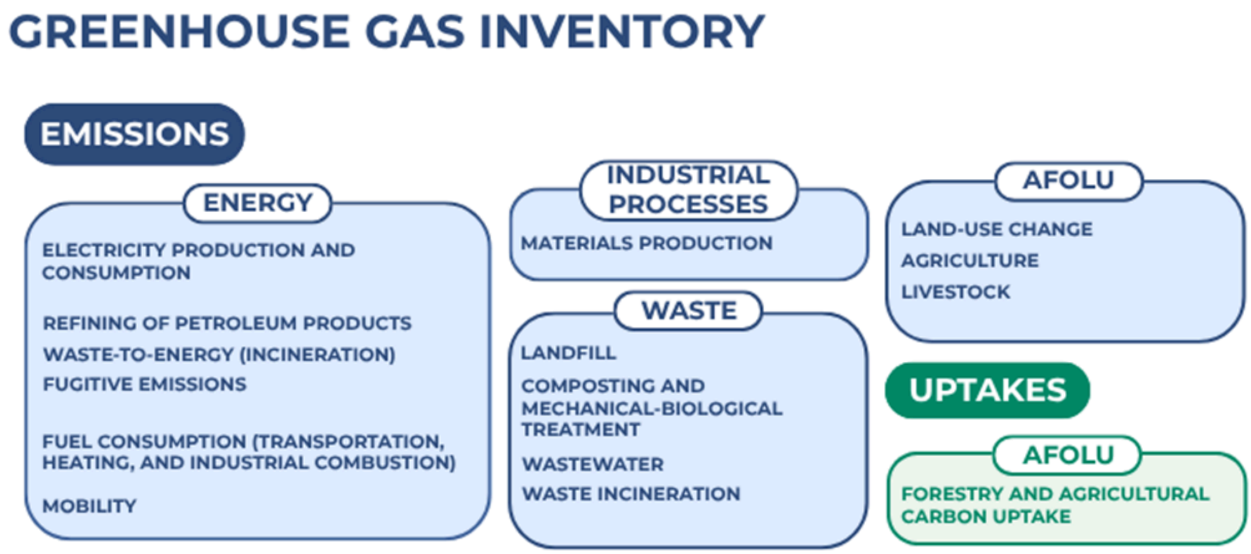


Figure 1. *Summary of emissions category and uptake sectors included in the IPCC methodology*

The IPCC methodology systematically categorizes anthropogenic greenhouse gas emissions into four main sectors, each characterized by specific emission sources, accounting criteria, and emission factors. This classification enables a detailed understanding of local emission dynamics and facilitates the identification of priority actions for decarbonization.

Figure 1 summarises the categories included in the IPCC methodology. Table 1 summarises the categories and subcategories considered for the GHG inventory of the three pilot islands of the CO2 PACMAN project, as described below.

Energy

The energy sector includes all emissions from fossil fuel combustion for energy production and consumption in residential, industrial, commercial, and transport contexts. The subcategories considered include: electricity production/consumption, fuel consumption, and mobility.

Industrial Processes and Product Use

This sector includes direct greenhouse gas emissions resulting from material production and industrial processes, as defined by the IPCC methodology. These emissions are not related to energy combustion but arise from chemical or physical transformations in specific industrial activities. Emissions from the use of certain products with high global warming potential, such as refrigerants, also fall under this sector.

In the context of the CO2 PACMAN project, the pilot islands do not host industrial activities that fall within the IPPU categories as defined by the IPCC. The industrial presence is limited to sectors that generate indirect emissions, primarily through energy and heat consumption, which are accounted for under the energy sector.

For this reason, IPPU emissions are reported as zero for all three islands. (See Deliverable 1.4.1 – Summary report of GHG balance of three target islands).

Waste

This sector includes emissions generated from municipal solid waste and wastewater management, including methane emissions from landfills, composting or incineration processes, and wastewater treatment systems. Emissions are calculated based on the volume of waste produced and the predominant treatment methods used on the island, applying IPCC emission factors for each specific technology or disposal practice.

Agriculture, Forestry, and Other Land Use (AFOLU)

The AFOLU sector encompasses both emissions (e.g., from livestock, crops, and land management) and the removal of CO_2 through natural sequestration processes, such as biomass growth in forests. This is, in fact, the only sector that includes both emission and removal activities. Key components include: a) emissions of methane (CH_4) and nitrous oxide (N_2O) from agriculture; b) land use changes (e.g., deforestation, agricultural conversion); c) CO_2 removals by forests, soils, and permanent grasslands. Estimates in this sector are based on land use and forest cover data, vegetation growth rates, and local agricultural practices.

Table 3. *Summary of the categories and subcategories considered in the calculation of the GHG balance of the three pilot islands*

Emission sectors and sub-sectors	
Energy	Electricity production/consumption
	Fuel consumption
	Mobility
Industrial	Material production
Waste	Wastewater
	Solid waste
AFOLU	Forest fires
	Livestock
	Agricultural production

Emissions were calculated using the standard IPCC formula:

$$Emissions\left(t\,CO_2eq\right) = Activity\ Data \times Emission\ Factor$$

Where: Activity Data refers to the quantitative input collected (e.g., litres of fuel consumed, kilowatt-hours of electricity used, tonnes of waste generated, cultivated agricultural area, etc.) and Emission Factor is a coefficient that indicates the amount of greenhouse gas emissions associated with a specific unit of activity, expressed in tonnes of CO_2 equivalent (tCO_2eq).

Emission factors were primarily sourced from IPCC databases and supplemented, where more up-to-date or geographically specific data were available, with official national or European sources (e.g., EEA, ISPRA, DEFRA).

According to the IPCC methodology, the natural CO_2 sequestration capacity of the islands' forested, agricultural, and natural areas was estimated in parallel with the emissions calculation. Key parameters considered include forestland, perennial crops, and green urban areas. This allowed for calculation of net emissions (emissions—removals), essential for assessing the remaining gap to be closed to achieve climate neutrality.

5.2 Activity data

Data collected from the sources described in the first section were harmonised and analysed according to the introduced IPCC methodology. The online repository offers access to the complete data set and all accompanying information and details. Table 4 reports the number, type, and details of the datapoints collected in each IPCC sector.

Here, only a summary of the data will be provided to illustrate the extent of the collection and the methodology used.

Table 4. *Summary of type and details of datapoints to collected for the GHG balance implementation*

Sector IPCC	Number, type, and details of data points
GENERIC DATA	• 3 MAIN DATAPOINTS (population, tourists, total area) • 1 DETAILED SET OF DATA (total area: cropland, perennial crops, forestland, grassland, settlements, green urban area, other)
ENERGY electricity consumption	• 3 MAIN DATAPOINTS (residential, tertiary, industrial)
ENERGY electricity production/consumption	• 8 MAIN DATAPOINTS (Import from national grid, thermoelectricity (Natural gas), geothermal, wind power, solar power, waste to energy, biomass (biogas), blue energy power)

ENERGY fuel consumption	• 4 MAIN DATAPOINTS (residential, service, industrial, agricultural) • 8 DETAILED SET OF DATA (natural gas, diesel, LPG, RES (biogas), RES (biomass/wood), other petroleum, fuel oil, coal)
ENERGY mobility	• 3 MAIN DATAPOINTS (road transportation, waterborne navigation, civil aviation) • 3 SETS OF DETAILED DATA (road transportation: diesel, gasoline, kerosene, LPG, RES (bioethanol); waterborne navigation: diesel (Pleasure boats and ferries); diesel (Fishing boats); civil aviation: JET A1 (kerosene, AVGAS 100)
INDUSTRIAL PROCESS material production	• 6 MAIN DATAPOINTS (glass industry, cement industry, paper industry, electronics industry, chemical industry, metallurgical industry)
WASTE Landfill, composting, and mechanical-biological treatment	• 6 MAIN DATAPOINTS (incinerated (waste to energy), landfilled, composted, selection plants (organic fraction), recycled, undifferentiated waste)
WASTE wastewater	• 2 MAIN DATAPOINTS (residential water supply, residential wastewater treatment) • 3 SETS OF DETAILED DATA (Residential (wastewater management), Sludge (landfilled), N in the effluent)
AFOLU Forestland loss	• 2 MAIN DATAPOINTS (fires, forest clearings)
AFOLU Agriculture	• 2 MAIN DATAPOINTS (agriculture production, fertilizers) • 7 SETS OF DETAILED DATA (agriculture production: cereals, roots and tubers, temporary fodder, permanent fodder; fertilizers: primary, secondary, and tertiary N fertilizers)
AFOLU livestock	• 3 MAIN DATAPOINTS (breaded animals, animals in the wild, stabled animals) • 7 SETS OF DETAILED DATA (dairy cows, other cattle, pigs, sheep, goats, horses, poultry)
AFOLU Forestry and agricultural carbon uptake	• 3 MAIN DATAPOINTS (forestland, perennial crops, green urban area) • 11 SETS OF DETAILED DATA (forestland: arboriculture, agroforestry areas, deciduous forests, coniferous forests, mixed coniferous and broad-leaved forests, heaths and bushes, areas with sclerophyllous vegetation, areas with evolving woodland and shrubby vegetation, areas with sparse vegetation; perennial crops: orchard, vineyard, olive grove).

5.3 Emission factors

Similar to the activity data presented earlier, this section provides a brief overview of the emission factors used in the calculation process. While activity data are typically derived from the analysis of primary or secondary sources, emission factors are primarily based on established literature and international guidelines.

In this study, the emission factors have been sourced directly from, or derived in alignment with, the ones provided by the IPCC. This approach ensures consistency and coherency with the methodology applied in this project. Also, this enhances the transparency and comparability of the results.

6. Decarbonisation policies and behavioural changes

Decarbonisation policies are strategic measures designed to reduce greenhouse gas (GHG) emissions across key societal and economic sectors. These policies aim to transform existing systems—such as energy production, transportation, land use, waste management, and agriculture—towards more sustainable, low-carbon models (IPCC Special Report on Global Warming of 1.5°C, 2018[12]; IEA – World Energy Outlook, various editions[13]; European Commission – A Clean Planet for all, 2018[14])

These measures can range from technological upgrades and infrastructure improvements to behavioural changes and regulatory reforms. By addressing individual practices and systemic transformations, decarbonization policies play a critical role in achieving climate neutrality targets, improving environmental resilience, and fostering long-term sustainable development.

The following decarbonisation policies address a wide range of intervention areas, encompassing both individual lifestyle adjustments and territorial and systemic strategies led by local and regional authorities. Key areas of intervention include:

- Energy management: improving energy efficiency and promoting renewable energy adoption.
- Buildings and infrastructure: optimizing energy use in residential and commercial buildings.
- Industry and production: reducing emissions through process innovations and efficiency gains.
- Mobility: encouraging a shift from private fossil-fuel vehicles to slow mobility, public transit, and electric transportation options.
- Waste and water management: promoting sustainable consumption, recycling, and efficient resource use.
- Sustainable agriculture: supporting conservation-based approaches that sustain productivity while preserving ecosystems.

Finally, significant attention is given to policies that support the energy transition, promoting the deployment of renewable energy sources such as wind, solar, and marine (blue) energy technologies to meet electricity demand sustainably.

Eventually, the rebound effect was considered for some of the policies studied. This refers to the potential for unintended increases in energy demand or fuel consumption that may partially offset the expected emissions reductions. In such cases the policy's calculated Relative CO_2 Savings (tCO_2) includes this adjustment and is marked with an asterisk (*) in the relevant column of Table 4.

Policy Table and Icon Description

Each policy is associated with a representative icon, which is also used throughout the tool interface to ensure recognizability and ease of use. This structure aims to facilitate an intuitive understanding of each policy's contribution. The structure of the policy table (Table 4) includes the following fields:

- Icon: The graphical symbol associated with each policy is also featured in the tool.
- Policy's Name: The reference name of the policy or the related policy group. Transformation's
- Description: A concise explanation of the policy and its intended scope of action.
- Adoption Rate / Number: Indicates the level of policy adoption, either as a percentage (0–100%) or as an absolute number, depending on the policy's nature.
- Relative Effectiveness: Expressed as a percentage or in appropriate units, this column indicates the expected impact or efficiency of the policy.
- Description and/or Source: The reference or basis used to estimate the policy's potential effect.

- Relative CO_2 Savings (tCO_2): The estimated amount of CO_2 emissions reduction attributable to implementing the behavioral change or policy. This is calculated using the decrease in consumption data in the specific unit of measurement multiplied by the relative emission factor (EF). (The type of consumption data could be found in Table 4).

Table 5. *Table which summarizes the policies of decarbonisation*

Icon	Policy's name	Description	Adoption rate or number	Description based on the Adoption rate or "number of" and relative effect	Motivations and/or Sources:	Relative tCO2 savings
	Reduction of domestic and office consumption	Reduction of electricity use in residential buildings and offices/services	Adoption rate (0-100%)	Adoption rate: % of residential and services that adopt the behavioural change; Effect: -10% of electricity consumption.	Relying on behavioural changes, no single percentage can capture all the several possibilities for reducing energy and water consumption at home and in offices. The potential savings range from 5% to 30%. For this analysis, a 10% reduction has been assumed for each of the three sectors.	Avoided tCO_2 relative to the adoption rate and the effect on electricity consumption.
		Reduction of heating use in residential buildings and offices/services	Adoption rate (0-100%)	Adoption rate: % of households and services that adopt the behavioural change. Effect: -10% of heat energy consumption.		Avoided tCO_2 relative to the adoption rate and the effect on heating consumption.
		Reduction of water use in residential buildings	Adoption rate (0-100%)	Adoption rate: % of households and services that adopt the behavioural change; Effect: -10 % water consumption.		Avoided tCO_2 relative to the adoption rate and the effect on water consumption.

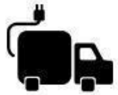
		Walking for short distances	Adoption rate (0-100%)	Adoption rate: % of less private cars; Effect: -4% of travel with cars replaced by walking.	The effect percentage has been elaborated from the ISFORT report 2023[15], considering the percentage of travel divided by different lengths.	Avoided tCO_2 relative to the adoption rate and the effect on diminishing the fuel consumption for private cars.
	Adopt sustainable travel habits	Using an electric bike for medium distances (2–10 km)	Adoption rate (0-50%)	Adoption rate: % of people who choose a bicycle over a car for medium distances; Effect: -25% of fuel consumption saved, setting a limit of ¼ of total rides that can be replaced.	The effect percentage has been elaborated from the ISFORT report 2023, considering the rate of travel divided by different lengths.[15]	Avoided tCO_2 relative to the adoption rate and the effect on diminishing the fuel consumption for private cars.*
		Carpooling	Adoption rate (0-50%)	Adoption rate: % of travel carpooled; Effect: -66% of fuel consumption saved, setting a limit of 1/3 of total rides that can be replaced.	The adoption rate has been considered a limit of 50% of travel that carpooling can replace. Considering an occupancy rate of 1.55 people per car, travel is reduced by -66% (1 car instead of 3 for the	Avoided tCO_2 relative to the adoption rate and the effect on diminishing the fuel consumption

					same number of people).	for private cars.
	Waste reduction	Reduction of unsorted waste in residential buildings	Adoption rate (0-100%)	Adoption rate: % of households and services that reduce their unsorted waste; Effect: -20% of waste sent to landfill. The reduced landfilled waste quantity is split between recycling (50%) and composting (50%).	Considering that one of the goals of the EU and SDGs is to increase waste recycling, it has been decided to decrease the 20% of total waste that is unsorted by personal choice.	Avoided tCO_2 relative to the adoption rate and the effect on diminishing the unsorted waste redirected to recycling and composting.
	Reduce industrial consumption	Optimize industrial processes to consume less electricity	Adoption rate (0-100%)	Adoption rate: % of companies that adopt the policy; Effect: -20% electricity consumption by optimised processes.	According to a study by CEMCO[16], a consulting firm specialized in energy efficiency solutions for manufacturing facilities, an average industrial plant can reduce its energy consumption by 10% to 20% by implementing optimized technologies and operational practices.	Avoided tCO_2 relative to the adoption rate and the effect on electricity consumption.
		Optimize industrial processes to consume less heating	Adoption rate (0-100%)	Adoption rate: % of companies that adopt the policy; Effect: -20% heat energy consumption by optimised processes.		Avoided tCO_2 relative to the adoption rate and the effect on heating consumption.

	Install solar thermal systems	Solar thermal for residential	Adoption rate (0-100%)	Adoption rate: % of residential units that install the solar thermal panel; Effect: -60% of heat energy savings for residential;	According to the U.S. Department of Energy, an active solar heating system can economically provide around 60% of a home's heating needs, depending on the system design and local climate conditions.	Avoided tCO_2 relative to the adoption rate and the effect on heating consumption.
	Residential efficiency improvement	Energy efficiency improvement in residential buildings for electricity and heating	Adoption rate (0-100%)	Adoption rate: % of residential units that adopt the policy; Effect: -15% of electricity and -65% of heat energy consumption.	The effect has been calculated considering the amount of electricity demand on total consumption for cooling the house in summertime (three/four months), and the amount of heating used during winter on the total energy consumption.	Avoided tCO_2 relative to the adoption rate and the effect on electricity and heating consumption.
	Invest in public transportation	Increase the number of buses	Number of additional buses	Number of additional buses: - Elba: 0-100 - Crete: 0-300 -Brac: 0-30; Effect: Reduction in tons of fuel from private cars	Estimation and calculation based on average bus consumption compared to car fuel consumption based on the mobility report ISFORT, 2023[15].	Avoided tCO_2 relative to the reduction of fossil fuels used by private cars *

				replaced by buses. MAYBE ADD WHICH IS THE RELATION OF BUS VS CARS		
	Invest in e-bike sharing services	Increase the number of e-bikes for sharing	Number of additional e-bikes	Number of additional e-bikes: - Elba: 0-400 -Crete: 0-2000 -Brac: 0-400; Effect: Reduction in tons of fuel from private cars and scooters replaced by e-bikes, accounting for 30% of the total kilometers driven by cars and scooters in a year.	Estimation and calculation of data collected on mobility for the GHG balance, considering the ratio of 0.005 kWh/km of consumption per e-bike.[17]	Avoided tCO_2 relative to the reduction of fossil fuels used by private cars and scooters. *
	Invest in waste management services	Reduction of landfill waste (structural)	Adoption rate (0-100%)	Adoption rate: % of wastes sent to landfill; Effect: -50% goal of waste sent to landfill. The exact quantity is sent to recycling (50%) and composting	Considering that one of the goals of the EU and the SDGs is to diminish the disposal of unsorted waste in favour of recycling and composting.	Avoided tCO_2 relative to the adoption rate and the effect on diminishing

				(50%).		the unsorted waste redirected to recycling and composting.*
	Conservation agriculture	Conservation agriculture	Adoption rate (0-100%)	Adoption rate: Increase in hectares of conservation agriculture of over 80% of the total UAA (Utilised Agricultural Area); Effect: $-1.14tCO_2$/ha/year savings.	$1.14tCO_2$/ha/year saving thanks to conservation agriculture strategies.[20]	Avoided tCO_2 relative to the adoption rate and the effect on emissions from agriculture.
	Electric-powered heat pumps (reduce in gas use)	Electric-powered heat pumps (reduce gas use)	Adoption rate (0-100%)	Adoption rate: % of households and services that convert their heating system; Effect: convert all the gas used for heating into electricity.	"Adopting electric end-use technologies instead of fossil-fueled alternatives, known as electrification, is an important economy-wide decarbonization strategy that also reduces pollutant emissions and improves air quality." [21]	Avoided tCO_2 relative to the adoption rate and the effect on heating consumption. *
	Substitution with electric cars instead of traditional cars	Substitution with electric cars	Adoption rate (0-100%)	Adoption rate: % of cars that will be converted to electric; Effect: Residual private car made fully electric.		Avoided tCO_2 relative to the reduction of fossil fuels used by private cars. *

	Substitution with electric trucks instead of diesel ones	Substitution with electric trucks	Adoption rate (0-100%)	Adoption rate: % of trucks that will be converted to electric; Effect: Conversion to fully electric trucks.		Avoided tCO_2 relative to the reduction of fossil fuels used by diesel trucks. *
	Substitution with electric maritime transport	Substitution with electric maritime transport	Adoption rate (0-100%)	Adoption rate: % of maritime transport that will be converted to electric; Effect: Conversion to fully electric maritime transportation.		Avoided tCO_2 relative to the reduction of fossil fuels used by maritime transport. *
	Invest in wind power plants	Microwind (on-shore)	Number of wind turbines	Number of turbines: Elba/Crete/Brac: 0 to 1000 Effect: Annual electricity generation per power plant: Elba: 117 MWh/turbine Crete: 569 MWh/turbine Brac: 320 MWh/turbine	The effect of a single turbine in the three pilot islands was calculated, through different articles and databases.[22, 23, 24]	Avoided tCO_2 relative to the reduction of fossil fuel sources for electricity.
		2MW Onshore wind turbine (80 to 120 meters high)	Number of wind turbines	Number of turbines: Elba/Brac: 0 to 30 Crete: 0 to 50		Avoided tCO_2 relative to the reduction of fossil fuel sources for

				Effect: Annual electricity generation per power plant: Elba: 3,509 MWh/turbine Crete: 7,516 MWh/turbine Brac: 5,046 MWh/power plant.		electricity.
		2MW Offshore wind turbine (80 to 120 meters high)	Number of wind turbines	Number of turbines: Elba/Crete/Brac: 0 to 30 Effect: Annual electricity generation per turbine: Elba: 4,600 MWh/power plant Crete: 7,972 MWh/power plant Brac: 5,624 MWh/power plant.		Avoided tCO_2 relative to the reduction of fossil fuel sources for electricity.
		6MW Offshore wind turbine (100 to 140 meters high)	Number of wind turbines	Number of turbines: Elba/Brac/Crete: 0 to 20 Effect: Annual electricity generation per turbine: Elba: 13,802 MWh/turbine Crete: 24,735 MWh/turbine		Avoided tCO_2 relative to the reduction of fossil fuel sources for electricity.

				Brac: 15,687 MWh/turbine		
	Invest in blue energy plants	Oscillating water column system (20 meters long)	Number of devices	Number of devices: Elba/Crete/Brac: 0 to 20 Effect: Annual electricity generation per device: 375 MWh/device	Data was gathered from the BLUE DEAL project website and research papers related to the project.[25, 26]	Avoided tCO_2 relative to the reduction of fossil fuel sources for electricity.
		Near Shore Wave Energy plant (3 meters wide)	Number of devices	Number of devices: Elba/Crete/Brac: 0 to 1000 Effect-Annual electricity generation per device: 500 MWh/device.		Avoided tCO_2 relative to the reduction of fossil fuel sources for electricity.
	Invest in photovoltaic plants	Renewable electricity by photovoltaic (Field) km^2	ha of fields covered with PVs	ha of fields covered: Elba: 0 to 411 Crete: 0 to 35,073 Brac: 0 to 25.18 Effect: Annual electricity generation per hectare: Elba: 1,460 MWh/ha Crete: 1,489 MWh/ha Brac: 1,998 MWh/ha	Space availability is calculated from the data provided by partners on the pilot islands, considering their physical conformation . The effect is localized on the three pilot islands.	Avoided tCO_2 relative to the reduction of fossil fuel sources for electricity.

				IS THIS CORRECT, CRETE PROBABLE HIGHER THAN BRAC		
		Renewable electricity by photovoltaic (Roof) m^2	m2 of roof covered by PVs	m^2 of roofs covered: Elba: 0 to 908,458 Crete: 0 to 1,091,887 Brac: 0 to 19,360 Effect: Annual electricity generation per square meter: Elba: 0.054 MWh/m^2 Crete: 0.27 MWh/m^2 Brac: 0.26 MWh/m^2	Country partners provided the roof space availability. The effect is localized on the three pilot islands[2, 27].	Avoided tCO_2 relative to the reduction of fossil fuel sources for electricity.

*: Rebound effect taken into account

Conclusions

The methodology presented in this deliverable, combining data-driven analysis, behavioural modelling and policy scenario evaluation, demonstrates how targeted actions can significantly reduce CO_2 emissions. Designed for three pilot Mediterranean islands, the approach is grounded in internationally recognized standards, particularly the IPCC Guidelines, and supported by rigorous data harmonization procedures. This has resulted in a comprehensive, transparent, and comparable dataset that enhances the credibility of the greenhouse gas (GHG) inventory and supports robust climate planning.

A key strength of the methodology lies in its flexibility, transparency, and scalability. While tailored to the specific context of the CO2 PACMAN project, its core principles can be readily adapted to other geographic areas. The framework remains valid and effective if applied to similar urban contexts, different utilities, or broader policy domains. Strong stakeholder engagement and creating a fair-aligned open data repository further enhance its replicability and usability.

While sustainability indicators provide valuable insights into environmental, economic, and social dimensions, their application only partially captures the complexity of island typology comparisons. In the context of Crete, Brač, and Elba, these indicators offer a foundational framework for assessing sustainability performance. Still, they fall short in fully reflecting the unique geographical, cultural, and infrastructural characteristics that distinguish each island. Crete, as a large and diverse island, presents different sustainability challenges and opportunities compared to the smaller and more tourism-dependent islands of Brač and Elba. The indicators may highlight general trends—such as energy use, waste management, or biodiversity—but they often overlook localized dynamics, such as seasonal population fluctuations, historical land use patterns, and governance structures. Therefore, while sustainability indicators are essential tools in comparative analysis of island typologies, they must be complemented by additional qualitative assessments and context-specific data to understand each island's unique profile comprehensively.

This work contributes to a broader vision of sustainable transition pathways by offering tools that are both actionable and transferable. These tools enable other Mediterranean islands and beyond to assess emissions, identify decarbonization strategies, and monitor progress toward climate neutrality. In doing so, the CO_2 PACMAN approach also directly supports several Sustainable Development Goals (SDGs), including access to sustainable energy, resilient urban development, and climate action.

Ultimately, the deliverable provides a replicable and scalable foundation for evidence-based policymaking, reinforcing local and global efforts toward climate neutrality and sustainable development.

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