CO2 PACMAN

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Table of contents

Abbrevations

3D	Three-Dimensional
AFOLU	Agriculture, Forestry and Other Land Use
ARRR	Agenzia Regionale Recupero Risorse (Regional Agency for Resource Recovery, Tuscany Region)
CER	Renewable Energy Communities
DEMs	Digital Elevation Models
ECLAS	European Council of Landscape Architecture Schools
EU	European Union
GHG(s)	GreenHouse Gas(es)
GIS	Geographic Information System
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial Processes and Product Use
LTC	Local Technical Committee
NGOs	Non-Governmental Organizations
NIMBY	"Not In My Back Yard"
RES	Renewable Energy Sources
RETs	Renewable Energy Technologies
SCMA	Spatial Multi-Criteria Analysis
SECAP	Sustainable Energy and Climate Action Plan
SMEs	Small Medium Enterprises
VR	Virtual Reality
YTT	Youth Think Tank

Executive summary

The CO2 PACMAN Toolkit was developed to support island territories in building robust, participatory, and data-driven roadmaps toward climate neutrality. Tested on the islands of Brač (Croatia), Crete (Greece), and Elba (Italy), the Toolkit combines greenhouse gas assessment, spatial analysis and design prototyping, multilevel engagement, educational actions, and open innovation into a coherent methodology that informs local planning and empowers communities.

The testing process followed a structured sequence: development of the methodology; implementation of the Rooting Labs; completion of GHG inventories; integration of results into the CO2 PACMAN Tool; and participatory activities engaging the local community, building on Youth Think Tanks, field surveys, and Open Innovation Collaborative Action. This integrated approach ensured that technical results and social insights informed one another, producing a shared, credible understanding of each island's climate profile and fostering the co-creation of paths toward its decarbonisation. Across the three pilots, the Toolkit proved effective in identifying and validating data, pinpointing priority areas for decarbonisation, enhancing climate literacy, and stimulating collaboration across institutions, citizens, schools, and businesses. The use of the CO2 PACMAN Tool helped make emissions and mitigation scenarios accessible to non-expert audiences, strengthening awareness and supporting informed debate. The Open Innovation cooperative process provided targeted solutions to local challenges, demonstrating how external expertise can accelerate the implementation of climate actions.

The lessons learned highlight conditions for successful replication: early stakeholder engagement, iterative use of the Tool, strong communication, integration of quantitative and participatory methods, and sustained institutional commitment. Together, these elements form a practical roadmap for other territories wishing to adopt the Toolkit.

Looking ahead, the next phase —*The Island I Would Like* Labs — will build on the assessment results to co-design climate-neutrality scenarios with local communities. The Toolkit has demonstrated strong transferability and alignment with EU strategies, offering a scalable and participatory pathway to accelerate climate action in islands, and is fully adaptable to other territories facing similar challenges.

CO2 PACMAN Toolkit: a helicopter perspective

The Toolkit **builds on methodologies and experiences from previous European projects**, including **COMPOSE/COMPOSE PLUS, BLUE DEAL, and the FP7 CityZen project**. From COMPOSE, it adopts **strategies to engage multiple stakeholder levels and empower local capacity,** ensuring inclusive planning across governance tiers and sectors. Building on BLUE DEAL and CityZen, it includes GHG calculation methods and systematic mitigation planning, while enhancing the BLUE DEAL six-stage framework by expanding it beyond blue energy to include mobility, waste, land use, and ecosystem-based solutions. By combining the participatory toolbox of COMPOSE with the technical rigor of BLUE DEAL and CityZen, the CO2 PACMAN Toolkit offers an integrated, cross-sectoral, and replicable approach to support climate-neutrality planning at the territorial level.

Building on the experience gained across the three pilot islands, the CO2 PACMAN Toolkit offers Mediterranean regions a shared methodological framework and a set of practical, adaptable tools to design achievable roadmaps toward climate neutrality collaboratively. Designed as both a scientific and participatory process, the Toolkit addresses the complex challenge of combining rigorous environmental assessment with collective awareness, co-creation, and decision support.

At its core, the Toolkit offers tools that enable users to **measure, interpret, and visualize Greenhouse Gas (GHG) emissions and uptakes**, translating complex data into accessible, straightforward, and user-friendly (easy to understand) information. This empowers local administrations and communities to engage with evidence-based insights while laying the groundwork for participatory co-creation of climate neutrality plans.

Recognising that the transition to climate neutrality cannot rely solely on data, the Toolkit integrates **scientific methodologies** with **collaborative and inclusive processes**. It was designed through iterative experimentation and refined through real-world application in the islands of Brač (Croatia), Crete (Greece), and Elba (Italy). The framework is structured around three complementary dimensions that together ensure a coherent, efficient, and replicable approach (Figure 1):

a) **Assessment phase — Understanding the present.**
   This phase focuses on analysing the current environmental, social, and territorial conditions of each island. It combines participatory data collection and technical analysis through the **Rooting Labs**, the **GHG Balance**, the **AskyourcitizenonCaN** survey, and a **contextual landscape study**. These activities provide an integrated picture of local emission and uptake sources, land-use characteristics, and community perceptions, grounding the transition process in evidence-based understanding.

b) **Scenario development — Designing the future.**
Building on the results of the assessment phase, this phase engages local and regional actors — public authorities, citizens, students, and SMEs — in co-designing and testing scenarios for achieving climate neutrality. Activities such as the **Youth Think Tank**, **Open Innovation Collaborative Action**, **Financing the Transition**, **The Island I Would Like Labs**, and **Virtual Reality explorations of the landscape** allow participants to visualize possible transformations, identify suitable technological solutions, and evaluate their social and environmental implications.

c) **Multi-level stakeholder involvement — Making it happen together.**
Beyond individual activities, the Toolkit promotes continuous collaboration among public authorities /institutions, the private sector, academia, and civil society. This multilevel engagement **fosters a shared vision of the transition, ensuring that no stakeholder is excluded from the planning and implementation** of the process.

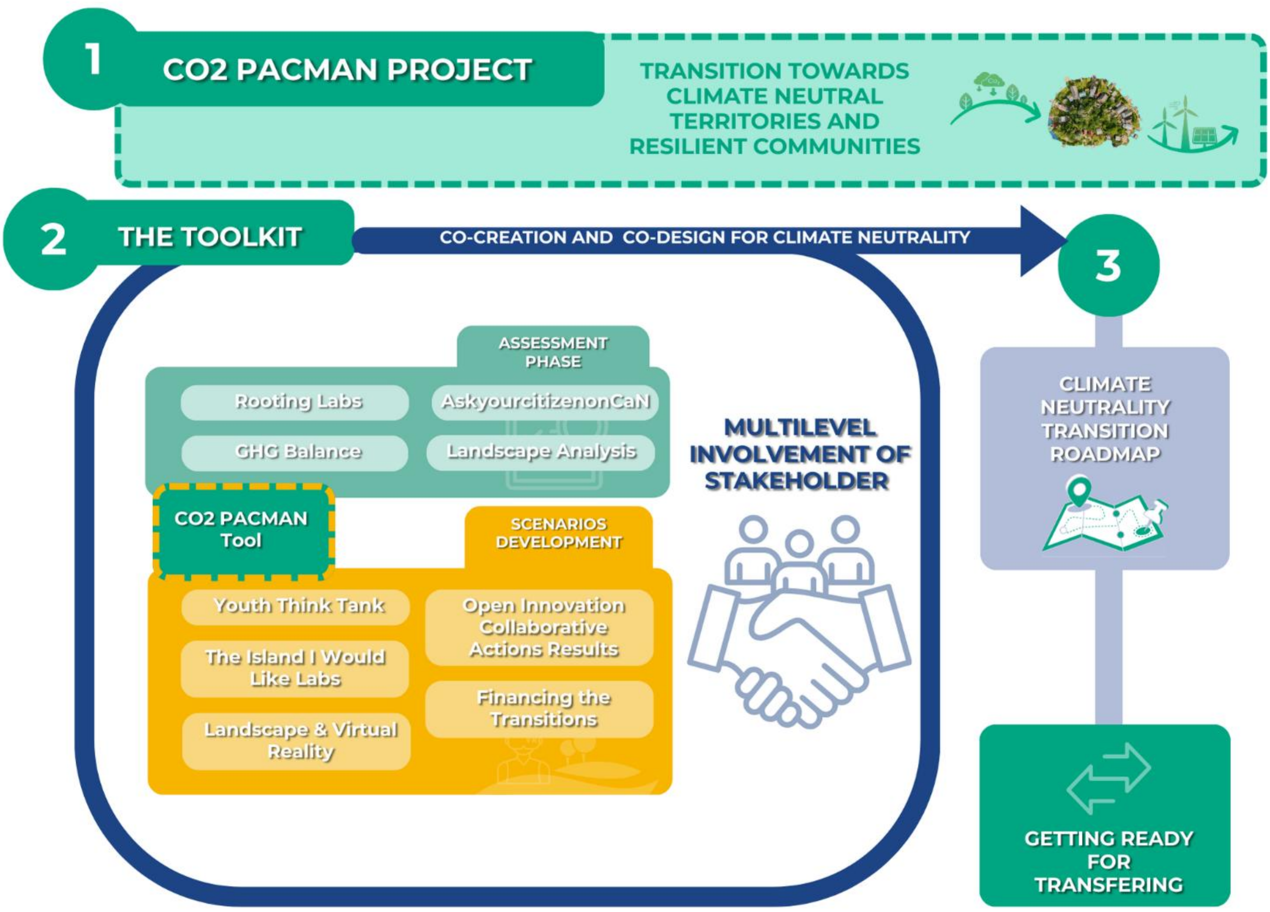


Figure 1: CO2 PACMAN Toolkit intervention logic

Through this integrated structure, the **CO2 PACMAN Toolkit** provides an efficient response to the **Mediterranean region's key challenges**: it bridges the gap between scientific knowledge and practical application, empowers communities to act on climate evidence, and **supports decision-makers in co-developing realistic, inclusive, and landscape-sensitive roadmaps toward a climate-neutral Mediterranean future**.

The Toolkit is designed as a fully **transferable and adaptable** methodology that can be replicated in diverse territories, regardless of their size, geography, or institutional capacity.

CO2 PACMAN Toolkit: Key Features and Innovations

The CO2 PACMAN Toolkit is outstanding for its integrated and participatory approach, developed through a co-creation process deeply embedded in the specific contexts of the pilot islands. Its implementation enables translating the conceptual framework into actionable strategies.

Beginning with a **comprehensive baseline assessment** of GHG emissions, uptakes, and energy systems, the toolkit evolved through **collaborative development of decarbonisation scenarios**, **strategic priority identification**, and the **co-design of policy and action roadmaps**. Its structure naturally emerged from the interaction between laboratory activities and local stakeholders, transforming what could have been a static reporting framework into a **dynamic decision-support and engagement tool** that links scientific data, stakeholder involvement, and policy innovation. In this way, the CO2 PACMAN Toolkit unifies IPCC-based GHG accounting — following the 2006 IPCC Guidelines and the 2019 Refinement — with a governance-oriented, multi-actor participation model within a single operational workflow, rather than a loose sequence of analytical and participatory steps.

Throughout the participatory process, the Toolkit transforms stakeholders from passive observers into **active agents of change**. The first round of the **Rooting Labs**, which reinforced local connections and contextual understanding, paved the way for ***The Island I Would Like Labs***. These initiatives shaped shared visions and practical solutions, illustrating how technical analysis and social creativity have to be merged into a unified transition process. Special emphasis was placed on **direct citizen engagement** through public consultation, open-air events, and interactive moments that enhanced awareness of the path toward carbon neutrality and encouraged individual and collective responsibility for the transition.

The **innovative character** of the Toolkit lies in its capacity to **bridge science, participation, and local planning within a single operational framework**. It integrates quantitative data on GHG emissions and uptakes with qualitative insights into citizen perceptions and landscape characteristics, transforming this complex information into shared, actionable knowledge. The use of distinctive digital and immersive tools — such as the **CO2 PACMAN Tool**, including the equivalent-forest visualization to make emissions and removals tangible, and **Virtual Reality applications** for place-sensitive deliberation — further translates abstract decarbonization strategies into **concrete, interactive landscape experiences, supporting evidence-based decision-making** and policy coherence. Evidence from the pilot islands shows that these tools improved accessibility to complex climate data, supported more informed discussions, and enhanced stakeholder engagement across public authorities, citizens, schools, and local businesses.

Replicability and adaptability of this Toolkit were validated through its development and testing across three distinct island contexts — Brač (HR), Crete (GR), and Elba (IT). This diversity ensures that the Toolkit can be transferred and scaled to other Mediterranean or coastal territories facing similar environmental and socio-economic challenges. The Toolkit is designed as **a modular approach that can be adapted to non-island settings** as well, since the presence or absence of the sea does not determine its effectiveness.

By combining scientific robustness with an operational, participatory, and easily adaptable method, the CO2 PACMAN Toolkit represents **a new generation of territorial planning instruments**, where **data becomes dialogue, and dialogue becomes action**.

The Toolkit goes beyond the methodologies followed in BLUE DEAL (Living Labs, Innovation campaigns, Business Forum, etc.) and fully enriches them. It comprises many scientific elements of COMPOSE/COMPOSE PLUS. It goes a step further from CityZEn. While COMPOSE, BLUE DEAL, and CityZen each provided valuable foundations in stakeholder engagement, renewable energy assessment, and emissions modelling, the **CO2 PACMAN Toolkit integrates these components into a single, coherent methodology**. It advances previous approaches by combining IPCC-aligned GHG accounting, spatial landscape suitability, participatory co-creation, citizen insights, and VR-enabled scenario design into **a single transferable framework**.

CO2 PACMAN Toolkit: ASSESSMENT PHASE

Each activity in the Assessment Phase provides essential evidence that directly informs the construction of the emission baseline and shapes subsequent scenario development, ensuring that all transition pathways are grounded in shared, validated, and context-specific data.

The **Assessment Phase** establishes the foundation of the CO2 PACMAN "recipe" by combining **scientific evidence, landscape analysis, and social insight**. Central to this phase is the creation of the **CO2 PACMAN Tool**, developed from the integration of **GHG balance data** and the **contextual study of local physical characteristics, landscape features, and socio-territorial dynamics**. This interactive tool enables users to **measure, interpret, and visualize Greenhouse Gas emissions and uptake, as well as the effects of policies, translating complex environmental information into accessible,** actionable knowledge. It provides the analytical basis for subsequent scenario development and supports evidence-based decision-making, allowing stakeholders to explore the consequences of different policy and lifestyle choices. The Assessment phase consists of five main elements (or "ingredients").

1. Rooting Labs

The Rooting Labs are three-day participatory workshops designed for local/regional authorities, citizens, businesses, schools, sectoral associations, and civil society representatives to explore the islands' current conditions and identify challenges and opportunities for decarbonisation. Combining interactive informational sessions, on-site investigations, structured consultations, and collaborative exercises, the Labs **anchored the project in the local context**, collecting essential data, sharing knowledge, and initiating the co-creation of solutions suited to each island's characteristics. Beyond methodology, the Rooting Labs produced **concrete outputs** that directly informed the Toolkit:

- Validated datasets and territorial evidence
- Stakeholder mapping and engagement
- Community priorities setting towards zero emissions pathways
- Insights from local perception and knowledge sharing
- Early co-creation of decarbonisation ideas
- Increased awareness and a shared vision.

Results of the Rooting Labs are detailed in the Testing the CO2 PACMAN Toolkit Section, while more details on the Rooting Lab methodology are provided in Technical Note 1.

2. GHG Balance

The **GHG balances** represent a fundamental step toward climate neutrality, providing the analytical foundation for quantifying, monitoring, and identifying policies for reducing **emissions over time**. They allow local authorities and stakeholders to **identify primary emission sources, prioritize mitigation measures, and track progress** in implementing low-carbon transition plans.

Developed in accordance with IPCC methodological guidelines (IPCC 2006, IPCC 2019 Refinement), the inventories cover key sectors—energy, transport, waste, and agriculture—ensuring **transparency, comparability, and scientific robustness**. The resulting datasets feed directly into the **CO2 PACMAN Tool**, providing a reliable reference framework for **scenario modelling, target setting, and participatory decision-making**, and enabling communities to visualize the impacts of alternative policies and actions in their territories. In the Testing the CO2 PACMAN Toolkit section, the GHG baseline results for the three islands are reported. Technical Note 2 reports the methodological details.

3. AskyourcitizenonCaN

At the core of the CO2 PACMAN Toolkit is the belief that achieving climate neutrality requires not only reliable data and technological solutions but also active citizen involvement and ownership. In this vision, the **AskyourcitizenonCaN survey** — inspired by the BLUE DEAL AskyourcitizensonBE one (Betti et al., 2022) — was developed to give citizens a voice and make them active participants in shaping their community's low-carbon future.

Assessing perceptions, awareness levels, and willingness to adopt behavioural and systemic changes toward decarbonisation is a crucial part of the CO2 PACMAN Toolkit. More than just a survey, **AskyourcitizenonCaN acts as a link between technical assessment and social readiness**, helping the CO2 PACMAN project partners and decision-makers understand both the quantitative aspects of emissions and the qualitative factors of public acceptance, motivation, and priorities.

Integrated into the Toolkit, this activity complements scientific components such as the GHG Balance and the CO2 PACMAN Tool by providing the **social insights needed for practical, inclusive climate planning**. It helps determine how ready communities are to support sustainable practices and renewable energy systems, or to participate in collective initiatives such as energy communities and circular economy models.

Results from AskyourcitizenonCaN **inform the design and prioritization of transition strategies**, guiding the selection of measures and shaping the second round of participatory labs, "**The Island I Would Like**". This ensures citizens are **active co-creators of change**, turning awareness into participation and reinforcing one of the core values of the CO2PACAMAN Toolkit that **climate neutrality must be built with people, not just for them.** The survey results of the three islands are reported in the Testing the CO2 PACMAN Toolkit section; for methodological details, see Technical Note 3: AskyourcitizenonCaN.

In addition, the Toolkit integrates the **Vox Populi interview method**, capturing spontaneous opinions from ordinary citizens during participatory sessions (Rooting Labs and Island I Would Like Labs). These brief public interviews complement quantitative data with real-time insights, providing a snapshot of collective sentiment and enriching understanding of social readiness for change.

4. Landscape Analysis

The **Landscape Analysis** provides the spatial and environmental foundation for planning renewable energy interventions and ensuring that decarbonisation roadmaps are compatible with local landscapes, ecosystem services, and cultural values. Because **Renewable Energy Sources (RES) typically require larger surface areas than fossil fuels**, it is **essential to assess both land availability and suitability**. The analysis aims to identify areas where Renewable Energy Technologies (RETs) can be implemented efficiently while minimizing trade-offs with other land uses and natural resources. It considers **multiple landscape aspects** — land use and cover, topography and slopes, solar and wind potential, soil quality, water balance, biodiversity, and protected areas — using **spatial and multi-criteria methods to determine suitable areas** without compromising environmental integrity or local identity. In addition to technical evaluation, the landscape analysis **incorporates stakeholder perspectives, ensuring that local knowledge, values, and priorities guide the planning process**. The Landscape Analysis also prepares the ground for participatory laboratories, providing data and insights for co-designing site-specific solutions and exploring potential scenarios. By **bridging environmental assessment, spatial planning, and community engagement**, it transforms complex territorial information into actionable insights for a sustainable energy transition. A detailed description of the methodology and data requirements for the Landscape analysis is provided in Technical Note 4: Landscape Analysis.

CO2 PACMAN Tool

To improve usability and engagement, the **CO2 PACMAN assessment framework** has been turned into an interactive visualization tool with an intuitive, colourful, and playful interface. The CO_2 equivalent emissions balance is represented as an "equivalent forest," where each island is defined as a grid of tiles, each corresponding to the area of forest required to absorb emissions from different sectors. This visual representation allows users to track the impact of the selected solutions in real time as forest tiles "disappear" to reflect emission reductions, providing an engaging, tangible way to explore possible climate-neutral roadmaps through the CO2 PACMAN Tool.

The **CO2 PACMAN Tool** integrates GHG inventory data and estimates of possible renewable energy production from local physical characteristics, along with key territorial features — such as land-use patterns — into an **interactive, user-friendly platform designed to help develop and apply customized decarbonisation strategies for Mediterranean islands.**

Structured around sequential steps, the tool guides users from entering baseline information to modelling decarbonisation strategies and possible offset measures.

The Tool's **modular design and intuitive interface** make it accessible to a wide range of stakeholders, including local authorities, schools, and citizens. It simplifies complex environmental data into actionable insights, transforming **scientific assessments into participatory decision-making** and empowering stakeholders to become active participants in the climate transition process. See Technical Note 5: CO2 PACMAN Tool for more details on the Tool features.

Although developed within the Assessment Phase, the CO2 PACMAN Tool is designed as a **transversal element of the Toolkit**, serving as a **bridge between assessment and scenario development**. It translates validated data into an interactive format that supports evidence-based co-design, ensuring a smooth connection between analytical results and participatory decision-making.

The **GHG inventories**, combined with **landscape evaluation** and **early citizen engagement**, form the backbone of the CO2 PACMAN Toolkit's assessment. They provide a **consistent, verifiable baseline** to quantify, monitor, and reduce emissions over time, enabling local authorities and communities to identify primary emission sources, prioritize mitigation measures, and implement evidence-based strategies aligned with territorial and environmental constraints.

CO2 PACMAN Toolkit: SCENARIO DEVELOPMENT

The Scenario Development phase builds upon the critical foundation of the Assessment Phase, transforming data, insights, and community knowledge into shared visions and actionable roadmaps toward climate neutrality. Central to this phase is the creation of participatory and innovative processes that enable stakeholders to co-design realistic transition scenarios, explore alternative futures, and identify feasible solutions that balance environmental ambition with social and economic viability.

This phase **integrates creativity, collaboration, and technological innovation to guide the definition of transition roadmaps**. It combines the forward-looking ideas of young generations, the technical expertise of enterprises, the strategic alignment of financial mechanisms, and the collective aptitude of communities through participatory laboratories. Immersive visualization tools further enhance understanding and engagement, turning abstract data into tangible experiences. The Scenario Development phase consists of five main elements:

1. Youth Think Tank

At the core of the Scenario Development phase is engaging the young generation—those who will bear the consequences of today's decisions and lead the transitions of tomorrow. The **Youth Think Tank (YTT)** was created to channel their creativity, curiosity, and sense of responsibility into co-creating climate-neutral futures. **Students are empowered as active contributors** rather than passive learners, shaping sustainable transformation within their communities.

The YTT makes education a collaborative effort, promoting a culture of critical thinking, innovation, and civic engagement. By combining learning with hands-on experimentation, students can interpret local data, explore decarbonisation strategies using the **CO2 PACMAN Tool**, and turn these insights into concrete ideas and shared visions for change. In doing so, it links scientific evidence with imagination, bridging the gap between knowledge and action. The use of the tool enables youngers to concentrate on the "how" and the "how much" rather than on the "if" or on the simple fear of the future.

Beyond raising awareness, the Youth Think Tank builds the capacity of a new generation of informed, skilled, and motivated climate advocates who can actively engage in local decision-making processes (**capacity building**). It introduces **fresh perspectives** and innovative ideas that enhance community discussions on the energy transition, creating space for creative and unconventional solutions. Simultaneously, it fosters **cross-generational dialogue** by connecting young people with institutions, experts, and local stakeholders, thereby strengthening a shared sense of responsibility for shaping a sustainable future. Lastly, the initiative directly contributes to **co-designing transition roadmaps**, offering qualitative and visionary insights that guide subsequent participatory activities, such as **The Island I Would Like Labs**.

Through the Youth Think Tank, the CO2 PACMAN Toolkit combines education, participation, and innovation into a unified process, ensuring the journey toward climate neutrality is not only technically effective but also socially inclusive and future-focused. The results of the Youth Think Tank testing phase are presented in the Testing the CO2 PACMAN Toolkit section, while the methodological details are provided in Technical Note 6.

2. Open Innovation Collaborative Action

The **Open Innovation Collaborative Action** serves as a strategic link between local challenges and external solutions. It connects the **demand for innovation from territories** with the **supply of ideas and technologies provided by European SMEs**, research centers, and startups. Within the CO2 PACMAN Toolkit, this initiative supports the transition toward climate neutrality by fostering a **collaborative setting** where knowledge, creativity, and technological expertise come together to deliver tangible solutions for decarbonisation. In this context, open innovation refers to a collaboration model in which organizations go beyond their internal capacities by engaging external actors to co-develop innovative products, processes, and services. It relies on flexibility, teamwork, and the sharing of knowledge across disciplines and sectors, making innovation a shared and participatory process rather than a competitive one.

Through this approach, the **CO2 PACMAN Open Innovation Collaborative Action** launches a series of "quests for solutions", inviting businesses and innovators to tackle specific local challenges related to renewable energy deployment, sustainable mobility, circular economy, or climate adaptation. The aim is to promote open dialogue between "challengers"—such as public authorities, institutions, corporates and community representatives—and "solvers," including SMEs, startups and innovators capable of delivering practical, scalable solutions.

All proposed solutions are gathered into the **Open Innovation Catalogue of Solutions**, a shared repository of best practices and applicable technologies. This catalogue functions as both a **knowledge base and a planning tool**, helping local actors incorporate innovative systems into cohesive, site-specific transition plans. By connecting local needs with external expertise, the initiative enhances SMEs' visibility as key contributors to the green transition and promotes the development of resilient, low-carbon communities.

More than just a technological exercise, this activity represents **a cooperative process that strengthens cross-sectoral and transnational collaboration**, encourages knowledge transfer, and transforms innovation into a collective asset for Mediterranean regions and beyond. The results of the Open Innovation Collaborative Action are detailed in the Testing the CO2 PACMAN Toolkit section, while the methodological details and procedures are outlined in Technical Note 7.

3. Financing the Transition

Financing the Transition emphasizes the economic dimension of the climate-neutrality journey, helping territories see how their visions can become practical, **financially viable roadmaps**. While other parts of the Scenario Development phase foster creativity, participation, and innovation, this component focuses on unlocking the **resources** needed to bring those ideas to life. This activity simplifies the **complex ecosystem of funding opportunities** available for sustainable and low-carbon projects. It guides stakeholders through the broader **European financial landscape** — highlighting EU **climate commitments**, key **funding programs**, and emerging **financial instruments** — while showing how **grants, loans, guarantees, equity mechanisms**, and **innovative funding models** can support different transition measures. Instead of treating finance as a separate or highly technical area, the activity frames it as a catalyst that can accelerate or delay the implementation of **local priorities**.

By combining expert insights, real-world experiences from public authorities, and innovators' needs, Financing the Transition **helps territories understand financial implications and navigate everyday challenges such as procurement rules, fragmented responsibilities, and sectoral funding gaps**. Within the Scenario Development phase, it links vision to action by connecting ideas from the Youth Think Tank, Open Innovation Collaborative Action, and The Island I Would Like Labs with the financial instruments needed for implementation, ensuring that the roadmaps are technically feasible, socially acceptable**, and economically resilient**. Methodological details are outlined in Technical Note 8.

4. The Landscape Scenario, Design Prototyping & Virtual Reality and Visualization Tools

In planning and design workflows, developing landscape scenarios, creating design prototypes, and visualizing in virtual reality are carried out by separate professional fields, often using parallel yet distinct methods. Within CO2 PACMAN, therefore, in this Toolkit, these elements are intentionally combined into a single, interconnected process that links analytical assessment, spatial design exploration, and immersive visualization. This integrated approach is a key innovation of the Toolkit, ensuring that landscape design reasoning and VR-based evaluation continuously inform each other, thereby enhancing both the technical strength and the participatory relevance of the decarbonization pathways examined.

4.1 The Landscape Scenarios and the design prototyping

The landscape scenarios lay the groundwork for the **spatial and visual scenario of the CO2 PACMAN Toolkit**. Developed directly from the assessment phase, they combine land-use categories with Renewable Energy Technologies (RETs) that received positive suitability ratings and incorporate insights from scientific literature, local partners, and Rooting Labs. Designed as descriptive and exploratory narratives, the scenarios do not offer specific solutions; instead, they pose questions about potential territorial futures, helping communities compare different landscape pathways related to renewable energy deployment. From these scenarios, a selection of sample sites is chosen to prototype specific landscape design configurations. Using a Research Through Design approach, the prototyping phase integrates additional morphological, environmental, and spatial data to create a range of representations — plan views, photorealistic top-down images, landscape sections showing the relationships between RET and existing features, and 3D models aligned with the Landscape Features methodology. These **design outputs form the technical foundation for subsequent visualization steps**. Additional methodological details are provided in Technical Note 9 (Subsection 9.1).

4.2. The Virtual Reality and Visualization Tools

Building on the landscape-scenarios design prototypes, the **Virtual Reality (VR) and visualization tools** are the most innovative features of the CO2 PACMAN Toolkit, designed to transform landscape-scenario and design prototype data into immersive, tangible experiences that bridge scientific assessment and public perception. This component helps stakeholders visualize future energy landscapes and understand trade-offs. Through **3D immersive simulations**, users can explore how renewable energy infrastructure and decarbonisation measures might interact with current landscapes in representative landscape design prototypes, observing their spatial footprints and potential synergies among environmental, social, and economic factors. By making the visual dimension explicit and enabling users to experience in advance how renewable energy installations would look in the real living environment, VR simulations also help address common **NIMBY (Not In My Back Yard)** reactions, reducing perceived risks and encouraging more informed acceptance of renewable technologies. This visual approach helps transform technical design information as technical drawings into experiential knowledge, supporting a shared understanding of what climate neutrality could look like in practice. More than just a communication or dissemination tool, the **VR environment acts as an interactive platform** for participation and decision-making. It enables citizens, planners, and policymakers to jointly evaluate options, visualize trade-offs, and discuss alternative configurations in real time. By transforming spatial data into dynamic narratives, the tool promotes inclusiveness, transparency, and shared ownership of the transition process. Integrated within the broader **CO2 PACMAN Toolkit**, the VR component complements analytical instruments such as the CO2 PACMAN Tool, the Landscape Scenario, and the participatory Labs. Together, they form a cohesive system where technical precision meets human perception—supporting evidence-based, socially accepted, and spatially sensitive decision-making. Additional methodological details, including guidance on designing and adapting VR and 3D visualization environments for different territorial contexts, are provided in Technical Note 9 (Subsection 9.2).

5. The Island I Would Like Labs

The Island I Would Like Labs marks the second participatory phase of the CO2 PACMAN Toolkit, where **assessment insights become action and shared knowledge develops into co-created visions for climate-neutral futures**. Building on the foundations laid during the Rooting Labs, this stage turns the analytical and social insights into concrete, **participatory scenario-building and decision-making processes.**

Rooting Labs not only provided baseline data on emissions, landscape, and citizens' perceptions but also served as a guiding tool for setting priorities, recognizing challenges, and shaping the design of these second-round workshops, *The Island I would Like Labs*, ensuring complete continuity between assessment and scenario development.

Designed as **collaborative co-design spaces**, *The Island I Would Like Labs* involve public authorities, planners, businesses, citizens, and especially young people in a shared reflection on potential roadmaps to achieve climate neutrality. Using the **CO2 PACMAN Tool**, participants can explore various combinations of measures, prioritise appropriate decarbonisation solutions, visualize their potential impacts, and evaluate the feasibility of actions within a collective, evidence-based environment. The exercise demonstrates a direct, practical link between the assessment findings and the scenario-planning process, actively engaging participants in critical reflection on real-world trade-offs. Through hands-on exploration of policy combinations and their projected impacts, participants are empowered to co-produce data-driven, context-specific decarbonisation strategies that are both evidence-based and locally grounded.

A key feature of the Labs is the use of **Landscape Scenarios, Design Prototypes, and 3D visualization tools,** which convert spatial and environmental data into sample landscape illustrations and immersive simulations. The landscape illustrations and the digital models strongly support participants' engagement and help them understand the interactions between decarbonisation options and their landscapes, fostering informed, place-sensitive decisions. The use of Landscape Scenarios, Design Prototypes, and 3D visualization tools improves dialogue between technical experts and citizens, making the complexity of the transition more tangible and easier to understand, and helping avoid an a priori NIMBY attitude.

The Labs foster **collaboration, creativity, transparency, and shared responsibility**, integrating insights from the Youth Think Tank and Open Innovation Collaborative Action into a unified participatory framework. They serve as spaces for collective learning and for testing, inspiration from planning tools, and transition scenarios tailored to different contexts.

Technical Note 10 provides methodological guidance and practical suggestions for designing, organising, and facilitating these workshops — including examples of agendas, formats, and engagement techniques — to support the replication of this approach in other territories.

Together, these components transform the CO2 Toolkit from an assessment framework into a **dynamic process of design and co-creation**, where evidence meets imagination and transition becomes a shared, **achievable vision for the future**.

CO2 PACMAN Toolkit: Multi-level Stakeholder Involvement

Achieving climate neutrality in island territories requires more than robust data, analytical tools, and technological solutions — it relies on the **active and coordinated participation** of those who make, implement, and live with decisions. Within the CO2 PACMAN Toolkit, **stakeholder engagement** functions as the connective tissue linking **assessment, scenario development**, and **action**. It transforms technical analyses into a dynamic, **participatory process** through which institutions, businesses, and citizens collaboratively **envision, plan, and realise a sustainable future**.

At the institutional level, **public authorities are steering and enabling the transition**. They provide access to key datasets, validate the results of the GHG balance and landscape analyses, and help define strategic priorities for the island's decarbonisation pathway. Their involvement ensures that **transition plans** developed through the CO2 PACMAN Toolkit **are technically sound, socially legitimate, and aligned with existing governance frameworks**. Their active engagement in participatory workshops such as the Rooting Labs and *The Island I Would Like* Labs strengthens interdepartmental coordination across energy, transport, land-use, and tourism planning under a shared vision of climate neutrality. Beyond ensuring institutional alignment, the process empowers public bodies

to act as facilitators of innovation rather than mere regulators. **Continuous dialogue** with the community **builds trust, transparency, and political legitimacy**, essential conditions for implementing sustainable, transformative policies in island contexts.

Within the CO2 PACMAN framework, **Small and Medium Enterprises** (SMEs) **serve as catalysts of operational and economic innovation**, bringing flexibility, practical know-how, and creativity to the decarbonisation process. Through the Open Innovation Collaborative Action, they help transform transition strategies into concrete, locally relevant solutions that align with circular-economy principles. By pairing territorial challenges with external expertise, the initiative creates a two-way exchange that **connects local needs with market-ready innovations.** SMEs participate as **active co-creators of the islands' low-carbon transformation** through solution "quests," contributions to the Catalogue of Solutions, and engagement in the Business Forum. Their involvement fosters a culture of open innovation, **enhances economic diversification, and strengthens both the feasibility and local ownership of the transition**. At the same time, companies gain visibility, networking opportunities, and access to emerging green markets, positioning themselves as key partners in advancing climate action.

Citizens and young people form the **social foundation of climate action.** The CO2 PACMAN Toolkit places them at the centre of the transition to climate neutrality- not as passive recipients of policy but as **active contributors to shaping territorial collective visions**. Through participatory tools such as AskyourcitizenonCaN, Vox Populi interviews, and hands-on laboratories, the project captures community perceptions, expectations, and willingness to act. These insights reveal how prepared communities are to embrace change, which behaviours they may adjust, and what types of support they need, ensuring that local voices meaningfully guide decision-making and help co-create viable, context-specific solutions. Youth engagement brings a particularly transformative dimension. By combining education with experimentation, **the Youth Think Tank nurtures climate-literate, civic-minded future leaders**. Students are encouraged to analyse data, develop informed opinions, and propose innovative decarbonisation pathways. Their ideas—reflected in activities such as The Island I Would Like Labs—**bring creativity, innovation, hope, and cross-generational dialogue** into the transition process. Their involvement enriches present-day decision-making while strengthening long-term capacity for sustainable governance.

CO2 PACMAN promotes a **shared pathway towards climate neutrality.** The convergence of engagement from public administrations, SMEs, and citizens leads to **shared ownership and collective responsibility**, the ultimate goals for achieving climate neutrality. Because no single actor can deliver the transition alone, it must be co-created through trust, collaboration, and a shared sense of purpose. The CO2 PACMAN Toolkit provides the structure and language for this collaboration, linking scientific evidence with lived experience and aligning strategic planning with community values. As stakeholders move from assessment to scenario development and from vision to action, they jointly assume responsibility for outcomes, **strengthening both the robustness and societal acceptance of transition plans**.

By integrating diverse forms of engagement into a cohesive participatory ecosystem, the **CO2 PACMAN Toolkit demonstrates that effective climate action is as much a social endeavour as it is a technical one**. This inclusive model of governance allows island territories to transform structural constraints into opportunities for innovation, resilience, and collective climate leadership.

Testing the CO2 PACMAN Toolkit

Testing the CO2 PACMAN Toolkit across the three pilot islands—Brač, Crete, and Elba—was a **crucial step in validating its methodological consistency, operational usability, and adaptability to different territorial conditions**, ultimately to plan *The Island I Would Like* laboratories. On each island, the Toolkit's full assessment phase was carried out, combining data collection, Greenhouse Gas (GHG) balance, participatory engagement, YTT activities, and Open Innovation Collaborative Action.

Across all three islands, the Toolkit demonstrated **its ability to integrate analytical modelling, stakeholders' involvement, and educational components into a cohesive process to support climate-neutrality planning**. The following cross-cutting insights emerged:

A strong analytical foundation across territories: GHG inventories were performed on all islands (Figures 2, 3, 4).

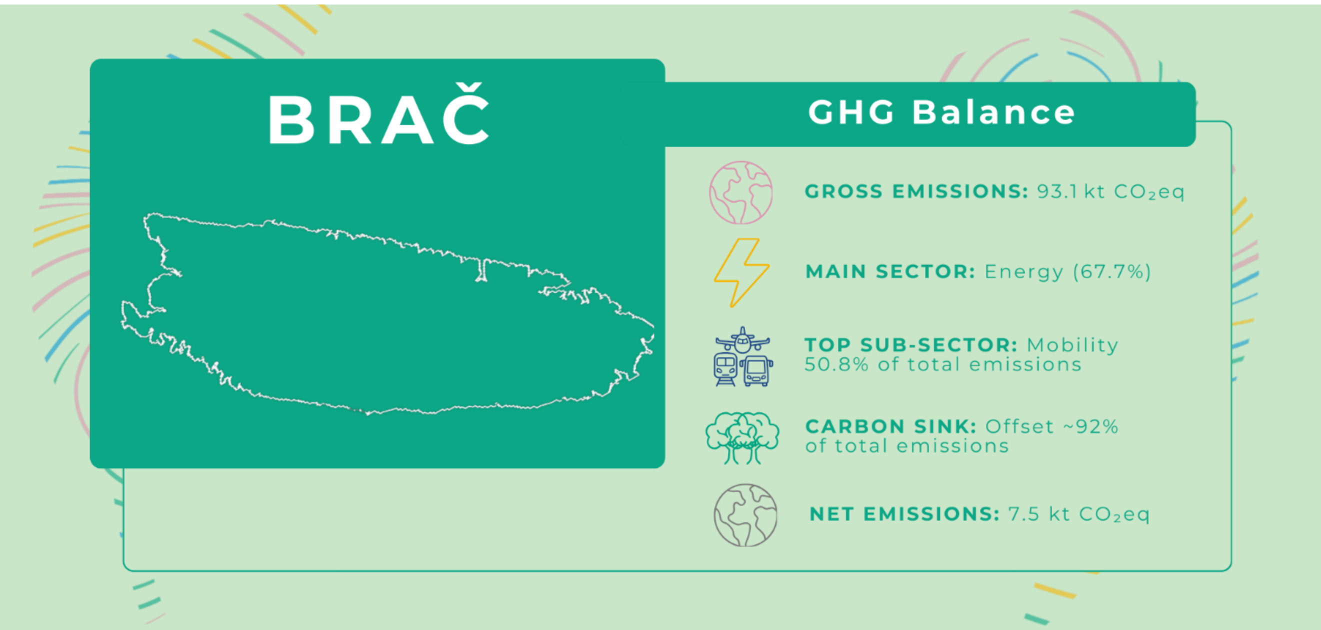


Figure 2: Summary of Brač GHG balance

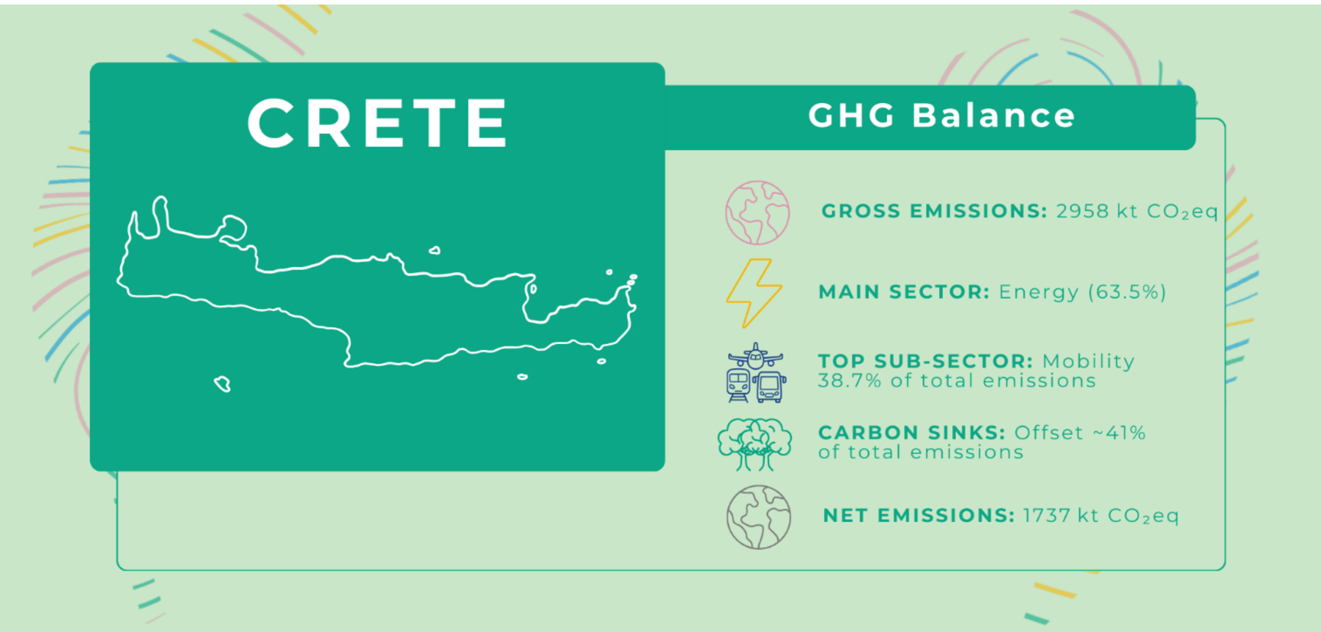


Figure 3: Summary of Crete GHG balance

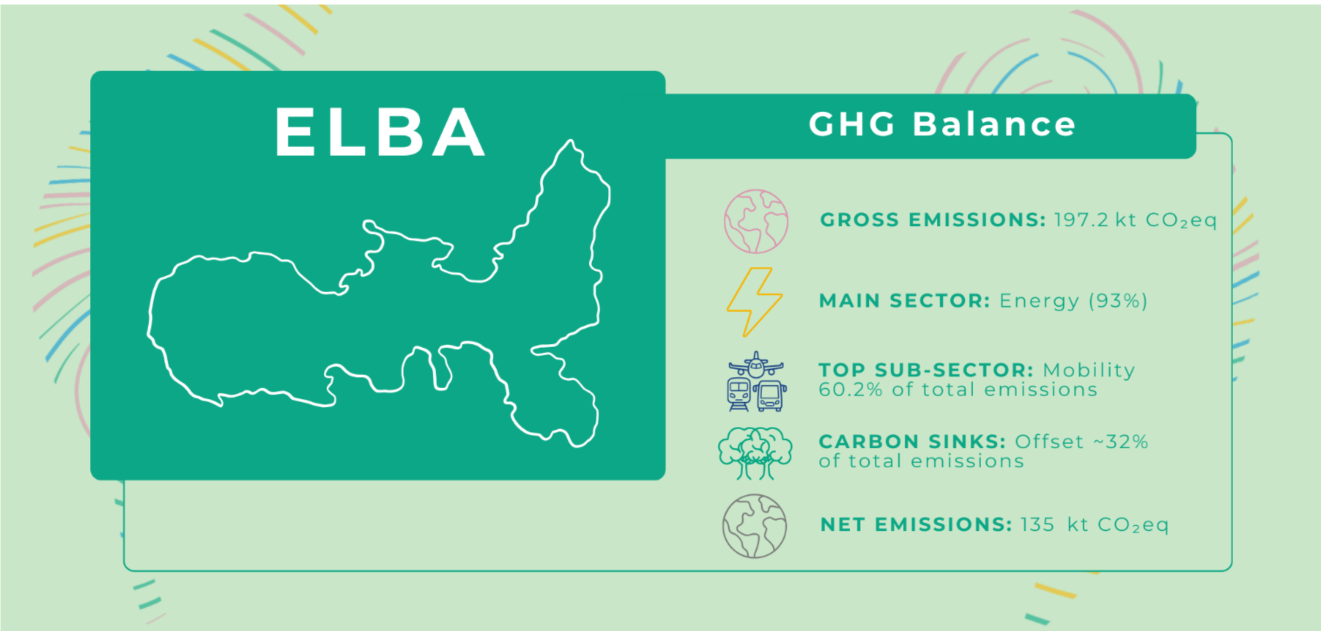


Figure 4: Summary of Elba GHG balance

For detailed results, see Testing the Toolkit: Insight on the final chapter of the document.

GHG balances establish a standardized emissions baseline and enable integration of results into the CO2 PACMAN Tool (Figures 5, 6, 7).

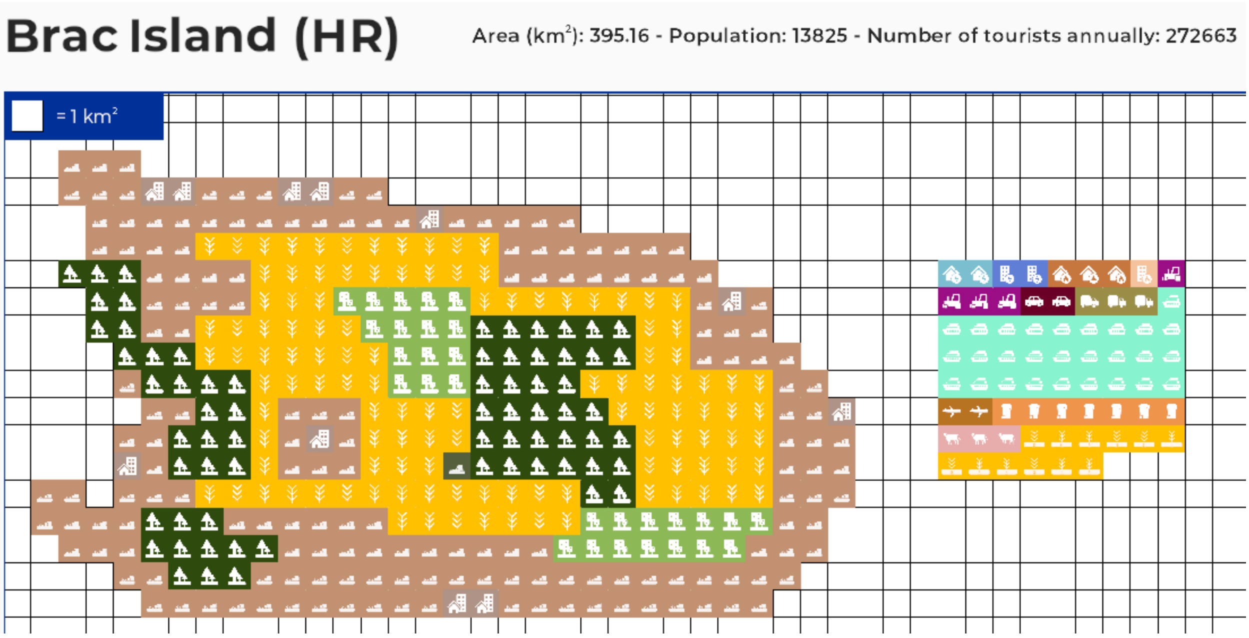


Figure 5: Visualization of the Brač land use map (left) and GHG balance expressed as "equivalent forest (right)

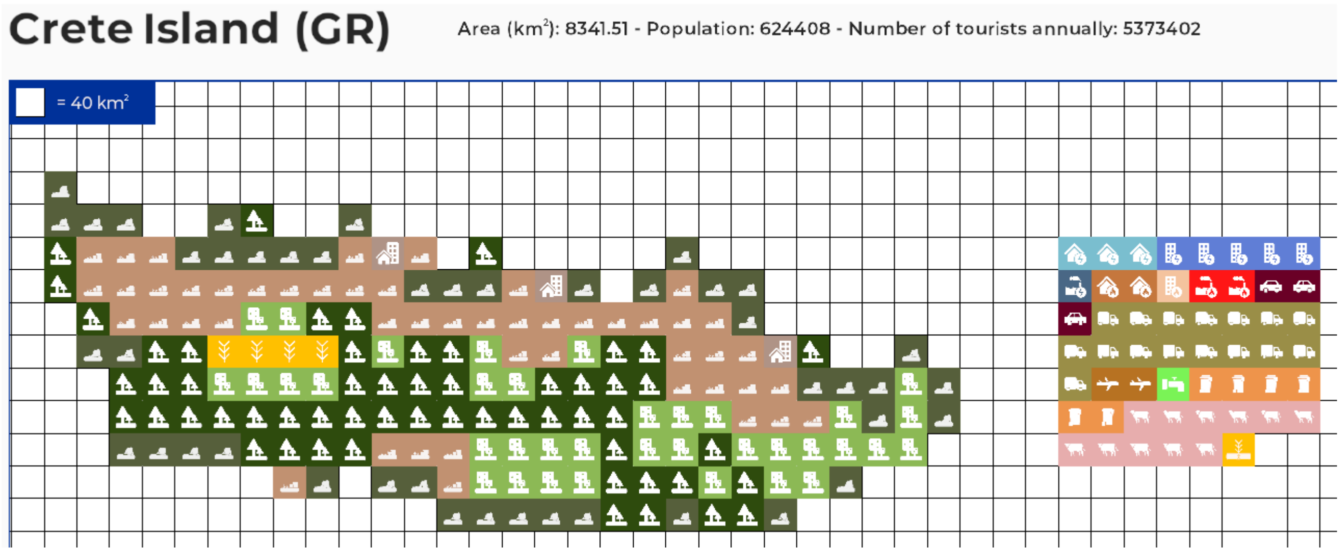


Figure 6: Visualization of the Crete land use map (left) and GHG balance expressed as "equivalent forest (right)

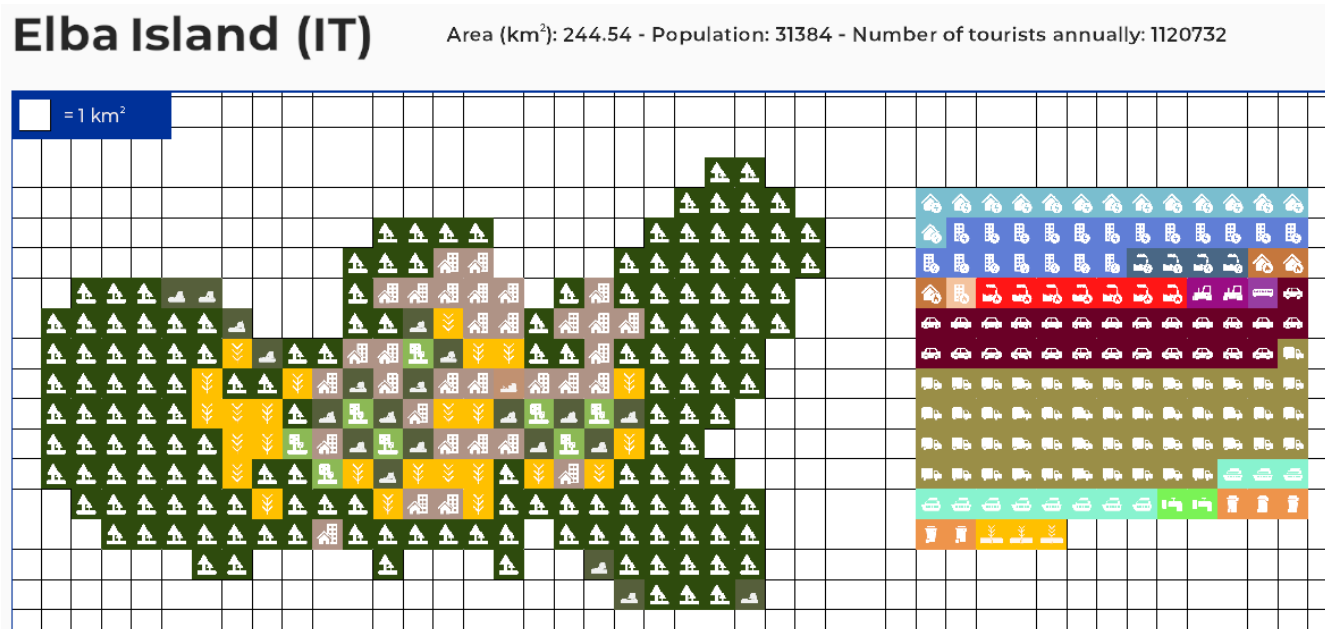


Figure 7: Visualization of the Elba land use map (left) and GHG balance expressed as "equivalent forest (right)

Despite differences in scale and sector profiles, the methodology proved robust and adaptable, able to manage diverse data structures, especially when statistical gaps or inconsistencies required additional validation with local partners. This robustness is further supported by the methodology's ability to accommodate heterogeneous data sources and levels of granularity, combining national statistics, regional datasets, and locally collected operational data through a harmonisation process that enables the integration of different formats, units, and spatial scales into a coherent analytical framework.

Stakeholder engagement served both as a diagnostic tool and a catalyst: the Rooting Labs played a vital role in supporting the project locally. They served as a site for data validation, a forum for discussing territorial priorities, and a platform to activate networks of cooperation among authorities, infrastructure providers, SMEs, NGOs, citizens, and youth. Although participation varied by island, all Labs emphasized the importance of a structured, multi-level engagement approach (Figure 8, 9 10).

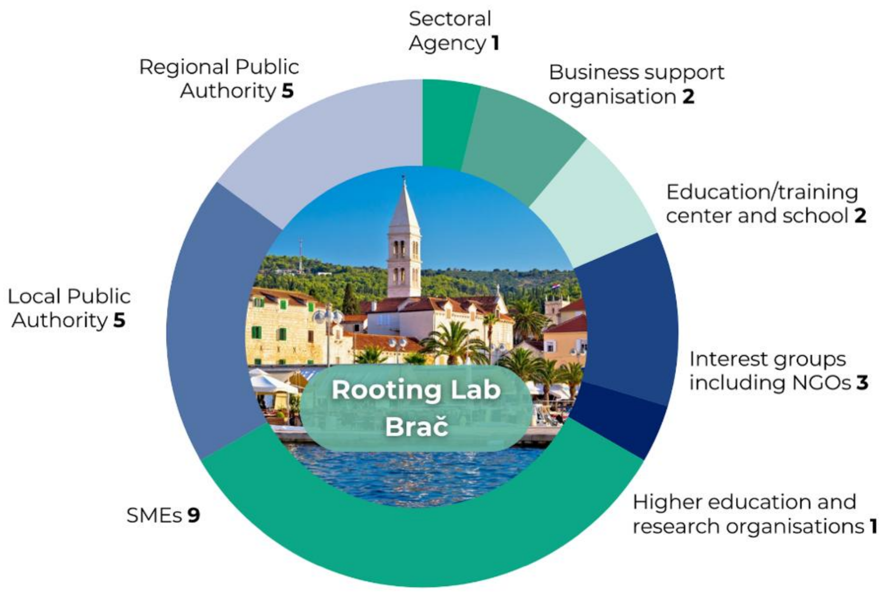


Figure 8: Stakeholders engaged in the Brač Rooting Lab, categorized by stakeholder typology rather than absolute number of participants

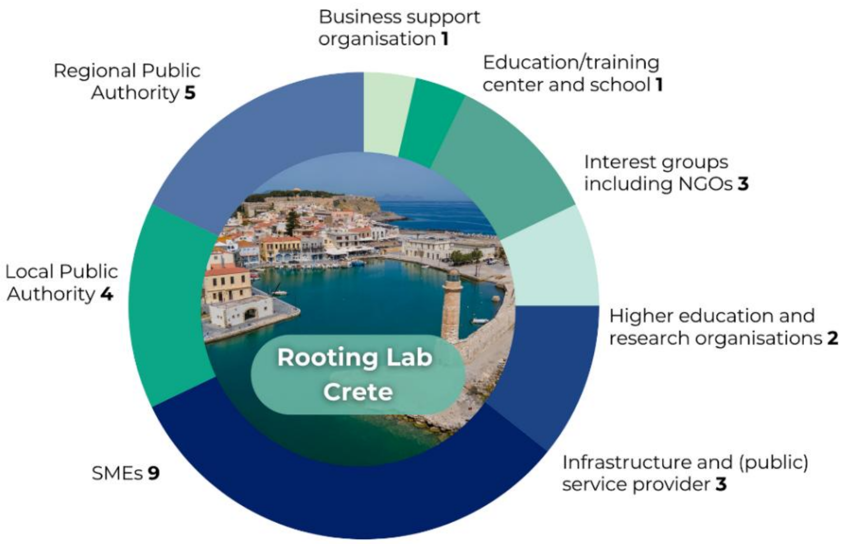


Figure 9: Stakeholders engaged in Crete Rooting Lab, categorized by stakeholder typology rather than the absolute number of participants

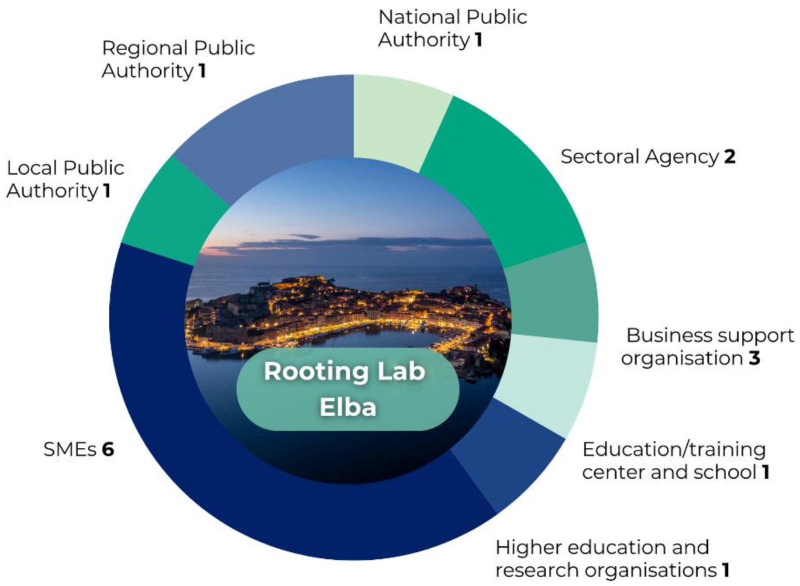


Figure 10: Stakeholders engaged in the Elba Rooting Lab, categorized by stakeholder typology rather than the absolute number of participants

Detailed results of the Rooting Labs are in Testing the Toolkit: Insight, the last chapter of this document.

Youth involvement as a driver of continuity: The Youth Think Tanks across the three islands showed consistent results: students expressed strong concern about climate change, but had varying familiarity with climate-neutrality concepts. Participatory learning, interactive exercises, simulation of design and decision-making processes, and digital tools or games significantly increased motivation and understanding. Notably, involving youth early in the process helped create continuity between the initial and later phases of the Toolkit (Figures 11, 12, 13).

Figure 11: Highlight from the YTT in Brač

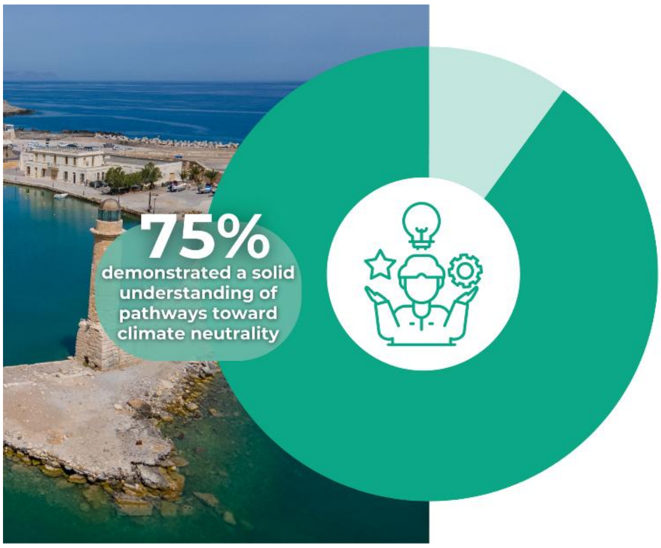


Figure 12: Highlight from the YTT in Crete

Figure 13: Highlight from the YTT in Elba

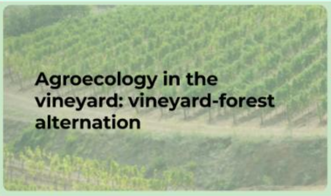
Open Innovation acts as a bridge between local needs and external solutions: the Open Innovation Collaborative Action enabled each island to identify specific decarbonisation challenges and connect them with EU-wide problem-solvers. Despite sectoral differences—waste, water, mobility, agriculture—the mechanism effectively translated abstract needs into concrete proposals, fostered new collaborations, and paved the way for pilot projects (Figures 14, 15, 16). These selected solutions may still evolve, as their final definition will be refined before the next phase, when challengers will confirm which options they wish to explore further.

BRAČ CHALLENGE	SOLVERS	
Route planner for identification of vessels and containers for waste on the island of Brač	Integra Estrategia y Tecnología	5
	LIS Data Solutions	
	Nordsense	
	SmartEnds BV	
	4 Colors	
FireSafeEV - increasing knowledge and safety for electric vehicle fires	Argos	6
	Fire Isolator	
	Legal Pythia	
	Luveti	
	Simon Rack EcoFire	
	University of Central Lancashire	
Applicative solution for monitoring and reducing drinking water losses from the water supply system	Defcom 8	7
	Fibsen	
	Immersia	
	Hulo	
	NRW Cockpit / Hydroscan	
	Uclan	
	Waterness	

Figure 14: Open Innovation Collaborative Action in Brač: challenges (on the left), solutions received (in the middle), categorized by nationality of the solvers and the number (on the right). The selected solvers are highlighted in green.

CRETE CHALLENGE	SOLVERS	
Substitution of peat (non-renewable) with other organic materials to enhance the circular economy	Cardiff Metropolitan University	5
	Durham University	
	Porto Protocol	
	SilviBio Ltd	
	Veganic	
Smart small-scale organic waste treatment system for medium and large hotels	AbonoKm0	6
	D-organic	
	Effiwaste	
	Legal-Pythia	
	Miogas	
	Sustainable Food Science and Technologies	
Designing for Sustainable mobility - Smart data collection system for modal split analysis	Equitus	6
	Findspo	
	Legal-Pythia	
	LIS Data Solutions	
	Raiven	
	Urban Life	

Figure 15: Open Innovation Collaborative Action in Crete: challenges (on the left), solutions received (in the middle), categorized by nationality of the solvers and the number (on the right). The selected solvers are highlighted in green.



ELBA CHALLENGE	SOLVERS	
Agroecology in the vineyard: vineyard-forest alternation	Durham University	5
	Eurecat	
	Integra Estrategia y Tecnología	
	Legal Pythia	
	Porto Protocol	
Sustainable Events: A Roadmap to Carbon Neutrality for the Island of Elba	AIMPLAS	7
	Bluease	
	Ecopulse	
	ELBA NEST	
	Green Living Projects	
	LIS Data Solutions	
	Sea the Change	
Sun, Sea & Hydrogen	Bailardi Boutique Engineering	8
	David de Haro Malo de Molina	
	Enerco	
	Equitus Engineering	
	European Marine Energy Centre	
	GreenShift Elba	
	Muhammad Waheed Azam	
	University of Central Lancashire	

Figure 16: Open Innovation Collaborative Action in Elba: challenges (on the left), solutions received (in the middle), categorized by nationality of the solvers and the number (on the right). The selected solvers are highlighted in green.

A shared perception landscape: the AskyourcitizenonCaN survey revealed remarkably similar patterns in public perceptions across the three islands (Figure 17, 18, 19).

- **Very high environmental awareness** (88–89%)
- **Moderate optimism about reaching neutrality by 2040** (32–37%)
- **Clear priorities for renewable energy and waste management, followed by mobility, buildings, and sustainable agriculture.**

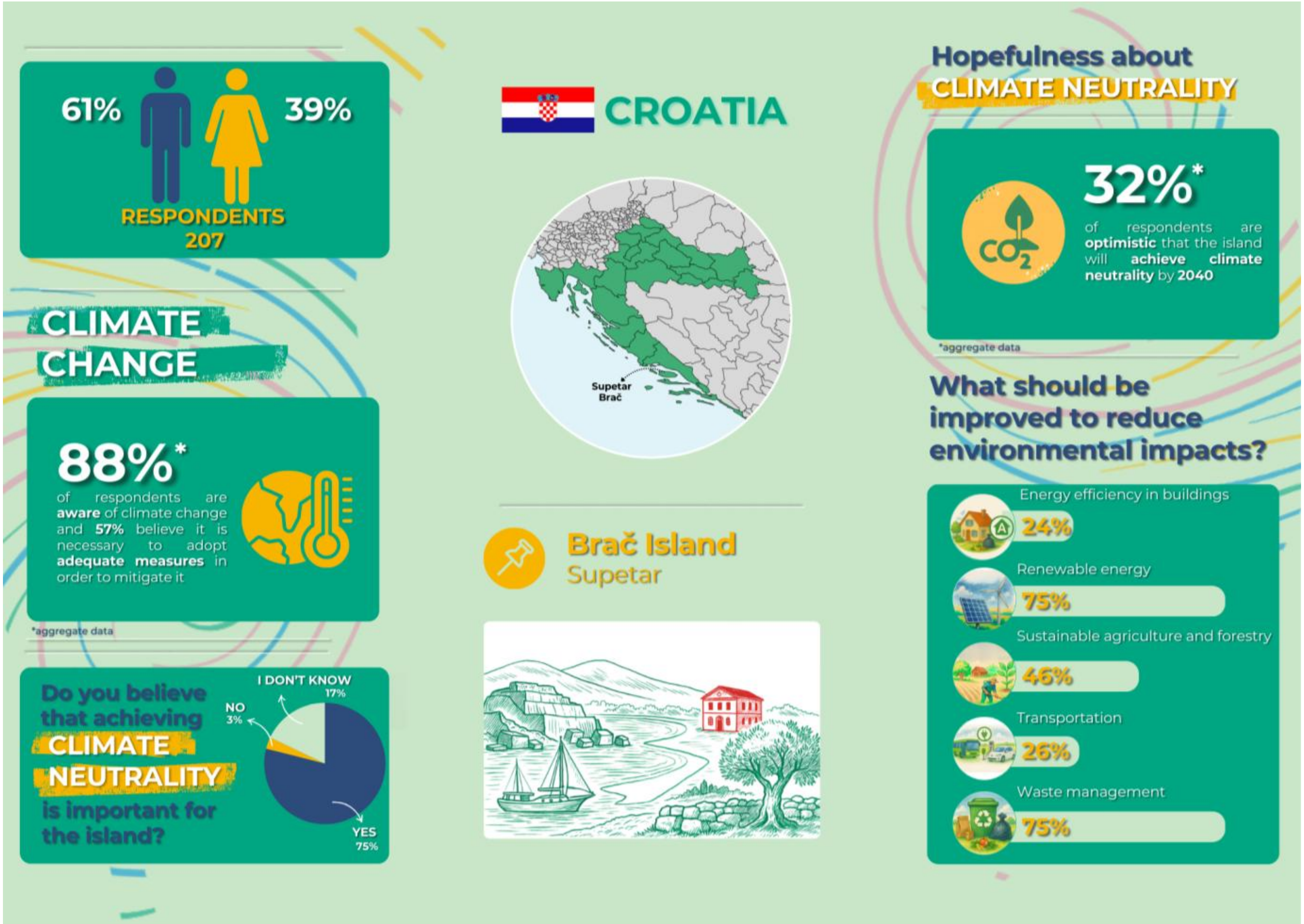


Figure 17: Key results of the survey AskyourcitizenonCaN in Brač island

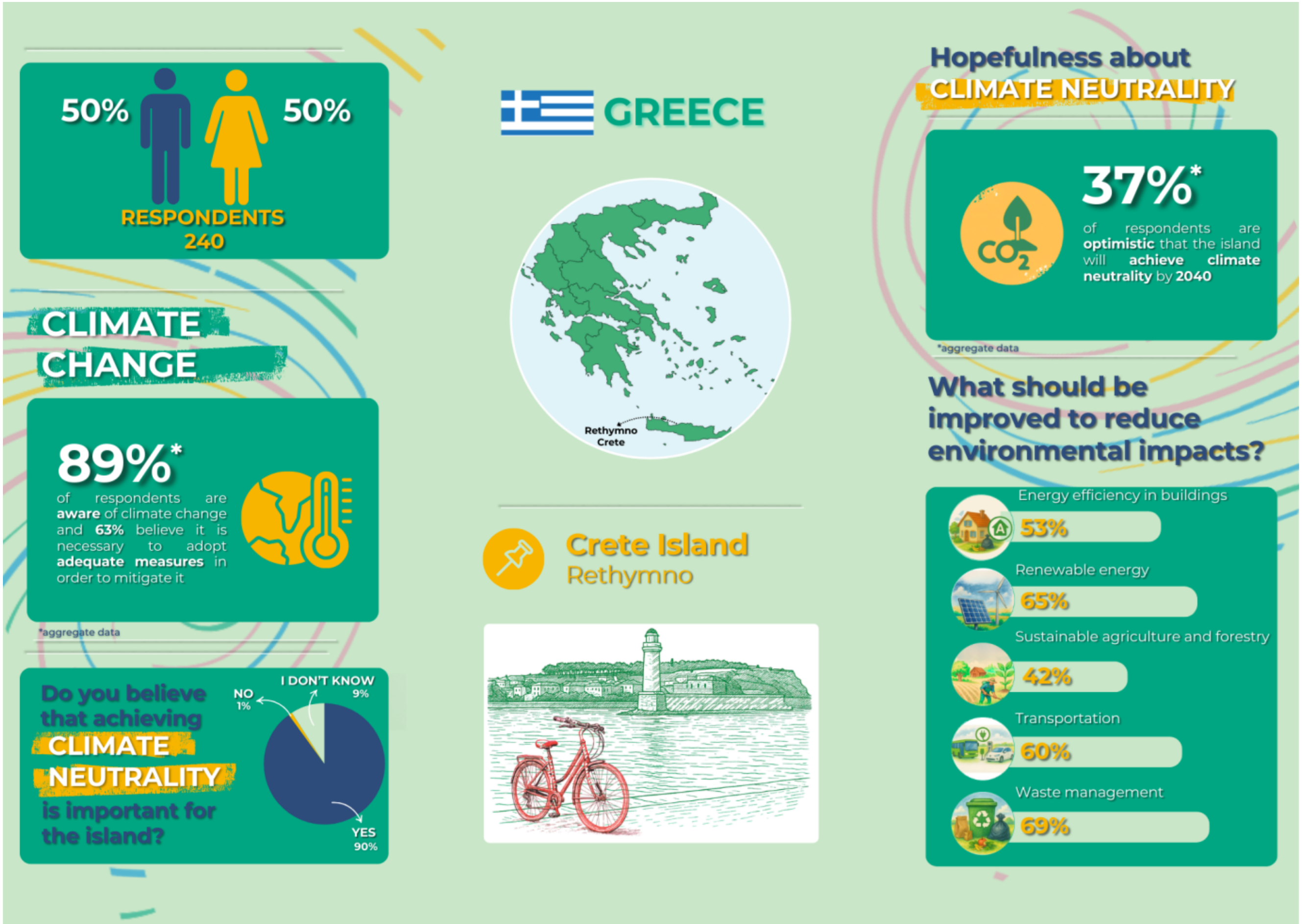


Figure 18: Key results of the survey AskyourcitizenonCaN in Crete island

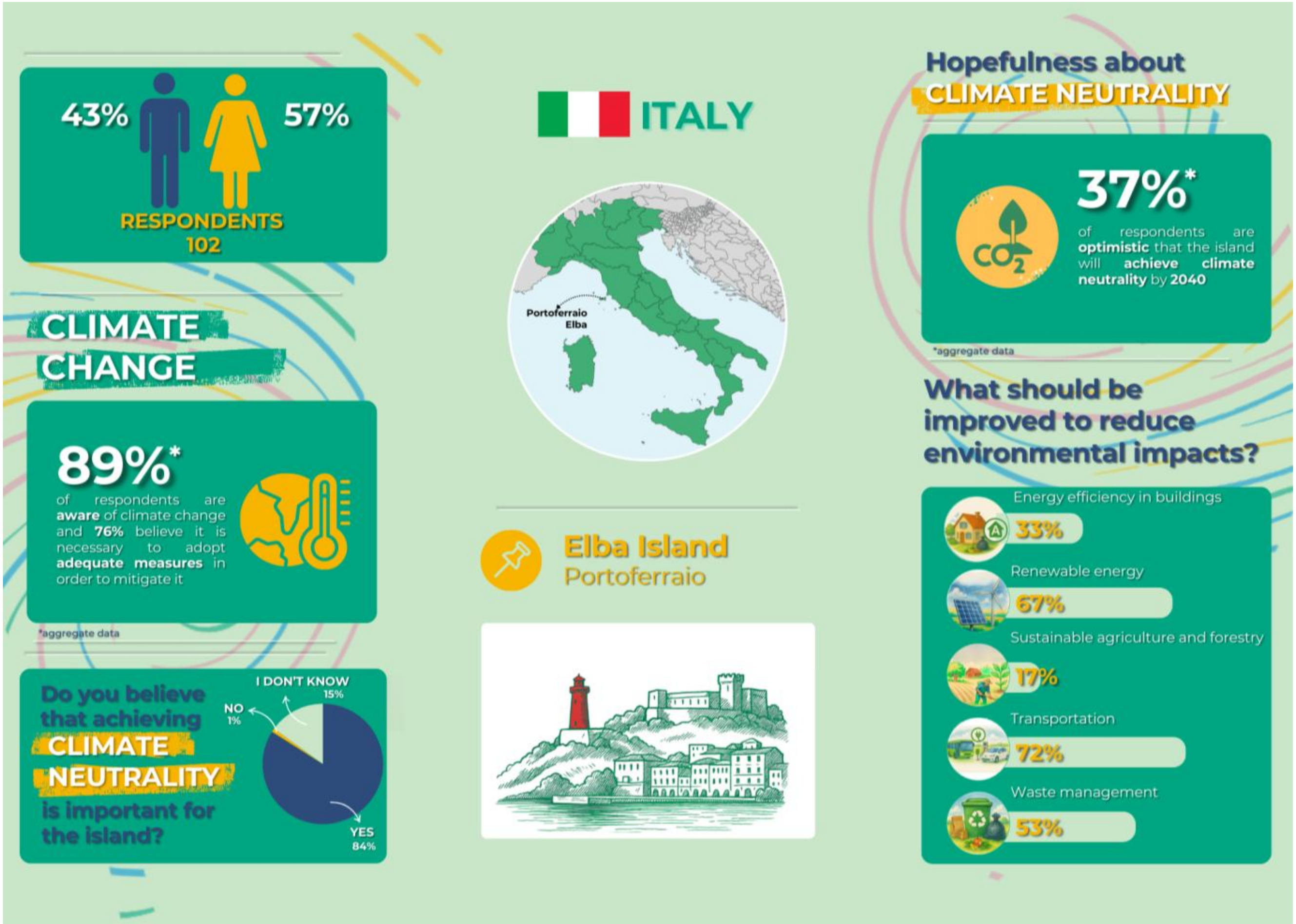


Figure 19: Key results of the survey AskyourcitizenonCaN in Elba island

These results aligned well with insights from Rooting Labs and Youth Think Tanks, confirming that the Toolkit consistently captures a socio-environmental signal across communities. Detailed results are presented in Testing the Toolkit: Insight, at the end of the document.

CO2 PACMAN Toolkit: Lessons from the Assessment Phase

The implementation of the CO2 PACMAN Toolkit across the three pilot islands provided valuable insights into integrating data, encouraging participation, and planning for climate neutrality. These lessons serve two primary purposes: they help future users apply the toolkit's methodology effectively and guide the design of the next participatory phase, *The Island I Would Like*, to ensure that future engagement activities are better suited to local contexts and stakeholder needs.

On Brač, Crete, and Elba, several common challenges arose, highlighting both technical and social aspects of the transition to climate neutrality. In particular, stakeholder engagement was sometimes hindered by limited availability, uneven awareness of climate-neutrality concepts, and competing local priorities, especially among SMEs and segments of the general public. To address these barriers, the project implemented a consistent engagement approach that combined targeted outreach, accessible communication tools, youth-driven initiatives, and flexible participation formats, ensuring that diverse audiences could contribute meaningfully throughout the transition process.

- **Data and technical challenges**: Local data on energy, mobility, and waste were often incomplete, inconsistent, or scattered across sectors. Harmonizing these datasets and ensuring reliable methods required significant effort. Additionally, some local administrations may lack the capacity or expertise to manage detailed GHG inventories, making some external technical support crucial for the toolkit's future success.
- **Stakeholder engagement and motivation**: While initial participation in the Rooting Labs was high, keeping stakeholders engaged over time was challenging. Groups such as smaller businesses and parts of the general public were more difficult to involve, often due to limited awareness, competing priorities, or doubts about the feasibility of climate neutrality. Differences in stakeholder priorities may slow down the discussions — for example, between economic growth interests and emission-reduction goals — highlighting the need for targeted messages, systematic engagement, and careful facilitation to ensure all voices are heard.
- **Communication and facilitation**: Explaining complex concepts like decarbonisation, climate neutrality, and scenario modeling required clear, accessible language. Interactive tools — including VR simulations and participatory games — were particularly effective in engaging youth and the broader community, turning abstract ideas into tangible, locally relevant scenarios. Language barriers and technical jargon have to be carefully managed to maintain inclusivity and understanding across diverse participant groups.
- **Logistics and organization**: Planning three-day participatory events on islands posed practical challenges. Travel times, timing during busy tourist seasons, and

venue accessibility affected attendance, especially among private sector representatives. Strategic scheduling becomes a key strategy to boost participation and maintain momentum.

Despite these challenges, the first round of Rooting Labs produced valuable insights and actionable results and achieved active engagement and genuine motivation of the local ecosystem. Brač concentrated on national and insular policy frameworks, analyzing local laws and inter-island cooperation. Crete focused on urban-level climate neutrality, combining visionary planning with multi-stakeholder participatory foresight, informed decision-making, and inclusive engagement of the full value chain of the community. Elba integrated data-driven planning, regional innovation, and multi-level governance, connecting concrete GHG inventories to practical solutions and policy discussions. Across all islands, these experiences emphasized **the importance of tailoring activities to stakeholder needs, encouraging interactivity, and aligning different interests toward a shared vision**.

These lessons directly inform the planning of **The Island I Would Like**, helping the next phase build on earlier experiences. They will ensure that co-design workshops engage stakeholders more effectively and produce outputs that are more tangible and actionable for local communities. In this way, **the CO2 PACMAN approach continually evolves, offering a flexible yet structured pathway for future adopters while fostering meaningful, locally rooted climate action**.

The implementation of the CO2 PACMAN Toolkit followed a **cyclical, iterative process** in which **analytical development and participatory engagement advanced simultaneously** and continually informed one another. While future users of the Toolkit will not need to redo the initial methodological development carried out by the project partners, understanding this sequence helps show how the components interact and support one another. In the **first six months**, the consortium focused on establishing the **methodological foundations of the Toolkit**, including the GHG Balance methodology, the participatory framework, and the operational structure of the CO2 PACMAN Tool. This initial work created the **technical backbone** that future adopters will implement, rather than rebuild.

With the foundations in place, the project moved into its **first implementation cycle**, centered on the **Rooting Labs**. Conducted over roughly six months, these Labs built the local evidence base by gathering and validating data while also mapping stakeholders, priorities, and early perceptions. During this same period, **other components started in parallel**: **Youth Think Tank** activities began in schools, the **AskyourcitizenonCaN** survey was conducted to assess social readiness, and local challenges were collected for the **Open Innovation Collaborative Action**. Schools also had their first chance to test and explore the CO2 PACMAN Tool, linking educational activities with real data from their area. After completing the Rooting Labs, the project entered its **second cycle**, focused on consolidating insights and transforming them into **forward-looking solutions**. The Open Innovation pathway was completed at this stage, culminating in a Business Forum that connected local challenges with proposals from SMEs and innovators. Schools were re-engaged to deepen their understanding of decarbonisation roadmaps, again using the CO2 PACMAN Tool to model scenarios and interpret the emerging evidence. The process then moved to the **scenario-building phase**, structured around **The Island I Would Like Labs** (conducted over approximately six months). These participatory workshops were **built directly on the outputs of the Rooting Labs, the Youth Think Tank, the AskyourcitizenonCaN survey, and the Open Innovation Action**. During these Labs, participants worked collaboratively with the CO2 PACMAN Tool — testing alternative strategies, comparing decarbonisation roadmaps, and assessing feasibility within the local context. The **Landscape Scenarios** also played a central role. Developed from spatial, environmental, and socio-economic analyses, these scenarios were presented to participants through **3D immersive simulations**. The results from the AskyourcitizenonCaN survey were shared and discussed collectively, enabling participants to evaluate how citizens see challenges and opportunities and how these insights should influence scenario design. To expand inclusion beyond those directly involved in the workshops, the vox populi method was used around the Labs to gather spontaneous reactions from passers-by and community members. These brief interviews helped verify whether citizens recognized themselves in the survey findings and the discussions in the Labs, thereby validating or enriching the shared vision.

Throughout the entire process, an iterative, cyclical approach guided the work: participatory activities refined analytical tools, while new data and evidence informed future engagement actions (Figure 20). **This adaptable structure (timeline included) is now part of the Toolkit, offering future users a flexible yet clear pathway for adapting the CO2 PACMAN approach to their own territories, with their specific needs and aims.**

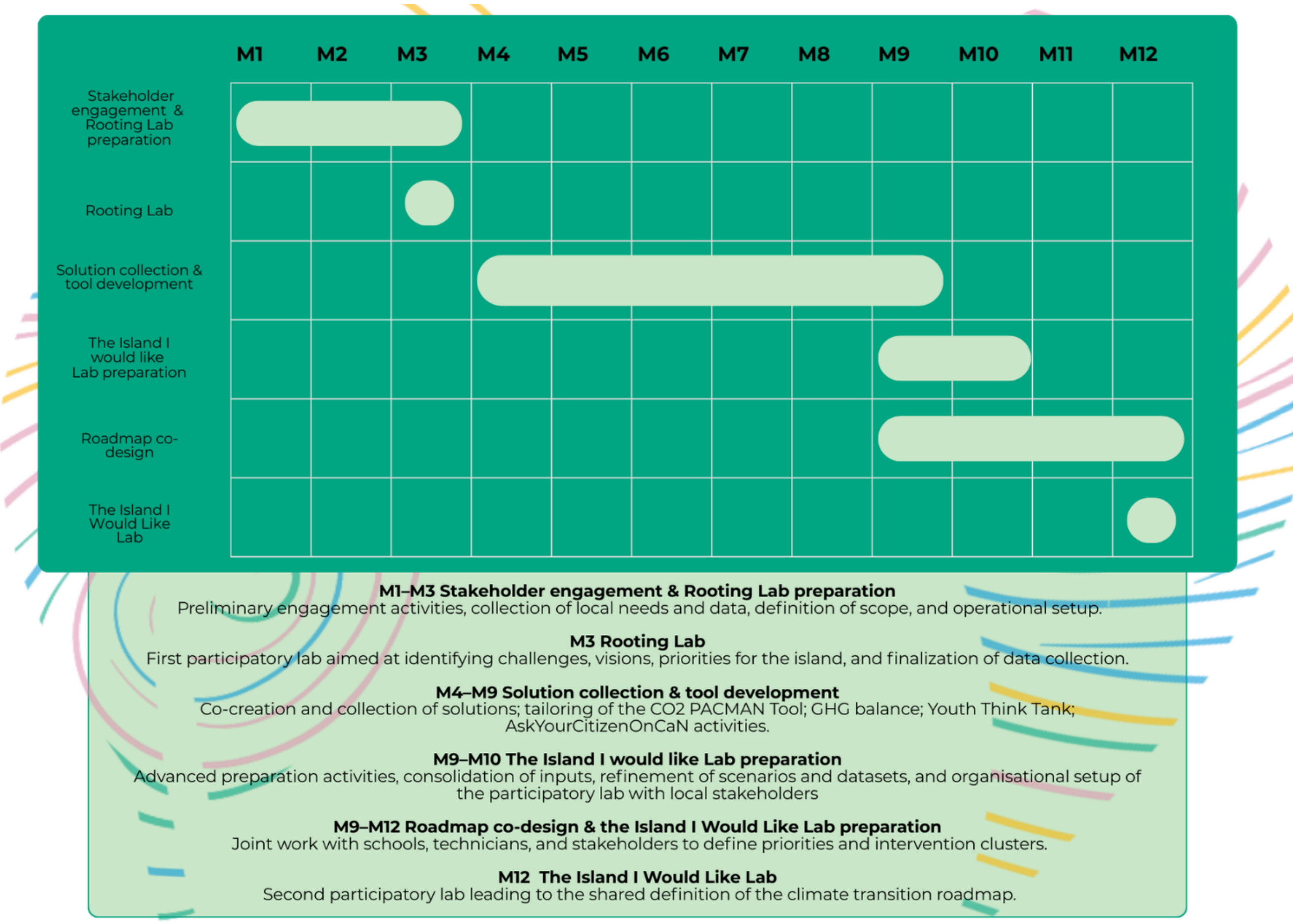


Figure 20: Timeline for the CO2 PACMAN Toolkit implementation

CO2 PACMAN Toolkit implementation: suggestions for replication

The piloting experience across Brač, Crete, and Elba confirms that the CO2 PACMAN Toolkit can be effectively replicated in other islands and territories, provided that a number of enabling conditions are established from the outset. The successful replication starts from a clear methodological foundation: while the project partners dedicated the initial months to developing and testing the Toolkit's architecture, future adopters can build directly on this consolidated framework, thereby shortening preparation time and starting with a reliable structure for data collection, stakeholder engagement, and strategic communication.

A second crucial element is the early creation of a representative stakeholder community: Rooting Labs demonstrated that inclusive engagement strengthens assessment quality by validating data and facilitating a shared understanding of local priorities. Involving local authorities, SMEs and businesses, schools, universities, NGOs, and citizens ensures that the process reflects the territory's complexity and that the resulting roadmaps are credible and socially grounded. Particular emphasis should be placed on engaging students and educators, whose involvement proved essential for bridging technical analysis with behavioural and cultural dimensions.

Replicating territories should also prioritize integrating quantitative analysis with participatory insights. The strength of the CO2 PACMAN approach lies in the continuous dialogue between data modelling — GHG inventories, mitigation scenarios, and spatial analysis — and the perceptions collected through the AskyourcitizenonCaN survey, the Youth Think Tank, and the Rooting Labs. Using these components in combination helps refine assumptions, prioritise interventions, and stimulate discussions that are both evidence-based and attentive to local preferences.

An additional lesson from the pilot islands is the importance of using the CO2 PACMAN Tool not as a one-off demonstration, but as a continuous learning platform. Repeated hands-on sessions with students, citizens, and institutional stakeholders helped consolidate understanding and awareness, making the transition more transparent and accessible. Territories replicating the Toolkit should therefore integrate iterative tool sessions throughout the process, especially during *rooting* and *the Island* (or any territory) *I would like* workshops or educational activities.

The open innovation component also played a decisive role in accelerating problem-solving. By linking local challenges to external solvers, the pilots identified promising solutions in areas such as waste management, mobility, water stewardship, and agroecology. Replicators should frame challenges based on the evidence emerging from the assessment phase and activate innovation ecosystems capable of bringing forward practical, scalable proposals.

A coherent timeline is essential, but flexibility is equally important. While the complete CO2 PACMAN process was implemented over around 24 months during the pilots, future adopters can adapt the pace to their administrative capacity, data availability, and policy cycles. What matters is maintaining the overall sequence—data collection, participation, scenario building, innovation, and iteration—while tailoring the intensity and duration of each phase to local needs.

Communication emerged as another key success factor. The Cretan experience in particular demonstrated how strategic outreach can broaden participation, enhance legitimacy, and increase the public resonance of climate neutrality efforts. Replicating territories should therefore embed communication and feedback loops throughout the process, ensuring that the work remains visible, accessible, and meaningful to the broader community.

Finally, it is essential to plan for continuity beyond the assessment phase. The results generated through the CO2 PACMAN process should not be seen as an end in themselves, but as a foundation for ongoing action. They can guide the implementation of the visioning Lab, The Island I Would Like, inform policy design, support climate-related community initiatives (e.g., energy communities), shape educational programs, and contribute to future updates of local and regional climate strategies. Ensuring continuity is what ultimately transforms the assessment from a technical exercise into a long-lasting driver of territorial transformation.

Of course, when the “adopters" use the Toolkit, they need to be realistic: CO2PACMAN's two-year implementation showed that to replicate the Toolkit, territories require a minimum set of reliable baseline data on energy, mobility, waste, land use, and demographic characteristics, as well as the institutional capacity to coordinate stakeholder engagement activities. A dedicated local authority or coordinating body could serve as an ideal entity to facilitate data sharing, mobilize community actors, and ensure continuity throughout the process. While advanced tools like VR visualizations or open innovation platforms enhance the experience, the core methodology can function effectively with basic datasets, a facilitation team, and the willingness of local stakeholders to participate.

Synthesis and Outlook

The CO2 PACMAN activities on the pilot islands Brač, Crete, and Elba demonstrate how a structured, transparent, and participatory assessment can act as a catalyst for territorial transformation. By integrating data, local knowledge, and collective learning, the Toolkit empowers local administrations, citizens, students, and SMEs to identify primary sources of emissions, explore potential mitigation options, and identify which transition scenarios best align with a shared vision for the future. This combination of analytical clarity and social engagement enables territories to move from abstract climate goals to actionable, locally grounded roadmaps. Across the three pilots, this approach led to evident results, including active participation from multiple stakeholder groups, engagement of schools and youth through dedicated educational activities, and the use of digital and VR-based tools to promote shared understanding and informed discussion.

The pilot phase also highlighted the Toolkit's high level of adaptability. Its modular design makes it suitable for territories with very different conditions — whether insular, rural, urban, or cross-border—and for those facing challenges such as seasonal variations, data fragmentation, or complex governance structures. This modularity enables the same methodological workflow to be used in non-island contexts, with adjustments to data sources and engagement formats without altering the approach's core structure. This flexibility ensures the approach can be adapted to diverse contexts without imposing rigid procedures, while still providing a coherent framework for climate-neutrality planning.

At the policy level, the methodology closely aligns with major European frameworks, supporting the European Green Deal, the Fit for 55 package, the EU Climate Adaptation Strategy, and the Clean Energy for EU Islands Initiative. The Toolkit also promotes several Sustainable Development Goals, especially those related to clean energy, sustainable communities, responsible consumption and production, climate action, and multi-stakeholder partnerships. Through its integrated and evidence-based approach, the CO2 PACMAN Toolkit encourages data-driven emission reductions, territorial resilience, and socially inclusive transition pathways. Its focus on adaptive planning, multi-level governance, and participatory co-creation reflects the priorities of the EU Climate Adaptation Strategy. Meanwhile, its methodological structure enhances the development of SECAPs (Sustainable Energy and Climate Action Plans) and other local climate plans. By addressing the specific needs of islands and remote territories—and remaining transferable to other contexts — the Toolkit provides a practical and replicable pathway for implementing EU climate goals at the local level, supporting the Union's long-term aim of achieving climate neutrality by 2050.

What most clearly emerged during the pilots is the distinctive added value of the CO2 PACMAN approach. It combines four often-separate dimensions: robust emissions accounting and spatial analysis; inclusive engagement with citizens, schools, institutions, and businesses; educational activities that foster long-term awareness and intergenerational dialogue; and a challenge-based innovation pathway that mobilizes external problem-solvers to address local constraints. When these elements work together, they reinforce each other, accelerating learning, increasing ownership, and improving decision-making quality. In practice, this led to increased access to climate data, greater stakeholder involvement, and a stronger ability to connect technical evidence with specific local priorities.

With the assessment phase complete, the process now advances into its forward-looking stage. Through The Island I Would Like, communities will translate the knowledge gained into climate-neutrality scenarios, engaging with trade-offs, opportunities, and priorities in a participatory manner. The iterative use of the CO2 PACMAN Tool — across stakeholder groups and in educational settings — will continue to boost climate literacy and embed the transition within daily community life.

Looking ahead, the Toolkit has the potential to serve as a long-term support tool for territories, allowing for regular updates to GHG inventories, improving mitigation strategies, and better integration with local and regional planning efforts. The data gathered during the assessment phase and the tools created in the scenario development phase — especially the CO2 PACMAN Tool — can further assist public administrations in preparing and updating climate-related action plans (e.g., SECAP), such as municipal or regional strategies for climate mitigation, adaptation, and carbon neutrality, by offering structured evidence, scenario modelling, and spatially explicit insights. It can also serve as a foundation for capacity-building programs for public administrations, schools, and civil society organizations — and as a replicable solution for other European islands and mainland regions. The assessment phase has thus established not only a robust technical baseline but also a durable framework for ongoing learning, collaboration, and climate action.

Technical Notes

The Technical Notes of the CO2 PACMAN Toolkit provide a detailed, operational overview of the activities involved in developing climate-neutrality scenarios for islands and territories. Unlike the narrative and strategic sections of the Toolkit, the Technical Notes are designed as technical, repeatable, and adaptable guidelines to assist local authorities, project partners, community stakeholders, and future users in implementing each stage of the Toolkit effectively.

Each note describes the activity, including its components, step-by-step procedures, involved actors, expected outputs, and its significance within the CO2 PACMAN Toolkit. The goal is to provide every interested territory with a clear, systematic, and transferable set of operational guidelines that promote easy replication across various geographic, institutional, and socio-economic contexts.

The Technical Notes also emphasize the distinct value each activity contributes to the overall Toolkit: its impact on key indicators, its relationship with other activities, and the benefits it offers to local communities and decision-makers. Through this structure, the Technical Annexes function not only as detailed methodological guides but also as practical manuals, helping territories and organizations adapt and replicate the CO2 PACMAN approach and Toolkit, transforming it into a flexible model for collaborative governance and participatory climate planning.

Technical Note 1: Rooting Labs

The Rooting Labs constitute a core phase of the CO2 PACMAN participatory approach (see Deliverable 1.2.1 CO2 PACMAN Cooperative Planning Guidelines). They aim to activate local communities, gather essential information, and create the collaborative environment needed to develop climate neutrality scenarios. The main goal is to engage public authorities, planners and technical experts, academia, businesses, civil society, and citizens, including the young generation, in the climate-neutrality transition, while generating technical data and social insights to support the co-creation and validation of scenarios during the subsequent "The Island I Would Like" Labs. Stakeholder involvement is organized around clear identification, targeted recruitment, engagement, and active participation. Participants are not just informed—they help map challenges, provide data, discuss expectations and constraints, and identify promising directions for co-creation.

On the pilot islands, local administrations, utilities, transport operators, urban planners, tourism representatives, school communities, SMEs, civil society, academia, and environmental organizations worked together to build a cross-sectoral view of the islands' functioning, revealing synergies and bottlenecks that wouldn't be visible through desk research alone. This phase also kicks off the Youth Think Tank, involving high school and university students to boost climate literacy and gather behavioural insights. In parallel, the Landscape Analysis examines spatial, cultural, and socio-environmental features that influence future transition pathways.

The Rooting Lab lasts three consecutive days:

- **Day 1:** Engagement and awareness-raising; introduction to CO2 PACMAN and climate neutrality; perception surveys; youth-focused activities.
- **Day 2:** Technical and territorial analysis; sectoral data contributions from authorities, businesses, and experts; thematic workshops and on-site observations.
- **Day 3**: Outcomes synthesis; validation of the stakeholder map; definition of focus areas for "The Island I Would Like" Labs; plenary discussion to consolidate key findings.

The Labs provide a clear, integrated understanding of each island's starting point, combining technical data, territorial dynamics, and community perceptions. They identify main challenges and opportunities, while boosting knowledge, awareness, motivation, and participation—laying the groundwork for meaningful co-creation in the following phases. Table 1.1 provides a synthesis of the Rooting Labs procedure.

And more importantly, the well-targeted activities inspired and engaged the local communities towards a commonly shared vision of climate neutrality and set the basis for tailored co-design formats and processes.

Table 1.1: Rooting Labs: key components and guidance

Component	Description/ Guidance
Purpose	Engage the whole value chain of the island's ecosystem: local authorities, businesses, academia, civil society, and citizens; generate technical and social insights; prepare for "The Island I Would Like" Labs.
Step-by-Step Procedure	**Day 1**: Activation & Awareness – Introduction to CO2 PACMAN, initial perceptions, youth activities, expectation alignment. **Day 2**: Technical & Territorial Analysis – Sectoral data sessions, thematic workshops, baseline reconstruction. **Day 3**: Synthesis & Priority Setting – Validation of findings, stakeholder map review, definition of thematic priorities for scenario-building.
Key Methods Used	Participatory mapping, structured discussions, perception surveys, focus groups, open-air citizens design labs, evidence validation, and cross-sectoral analysis.
Who Should Be Involved	Local authorities; utilities and operators; businesses (tourism, transport, services); schools and universities; environmental organizations and NGOs; citizens; youth groups; planners and technical experts.
Roles and Responsibilities	**Local authorities** – coordinate institutions and provide data. **Project team/facilitators** – design and run Labs, consolidate data. **Stakeholders** – offer evidence and perspectives. **Students/teachers** – share youth insights and engage in climate literacy activities.
Data Required (Inputs)	Existing datasets on energy, mobility, waste, buildings, land use, demographics, and tourism data, institutional documents, stakeholder lists, and local policies.
Data Produced (Outputs)	Validated datasets; updated territorial evidence; stakeholder map; set of priority themes; shared understanding of challenges/opportunities; behavioural and perceptual insights; initial decarbonisation ideas.
Tools & Materials Needed	CO2 PACMAN project presentation; perception surveys; facilitation materials; maps; preliminary datasets; Youth Think Tank toolkit; landscape analysis guidelines.
Link with Other	Provides a baseline for The Island I Would Like Labs; supplies data for the GHG Balance and CO2 PACMAN Tool; activates the

Toolkit Components	Youth Think Tank; initiates a Landscape Analysis; informs Open Innovation challenge-setting.
Expected Outcomes	A consolidated baseline integrating technical data and community perceptions; validated stakeholder map; shared understanding of challenges; priority themes for scenario development; increased awareness and engagement; strengthened trust among actors.
Value for Users / Why This Module Matters	Ensures that planning is grounded in local realities; creates ownership and legitimacy; improves data quality through local validation; reveals cultural, behavioural, and governance conditions; prepares both community and institutions for collaborative scenario-building.
Adaptability & replicability	The Rooting Labs can be tailored to different territories by adjusting stakeholder selection, timing, and scope of technical/territorial analysis. Activities can be scaled for islands or small communities of varying sizes, with varying governance structures and data availability. Core methodology—stakeholders identification and engagement, three-day labs structure, participatory workshops, youth engagement, and data validation—remains consistent, ensuring results are comparable and transferable. Territories can replicate the approach using local datasets, adapted facilitation tools, targeted messages, and culturally relevant engagement strategies while maintaining alignment with the CO2 PACMAN Toolkit objectives.

Technical Note 2: GHG balance

The Greenhouse Gas (GHG) Balance is a key part of the CO2 PACMAN Toolkit, providing a transparent, island-specific picture of anthropogenic emissions and carbon removals.

The GHG inventories need to align with the methodology set by the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, supplemented by the 2019 Refinement, as detailed in Figure 2.1.

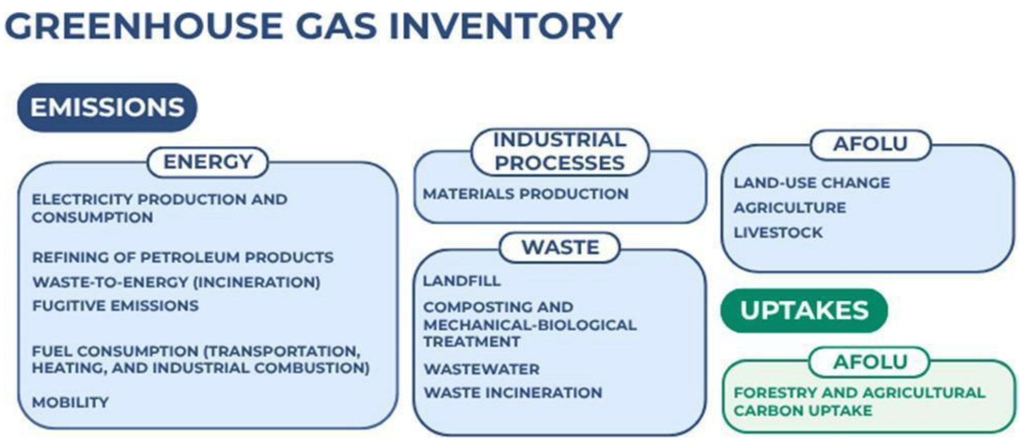


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Figure 2.1: Summary of emissions category and uptake sectors included in the IPCC methodology

By integrating diverse datasets — from national statistics to operational local data —this phase establishes a reliable baseline that supports decarbonisation planning and scenario development (Table 2.1). The data collected and results calculated for all three islands are combined and published in an online data repository accessible to the public. Users can freely access and use the data through a dedicated website, organized according to the FAIR principles to ensure that data are Findable, Accessible, Interoperable, and Reusable. Data are openly accessible via standardized communication protocols that do not require authentication or authorization. To promote interoperability and reuse, datasets use SI units for relevant indicators and clearly document calculation methods aligned with the IPCC methodology. The data repository is publicly accessible at: https://www.co2pacman.eu/data-repository

Table 2.1: 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

Implemented in accordance with IPCC guidelines, the inventory records emissions from energy, waste, agriculture, forestry, and other land uses, while accounting for natural carbon sequestration. Beyond technical calculations, the GHG Balance enhances local capacities, promotes multi-level stakeholder collaboration, and ensures that participatory activities, including “The Island I Would Like” Labs, are grounded in measurable reality. It helps identify sectoral hotspots, validate assumptions, and provide actionable data for policy and planning, making sure that climate-neutrality pathways are both practical and locally relevant. Deliverable 1.3.1 (CO2 PACMAN Datasets and Tools) offers a detailed overview of data and methodology for implementing the GHG balance. Table 2.2 provides a summary overview and its main components.

Table 2.2: GHG Balance Key component

Component	Description/ Guidance
Purpose	Provide a transparent, island-specific overview of anthropogenic emissions and removals; establish a science-based baseline for decarbonisation planning; support evidence-based scenario development and policy-making.
Step-by-Step Procedure	**1.** Identify data sources and actors (national, regional, local, utilities, stakeholders). **2.** Collect datasets on energy, mobility, waste, AFOLU, and land use. **3.** Harmonise temporal, spatial, and sectoral references. **4.** Implement the IPCC methodology (2006 Guidelines + 2019 Refinement) to calculate emissions/removals: **Emissions tCO_2eq = Activity Data × Emission Factor** **5**. Estimate net emissions including carbon sequestration. **6.** Validate results through stakeholder consultation (Rooting Labs).
Key Methods Used	IPCC inventory methodology, data harmonization, cross-sectoral analysis, stakeholder validation, spatial-temporal alignment, and activity data reconciliation.
Who Should Be Involved	National statistical offices, environmental protection agencies, energy/transport/waste utilities, regional and municipal administrations, technical experts, and local project partners to smooth the data acquisition and validation.
Roles and Responsibilities	Data providers – supply official and operational datasets. Project team/facilitators – harmonise data, perform calculations, coordinate validation, provide missing activity data, and contextual insights.
Data Required (Inputs)	National and regional statistics, sectoral data from ministries and agencies, utility operational data, municipal/territorial plans, international datasets (IPCC emission factors).
Data Produced (Outputs)	Island-specific GHG inventory; validated emissions by sector; net emissions estimates; identification of sectoral hotspots; basis for decarbonisation scenarios; input for CO2 PACMAN Tool and “Island I Would Like” Labs.
Tools & Materials Needed	IPCC Guidelines 2006 & 2019 Refinement; spreadsheets and modelling templates; harmonisation protocols.

Link with Other Toolkit Components	Provides baseline for scenario modelling in CO2 PACMAN Tool; informs Rooting Labs and subsequent participatory co-creation; integrates with landscape and socio-environmental analyses.
Expected Outcomes	Robust and science-based GHG baseline; clear understanding of emissions/removals; sectoral hotspot identification; validated, island-specific evidence; foundation for scenario development.
Value for Users / Why This Module Matters	Ensures climate-neutrality planning is based on reliable, local evidence; reduces modelling uncertainty; strengthens local capacity for data governance; ensures alignment with international standards; provides evidence for multi-level decision-making; supports stakeholder engagement and participatory planning.
Adaptability & replicability	Methodology can be applied to other territories by adapting data collection to local sources and availability. The core IPCC-based calculation process ensures comparability, while stakeholder validation enables contextual tailoring. Suitable for islands or other communities with variable governance, data completeness, and technical capacity.

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Technical Note 3: AskyourcitizenonCaN

Citizen engagement is a crucial part of the CO2 PACMAN Toolkit, recognizing that achieving climate neutrality involves more than technology and data alone. Meaningful participation, social ownership, and understanding community perceptions are vital for creating realistic, accepted, and effective transition pathways. Within this framework, the AskyourcitizenonCaN survey offers a scientifically rigorous and socially grounded assessment of how island communities view climate change, climate neutrality, and the behavioural and systemic changes needed for decarbonisation. Inspired by the BLUE DEAL, AskyourcitizenonBe experience, the survey empowers citizens to help shape the future of their territory, ensuring the transition includes people, not just for them. Built on a solid methodology developed by the University of Siena and applied in Brač, Crete, and Elba, the structured questionnaire was translated into local languages and administered face-to-face using stratified sampling. It measures awareness of climate risks, familiarity with climate neutrality, support for decarbonisation measures, willingness to change daily habits, and expectations regarding local interventions. This systematic approach uncovers behavioural patterns, perceived barriers, and levels of social readiness, complementing technical analyses like the GHG Balance and the CO2 PACMAN Tool. To add depth to the quantitative data, the Toolkit also features Vox Populi interviews—short, informal conversations in public spaces that capture spontaneous opinions, emotions, and stories. While the survey provides structured data, Vox Populi reveals local sensitivities and cultural references that might not surface through formal questionnaires. Together, these components form a comprehensive social portrait and increase representation in the participatory process. The combined findings help prioritize decarbonisation measures, support communication and education efforts, and inform activities such as the Rooting Labs and "The Island I Would Like" co-creation sessions. By turning perceptions into participation, the AskyourcitizenonCaN survey and Vox Populi interviews ensure that transition pathways reflect both scientific evidence and community aspirations, strengthening the relevance and legitimacy of climate-neutrality actions. The report on the citizen survey "AskyourcitizenonCaN" details the methodology and results, which are also available online (askyourcitizenoncan.unisi.it). Table 3.1 offers an overview of the main components of this activity.

Table 3.1: AskyourcitizenonCaN key components and features

Component	Description/ Guidance
Purpose	Assess climate awareness, perceptions of climate neutrality, and willingness to adopt behavioural or systemic changes, ensuring that transition strategies align with community priorities.
Step-by-Step Procedure	**1)** Prepare the survey package (questionnaire, translations, sampling plan). **2)** Coordinate with municipalities for access and communication. **3)** Conduct stratified face-to-face interviews using trained fieldworkers. **4)** Code responses and run island-level analysis. **5)** Carry out Vox Populi interviews in selected public spaces during participatory events. **6)** Summarise and integrate qualitative and quantitative insights. **7)** Feed results into participatory labs and strategy development.
Key Methods Used	**Survey**: Structured questionnaire (about 22 questions on climate-neutrality knowledge and willingness to take or support climate-related actions), translation in the local language, stratified two-stage sampling, face-to-face interviews conducted by trained fieldworkers, and responses coded and analysed at the island level. **Voxpopuli**: Short, informal interviews in public spaces (squares, markets, port areas); spontaneous opinions on survey results, desired future island, and impacts of renewable energy systems; recorded and summarised to capture narratives and emotional responses.
Who Should Be Involved	Citizens from diverse demographic segments, municipal representatives, field researchers/interviewers, project partners coordinating logistics and analysis, and expert statisticians with knowledge on climate change for tailoring the methodology and analysing results.
Roles and Responsibilities	**Statistician:** Methodology design, training, and analysis. **Project Partners:** Coordination, communication, logistical support. **Municipalities:** Facilitation and access to public spaces, outreach. **Fieldworkers:** Data collection and interview implementation. **Citizens:** Providing perceptions, preferences, and lived experiences.
Data Required (Inputs)	Demographic information; sampling framework; translated questionnaires; local context notes; locations and timing for Vox Populi interviews; communication support from municipalities.

Data Produced (Outputs)	Quantitative indicators on awareness, acceptance, readiness for change; qualitative insights capturing expectations, concerns, cultural elements; Vox Populi videos or summaries; island-specific social readiness profiles.
Tools & Materials Needed	Printed or digital questionnaires; consent forms; tablets or notebooks for data entry; audio/video devices for Vox Populi (optional); fieldwork guidelines; dissemination materials for public engagement.
Link with Other Toolkit Components	Complements GHG Balance and CO2 PACMAN Tool by adding a social perspective; informs "The Island I Would Like" Labs; supports the prioritisation of decarbonisation policies and communication strategies.
Expected Outcomes	Clear overview of local climate-awareness levels; identification of behavioural patterns and perceived barriers; community insights to refine transition pathways; enhanced inclusiveness of planning processes.
Value for Users / Why This Module Matters	Ensures that climate strategies are aligned with public expectations and capacities; enhances legitimacy and acceptance of the transition; strengthens the connection between scientific analysis and everyday experience.
Adaptability & replicability	Fully replicable in other territories; questionnaire and Vox Populi format can be adapted to local languages, cultural contexts, and different stages of the transition; suitable for periodic repetition to track changes over time

Technical Note 4: Landscape Analysis

The Landscape Analysis phase provides a spatially grounded assessment of how Mediterranean islands can support the energy transition through the deployment of Renewable Energy Technologies (RET) in alignment with the steps 1-3 of the landscape approach (Deliverable 1.1.1 Fine-tuning of the CO2 Pacman Assessment system). Its primary purpose is to provide a preliminary screening functional to the scenario development. The Figure 4.1 shows where landscape analysis fits within the general framework.

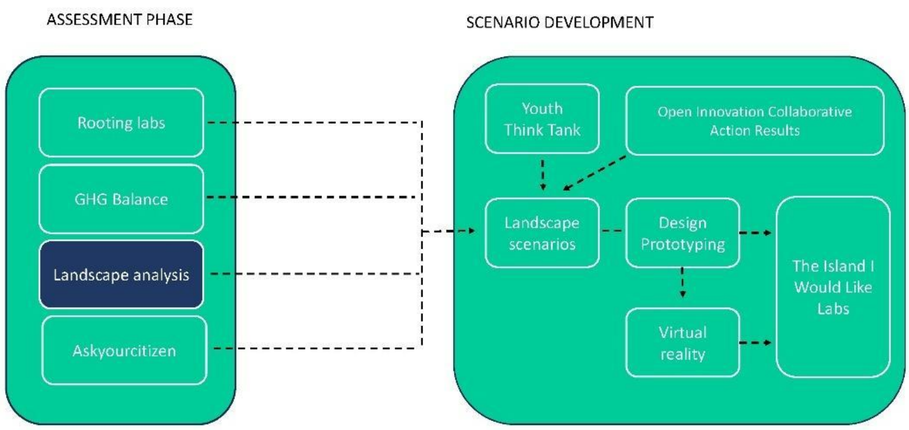


Figure 4.1: the landscape analysis in the assessment phase.

The assessment phase landscape analysis consists of a preliminary land-use based screening according to the available data and comparable among the three islands as described in Deliverable 1.3.1 (CO2 PACMAN Datasets and Tools) (Table 4.1).

Table 4.1: Data used for the assessment phase

Data set	Format
COPERNICUS Land cover and use	Vectorial map
Digital Elevation model and Digital Terrain Model	Vectorial map
Natura 2000 sites	Vectorial map
Solar energy potential	Vectorial map
Global wind atlas	Vectorial map

The screening output is a matrix of the different land uses capability to generate Renewable Energy (RE) through different sets of RET. The preliminary screening is divided into three primary sequences: Landscape Features, Landscape Suitabilities, and Landscape Capabilities.

The landscape features are summarized by providing a sampling of the different land uses on the island. Corine land uses are standardized across Europe, but the same land use class can differ depending on local context, where landscape infrastructure (Belanger, 2009) and the social-ecological system in which to integrate RET can vary (Picchi et al., 2025). The sampling is based on detecting through an aerial photogrammetric scanning different typologies of landscape features per land use (Figure 4.2).

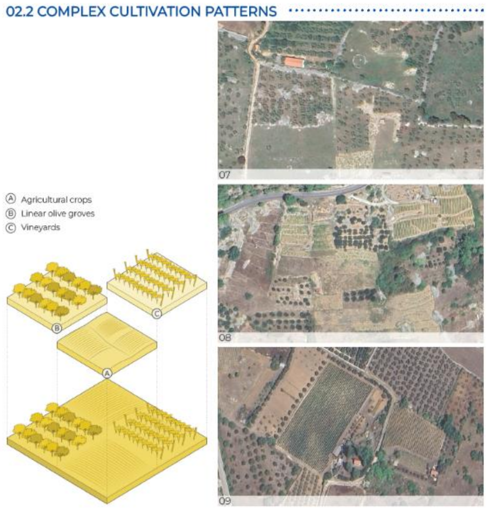


Figure 4.2: Example of summarizing landscape features per Copernicus land use class complex cultivation pattern in the island of Brač.

The landscape suitability for RET is expressed by expertise on the possible trade-offs with ecosystem service supply for each land use, excluding the Natura 2000 area and topography with slopes >25% (which excludes any RET installation). The suitability is expressed anyway in a positive attitude, beyond a standard impact assessment approach, yet as an opportunity for the specific land use to change through the installation of a specific set of RET (Jackson et al. 2012). Table 4.2 reports five values for the landscape suitability for RET.

Table 4.2: The five values for the landscape suitability for RET

Suitability A - high opportunity for change	**Suitability B - opportunity for change**	**Suitability C - possible opportunity for change**	**Unsuitability D - critical change**	**Unsuitability E - very critical change**	**not applicable**
A	**B**	**C**	**D**	**E**	
Opportunity for change with strong habitat enhancement at all levels -highly beneficial impacts on multiple ecosystem services could occur from appropriate designed change.	Partial opportunity for change with habitat enhancement at globe and site levels - at least one ecosystem service will be positively impacted by change from appropriate designed change.	Opportunity for change at global level (avoided CO_2 emissions) without relevant trade-offs with other ecosystem services, yet possible synergies to be checked according to design prototyping.	Installation of RET is critical for the preservation of habitat - critical trade-offs with some other ecosystem services at island and site level.	Installation of RET is very critical for the preservation of habitat - very critical trade-offs with several ecosystem services at all levels.	The land use is not supporting the specific set of RET

The landscape capability expresses the effective opportunities to install RET in a specific land use by crossing the information on solar and wind energy potential based topography with the landscape suitability. For example, if a land use has a suitability A for a specific RET or set of RET, and in a specific area the polygon of that land use also presents a high RE potential (wind or solar) the landscape suitability turns into landscape capability to generate RE in a highly integrated way and with possible positive externalities on the local context and value chain. Figure 4.3 shows a map of landscape capability related to specific land uses and a set of technologies on the island of Brač.

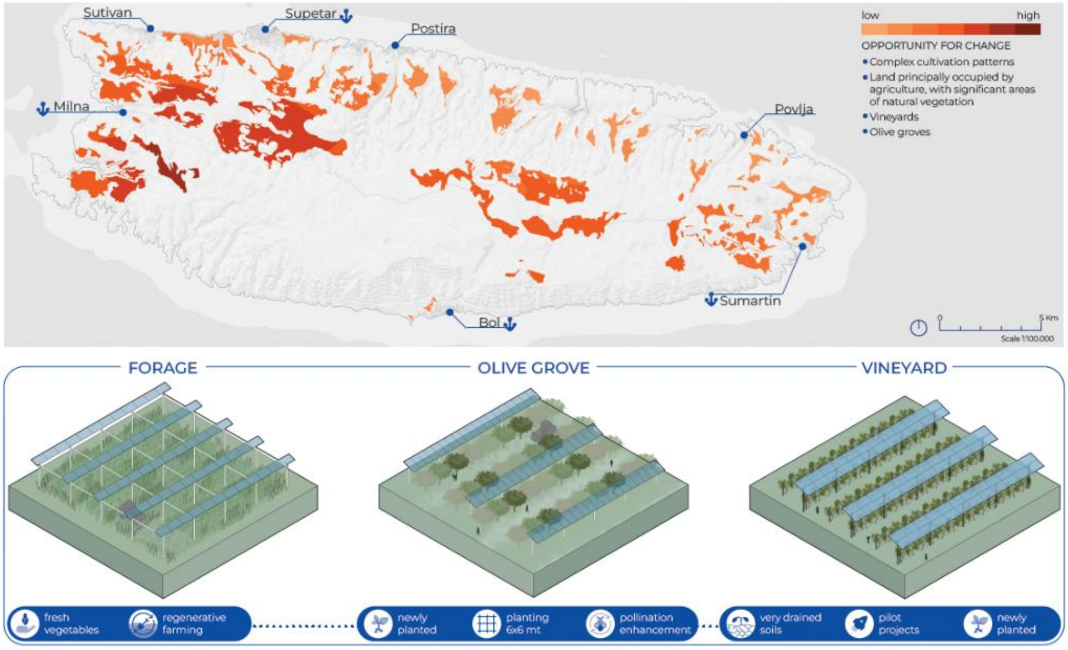


Figure 4.3: Example: the landscape capability for agrivoltaic systems on the island of Brač, related to the land uses “Complex cultivation patterns”, “Land principally occupied by agriculture, with significant areas of natural vegetation”, “Vineyards” and “Olive groves”. The map expresses the landscape capability for agrivoltaic systems. Below, the models represent the possible way to spatially integrate agrivoltaic systems in agriculture.

Together, these activities connect technical and territorial data to participatory processes, laying a strong foundation for “The Island I Would Like” labs and supporting context-sensitive energy transition scenarios. By anchoring the Toolkit in spatially explicit analyses, the Landscape Analysis guarantees that scenario development is not only technically feasible but also socially and environmentally appropriate, boosting the legitimacy and effectiveness of decarbonisation pathways. Table 4.3 offers an overview of the main components of this activity.

Table 4.3: Landscape analysis key components and features

Component	Description/ Guidance
Purpose	Provide a spatially grounded understanding of the islands landscapes capability to accommodate Renewable Energy Technologies (RET)to inform energy transition planning and Living Labs.
Step-by-Step Procedure	**1.** The landscape features: providing a sampling of the different land uses on the island. Corine land uses are standardized across Europe. The sampling is based on detecting, through aerial photogrammetric scanning, different typologies of landscape features per land use. **2**. The landscape suitability for RET: expertise on the possible trade-offs with ecosystem services supply for every land use, excluding the Natura 2000 area and the topography with slopes >25% (this makes any RET installation). The suitability is expressed as an opportunity for the specific land use to change through the installation of a specific set of RET **3.** The landscape capability: expressing the effective opportunities to install RET in a specific land use by crossing the information on solar and wind energy potential based topography with the landscape suitability. **4**. The capability matrix: the different land uses capability to generate renewable energy per different sets of Renewable Energy Technologies (RET), selected on existing scientific literature and expert panels.
Key Methods Used	Photogrammetric inspection and fieldwork for landscape feature identification per land use; Spatial Multi-Criteria Analysis (SMCA) for suitability and suitability
Who Should Be Involved	Project team (data analysis, modelling, GIS), agronomists, biologists, local authorities, landscape planners, technical partners providing datasets, stakeholders consulted in participatory labs as Local Action Groups for validation and input.
Roles and Responsibilities	Project team – dataset collection, SMCA, GIS processing, suitability/capability analysis; Experts – validate landscape assessment; Local authorities – provide data and facilitate access; Stakeholders – contribute local knowledge and feedback.
Data Required (Inputs)	CORINE land cover, solar/wind potential, digital elevation model, digital terrain model, Natura 2000, soil quality, hydro-climatic balance, biodiversity, cadastral/technical maps.
Data Produced (Outputs)	Landscape features maps and models, Land use suitability scores (A–E) for a set of RET, capability, and suitability maps.
Tools & Materials Needed	GIS software, WMS layers, remote sensing data, photogrammetric images, expert panels, field surveys, stakeholder inputs, and landscape semiology records.

Link with Other Toolkit Components	Feeds into "The Island I Would Like" Labs for energy planning, informs the CO2 PACMAN Tool by integrating renewable potential and landscape constraints; connects with the GHG Balance for potential energy generation scenarios.
Expected Outcomes	Clear identification of areas suitable for RET through the land use capability
Value for Users / Why This Module Matters	Supports evidence-based, locally grounded planning; reduces the risk of conflicts between RET deployment and ecological/social factors; enables participatory validation; and ensures RET interventions are technically feasible and socially acceptable.
Adaptability & replicability	Methodology can be applied to other islands or territories; flexible datasets can be replaced or updated; the land use matrix approach is transferable to diverse landscapes and socio-cultural contexts.

Technical Note 5: CO2 PACMAN Tool

The CO_2 PACMAN Tool is the core modelling component of the Toolkit, transforming GHG baseline and territorial data into an interactive decision-support environment designed for Mediterranean islands. It allows users to explore how various decarbonisation measures affect future emission paths and to create realistic, context-specific scenarios for climate neutrality. Based on harmonized datasets and aligned with IPCC methodologies, the Tool incorporates 28 policies, structured into 18 macro-policies, as shown in Figure 5.1, some of which include multiple specific measures (e.g., the policy to reduce domestic and office consumption includes separate actions for electricity, water, and heating). These policies range from actions accessible to citizens—such as reducing household energy use or adopting sustainable mobility—to decisions requiring institutional commitment —such as deploying renewable energy, upgrading waste infrastructure, or improving land use. Together, they form a cohesive portfolio that users can combine to simulate different transition pathways. The CO2 PACMAN Tool is available at: co2pt.unisi.it

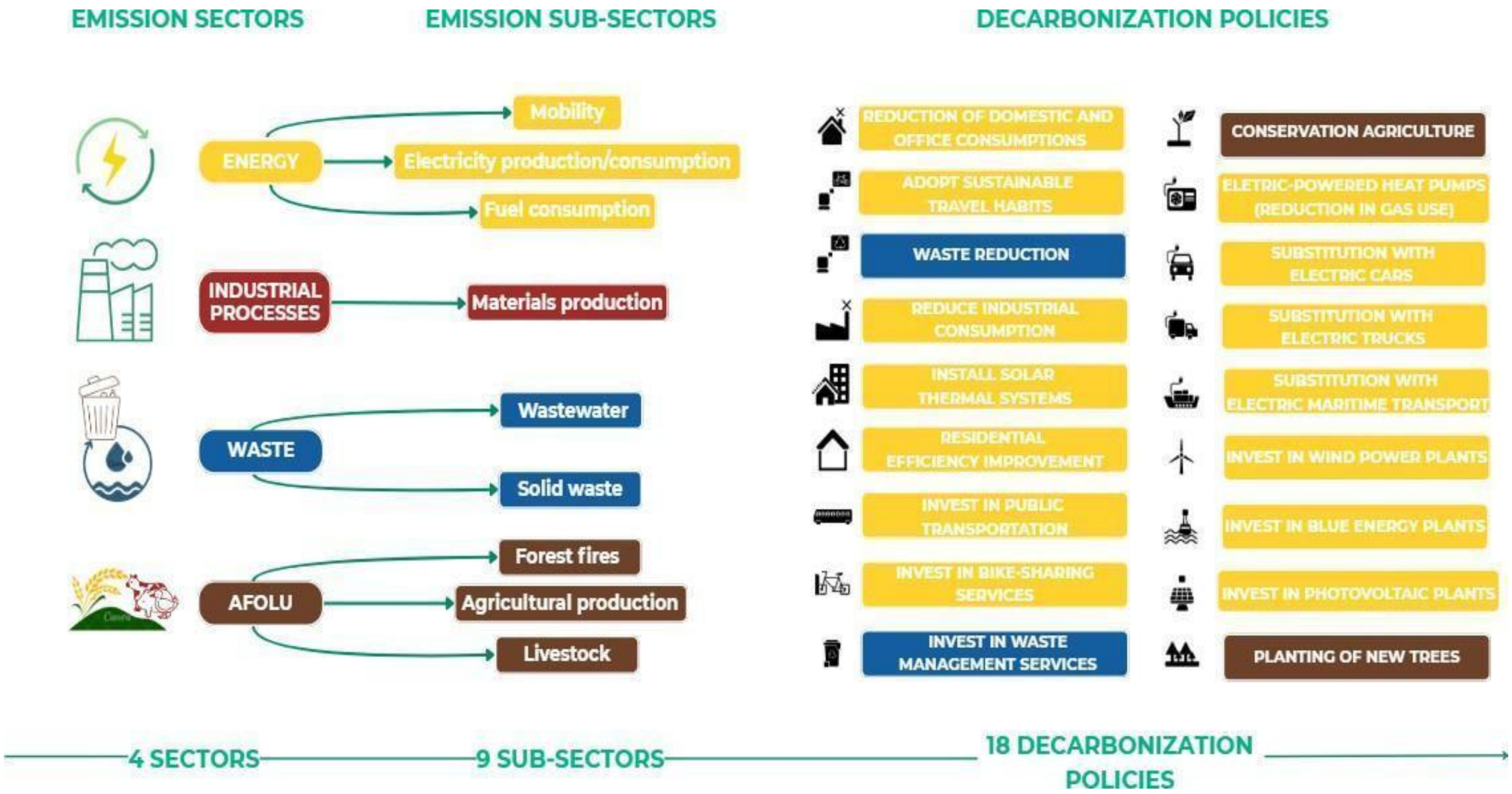


Figure 5.1: Relationship between key emission sectors and sub-sectors and the developed decarbonisation policies. This conceptual map represents the structural foundation of the CO2 PACMAN Tool.

The tool's structure mirrors the logic of the modeling workflow. It starts with internal system data (not visible to users) and then proceeds through five steps that users see (Figure 5.2). **Step 0** – General Data introduces the island through key descriptors like area, resident population, and tourist flow scale. **Step 1** – Land Use shows the distribution of forests, built-up areas, farmland, and green spaces, helping contextualize emissions and mitigation options. **Step 2** – GHG Balance displays the full inventory and offers easy-to-understand indicators—such as the equivalent forest—to help users grasp the scale of emissions. **Step 3** – Decarbonisation Strategies lets users explore policies (depending on the island), estimate potential reductions, adjust assumptions, and compare options. Lastly, **Step 4** – Residual CO_2 Emissions visualizes the remaining emissions after selected measures and suggests offset options—such as increasing forest cover—while respecting the island's physical and ecological limits.

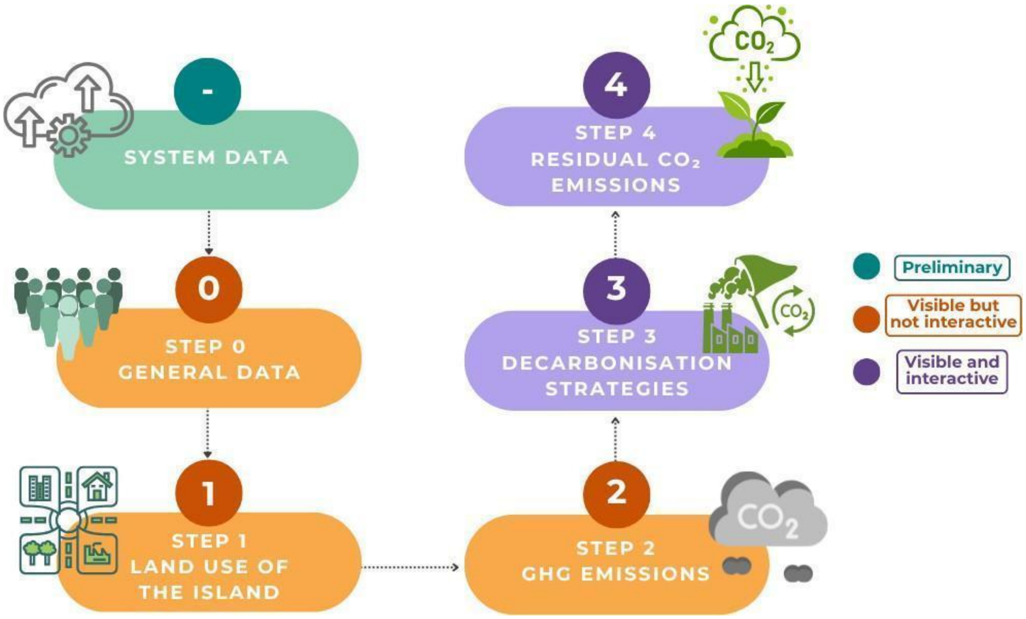


Figure 5.2: Structure and workflow of the CO2 PACMAN Tool.

By integrating data, sector analysis, and policy modelling into a single platform, the CO2 PACMAN Tool enables stakeholders to build shared, evidence-based roadmaps. It strengthens transparency, supports informed decision-making, and creates a common language for collaboration during *The Island I Would Like* Labs and beyond. Deliverable 1.3.1 (CO2 PACMAN Datasets and Tools) offers a detailed overview of Decarbonisation policies and behavioural changes, and Deliverable 1.4.1 (Summary report of GHG balance of three target islands) provides a summary of the Tool's key features. Table 3.1 provides an overview of the main components.

Table 5.1: CO2 PACMAN Tool key components and features

Component	Description/ Guidance
Purpose	Provide an interactive environment that enables users to interpret the island's current emissions, simulate the impact of different decarbonisation policies, and build coherent scenarios to achieve climate neutrality.
Step-by-Step Procedure	**Step 0 – General Data:** island descriptors (area, population, tourists). **Step 1 – Land Use:** distribution of built-up areas, forests, farmland, and green spaces. **Step 2 – GHG Balance:** sectoral emissions, aggregates, "equivalent forest" indicator. **Step 3 – Decarbonisation Strategies:** simulate impacts of 28 mitigation measures and compare scenarios. **Step 4 – Residual CO_2 Emissions:** display emissions after interventions and explore offset options (e.g., forest expansion).
Key Methods Used	IPCC-aligned accounting; emission-modelling algorithms; scenario simulation; interactive policy impact estimation; data visualisation.
Who Should Be Involved	Local authorities, planners, technical departments, utilities (energy, transport, waste), consultants, researchers, schools/universities for educational use, and citizens in participatory settings.
Roles and Responsibilities	**Project team/experts:** configure Tool, harmonise data, define policy assumptions. **Local authorities/holders:** provide and validate datasets, interpret outputs. **Stakeholders:** explore policy impacts during workshops. **Educators/students:** use the Tool in climate-literacy activities.
Data Required (Inputs)	Harmonised GHG inventory; land-use data; demographic and tourism data; energy, transport, waste, and AFOLU datasets; emission factors; policy parameters.
Data Produced (Outputs)	Emission scenarios; policy impact estimates; residual emissions and offset needs; comparative pathway assessments.
Tools & Materials Needed	CO2 PACMAN Tool interface; validated datasets; GHG Balance outputs; land-use maps; policy catalogue; guidance notes for facilitators and educators.
Link with Other	Uses GHG Balance as baseline; feeds into The Island I Would Like scenario co-creation; supports educational activities via

Toolkit Components	Youth Think Tank; relies on Rooting Labs for validated data and initial assumptions.
Expected Outcomes	Quantitative understanding of emission-reduction potential; transparent comparison of mitigation options; evidence for scenario-building; clarity on residual emissions and offsets; strengthened local capacity to interpret climate data.
Value for Users / Why This Module Matters	Provides a robust, data-driven foundation for planning; enables informed dialogue among institutions and citizens; makes complex climate modelling accessible; and supports transparent, realistic transition pathways.
Adaptability & replicability	**Adaptability:** Policies, parameters, and datasets can be updated to reflect different contexts, data availability, and policy frameworks. The Tool can incorporate additional sectors or measures where relevant. **Replicability:** Built on IPCC standards and modular datasets, enabling use in diverse island or mainland territories. Straightforward workflow and harmonised steps facilitate consistent application across regions.

Technical Note 6: Youth Think Tank

The Youth Think Tank (YTT) is a core component of the CO2 PACMAN participatory framework, designed to engage high school and university students in understanding, discussing, and shaping climate-neutral futures for their islands. Its primary purpose is to combine education, participation, and scenario co-design, ensuring that young people are not only informed about decarbonisation and climate neutrality but also directly contribute to decision-making processes. The YTT follows a structured pathway, starting with engagement with schools and universities to schedule dedicated sessions. Students are introduced to key concepts such as decarbonisation, climate neutrality, and landscape integration, while participating in interactive activities including debates, peer-to-peer learning, and creative exercises. Between the two rounds of Living Labs, students maintain engagement through practical initiatives such as clean-up events, tree planting, exhibitions, podcasts, and school-led dissemination actions.

Access to the CO2 PACMAN Tool allows students to explore hypothetical solutions and develop preliminary scenarios for climate-neutral islands. Teachers, project partners, and local authorities support the process, helping students interpret data, refine ideas, and link proposed solutions to real territorial constraints. The YTT produces both educational and operational outcomes: students enhance climate knowledge, critical thinking, and motivation to engage with decarbonisation topics, while providing tangible inputs to the CO2 PACMAN Tool, such as proposed measures and student-designed scenarios. The Youth Think Tank also fosters community engagement by empowering students to act as ambassadors of climate neutrality within schools and local communities.

The activity is highly replicable: it relies on early coordination with schools, structured sessions, participatory methods, and continuous interaction between Lab rounds. Figure 10.1 shows the suggested timeline and steps for the YTT development.

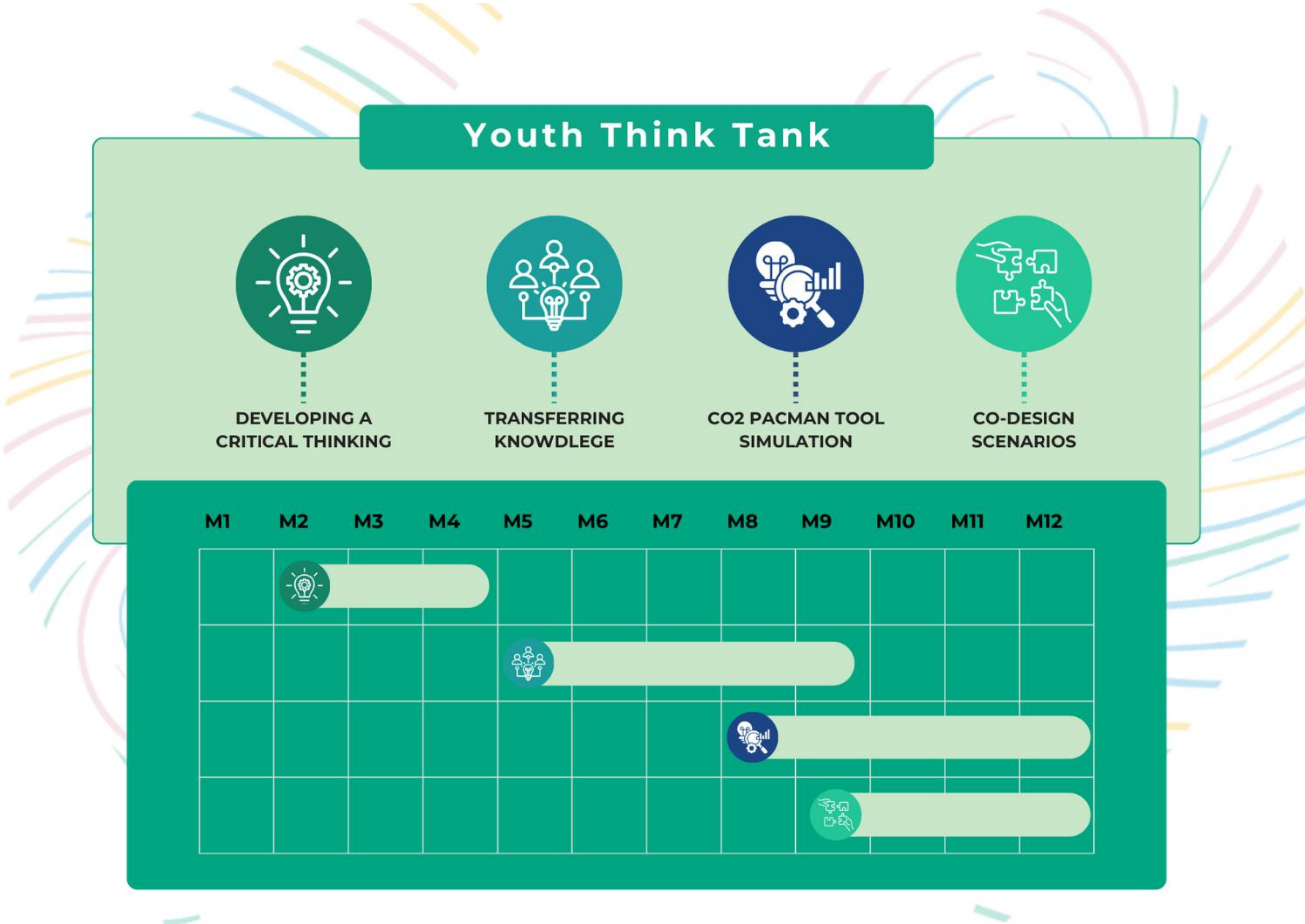


Figure 10.1: CO2 PACMAN Youth Think Tank Timeline

By bridging technical assessment and social awareness, the Youth Think Tank ensures that scenarios are creative, socially supported, and intergenerationally relevant, enhancing the legitimacy and long-term effectiveness of CO2 PACMAN's climate-neutrality pathways. More details in D2.2.1 Citizen survey, Youth Think report, Financing the transition: evaluation report. Table 6.1 provides an overview of the main components and key features of this activity.

Table 6.1: Youth Think Tank key components and features

Component	Description/ Guidance
Purpose	Engage youth in climate-neutrality education, participatory scenario design, and contributions to the CO2 PACMAN transition roadmap; generate both learning outcomes and tangible project inputs.
Step-by-Step Procedure	**1.** Contact primary and secondary school directorates, school directors, and universities, and schedule sessions. **2.** Introduce key concepts and project tools. **3.** Conduct interactive learning activities. **4.** Facilitate practical initiatives between Lab rounds. **5.** Access the CO2 PACMAN Tool to explore solutions and draft scenarios. **6.** Collect student outputs for integration in participatory labs.
Key Methods Used	Interactive workshops, debates, peer-to-peer learning, project tool-based scenario building, creative projects (podcasts, exhibitions, tree planting), structured documentation of outputs.
Who Should Be Involved	Students (high school and university), teachers, school managers, project partners, and local authorities.
Roles and Responsibilities	Students: learn, co-design scenarios, act as ambassadors. Teachers: enable classroom access, facilitate sessions. Project partners: provide scientific content, tool access, guidance. Authorities/organisations: contextual insights, support student-led initiatives.
Data Required (Inputs)	Educational materials on decarbonisation, climate neutrality, landscape integration, access to the CO2 PACMAN Tool, and templates for scenario development.
Data Produced (Outputs)	Student-designed scenarios, proposed solutions for islands, creative outputs (videos, exhibitions, podcasts), and enhanced community awareness.
Tools & Materials Needed	CO2 PACMAN Tool, presentation materials, recording devices (for podcasts/videos), stationery, and outdoor activity supplies.

Link with Other Toolkit Components	Outputs feed into "The Island I Would Like" Labs; complements technical components like GHG Balance and landscape analysis by incorporating youth perspectives and social readiness.
Expected Outcomes	Improved youth knowledge and engagement, critical thinking on decarbonisation, community awareness, and actionable contributions to project scenarios.
Value for Users / Why This Module Matters	Bridges education with participatory planning, generates intergenerational insights, and strengthens the legitimacy and creativity of climate-neutrality scenarios.
Adaptability & replicability	A structured methodology allows implementation across different islands or communities; activities are scalable based on school resources; and engagement and scenario-development formats are transferable.

Technical Note 7: Open Innovation Collaborative Action

The Open Innovation Collaborative Action is a key part of the CO2 PACMAN participatory and assessment framework, serving as the strategic link between local territorial needs and external innovation capabilities. Its goal is to create a structured, collaborative environment where companies, research centers, SMEs, and startups can work together to develop solutions that address specific barriers to decarbonisation on the islands of Brač, Crete, and Elba. Building on a bottom-up approach inspired by the BLUE DEAL experience, the process ensures that all innovation efforts respond directly to locally grounded challenges rather than to abstract or externally driven priorities.

In this context, open innovation is a model in which public authorities, communities, and institutional actors ("challengers") invite external innovators ("solvers") to contribute ideas, technologies, and processes that are difficult to develop internally. By facilitating the sharing of knowledge, resources, and creativity across sectors and disciplines, innovation becomes a collective asset rather than a competitive pursuit. Through the publication of island-specific "quests for solutions," the CO2 PACMAN project mobilizes a diverse ecosystem of innovators to propose tangible, scalable approaches to renewable energy integration, sustainable mobility, circular economy models, digital monitoring, and climate adaptation.

The process proceeds through a series of structured steps. First, challenges were identified during Rooting Labs through participatory roundtables involving municipalities, local authorities, and community representatives. These challenges are then refined with stakeholders to ensure they are technically clear and practically feasible. Once validated, they are published online and open to European SMEs, startups, and research groups, who submit their solutions via the dedicated digital platform. A Local Technical Committee (LTC) reviews all submissions and selects the most promising proposals based on relevance, feasibility, and potential impact. These selected solutions were presented at a transnational event—CO2 PACMAN's Business Forum (in Valencia)—where solvers and challengers participate in co-creative sessions, interactive workshops, and bilateral dialogues to refine the proposed approaches. One solution per challenge is then chosen to continue collaboration during the second round of Labs ("The Island I Would Like"), allowing local communities to directly interact with innovators to explore pathways for adaptation or early implementation.

All solutions submitted to the process are compiled into the Open Innovation Catalogue of Solutions, which acts as a shared, accessible repository of technologies, practices, and methodologies relevant to Mediterranean islands (https://www.innovationcolab.eu/). This catalogue supports both knowledge transfer and territorial planning, enhances scenario-building, and strengthens the islands' capacity to design realistic, innovative, and socially supported transition pathways.

The Open Innovation Collaborative Action is more than a technical competition; it is a multi-level, cooperative mechanism that aligns territorial priorities with external expertise, promotes cross-sectoral and transnational collaboration, and raises the visibility of SMEs as key actors in the green transition. Its outputs directly contribute to the Testing the Toolkit phase and to the broader participatory framework of CO2 PACMAN, helping to create transition pathways that are technically sound, socially acceptable, and aligned with the long-term climate-neutrality goals of Mediterranean islands.

More details are available in D2.1.1 Method and evaluation of involvement of PAs in participatory planning and Open Innovation showcase. Table 7.1 provides an overview of the main components and key features of this activity.

Table 7.1: Open Innovation Collaborative Action key components and features

Component	Description/ Guidance
Purpose	Connect local decarbonisation challenges with external innovation capabilities; support joint solution development by linking public authorities, community representatives, SMEs, startups, corporates, and research centers. Enhance climate-resilient and innovation-driven transition pathways for Mediterranean islands.
Step-by-Step Procedure	**1. Challenge Identification:** Challenges are identified during Rooting Labs through roundtables with local authorities, stakeholders, and citizens. Refinement meetings are held with challenge-sending entities to formalize needs, technical requirements, and context. **2. Publication & Call for Solutions:** Challenges are uploaded to the online platform; SMEs and startups are invited to submit proposals (including pitch, summary, detailed description, expected impact, team profile). **3. Evaluation & Selection:** Local Technical Committees (LTCs) review submissions and shortlist three solutions per challenge. **4. Presentation & Interaction:** Shortlisted solvers present at the Business Forum; co-creative workshops involve challengers and solvers; one solution advances to the second Labs. **5. "Island I Would Like" Labs:** Solvers engage with island actors, refine proposals, explore agreements, and assess feasibility for early implementation. **6. Final Event:** Review progress, analyse collaborations, barriers, and future adoption pathways**.**
Key Methods Used	Bottom-up challenge definition; open innovation call; digital submission platform; structured evaluation by LTCs; co-creative workshops; solver–challenger interaction; compilation of solutions in an online catalogue.
Who Should Be Involved	Local authorities, public institutions, community representatives, SMEs and startups, research centers, teachers and students (when relevant to cross-sector activities), project partners, innovation experts.
Roles and Responsibilities	**Challengers:** Define challenges, engage with solvers, and help refine ideas. **Solvers (SMEs/startups):** Submit proposals, present solutions, and co-develop practical approaches. **Local Technical Committees (LTC):** Review solutions and select finalists. **Project Partners:** Manage the process, support scouting and communication, and provide templates and guidance. **Facilitators/Experts:** Support workshops and ensure methodological consistency.
Data Required (Inputs)	Challenge definitions; contextual and technical information from authorities; guidance materials; platform submission data (pitches, descriptions, impacts); stakeholder insights from Labs.

Data Produced (Outputs)	Shortlisted proposals; selected solutions for each challenge; refined technical concepts; collaboration reports; online Catalogue of Solutions; contributions to scenario development and testing the toolkit.
Tools & Materials Needed	Online innovation platform; challenge templates; methodological guidelines; communication materials; evaluation forms; workshop facilitation tools; podcast/recording equipment (optional).
Link with Other Toolkit Components	Provides input to Living Labs ("The Island I Would Like"), supports the scenario-building process, complements Landscape Analysis and Youth Think Tank insights, and contributes to the overall development of context-specific transition pathways.
Expected Outcomes	Identified technical and organizational solutions; improved collaboration between regions and innovators; strengthened local capacity for implementation; clearer pathways for adopting Renewable Energy Technologies, circular systems, mobility solutions, and more.
Value for Users / Why This Module Matters	Enables islands to access innovation beyond local limits; speeds up the adoption of climate-neutral solutions; increases SME visibility; guarantees solutions meet real territorial needs; encourages cross-sectoral, transnational learning.
Adaptability & replicability	Fully replicable using predefined templates, platform-based workflows, structured evaluation systems, and clear methodological guidance. Can be adapted to various geographic, thematic, or institutional contexts.

Technical Note 8: Financing the Transition

The **Financing the Transition** session is designed to equip stakeholders with the knowledge and tools needed to navigate the complex landscape of funding for sustainable, low-carbon projects. The activity is organized to ensure that participants can identify, evaluate, and access financial instruments suitable for supporting climate-neutral initiatives.

The activity is carried out in **four main phases**. First, the **Preparation Phase** involves mapping the relevant financial ecosystem, including EU, national, and innovative funding opportunities, and designing and adapting content to fit the specific local or thematic context of the session. The facilitator identifies real-world examples and resources that participants can consult immediately, ensuring practical relevance and applicability.

The **Presentation and Discussion Phase** turns this preparatory work into an interactive knowledge-sharing session. Here, experts provide an overview of available funding instruments, while partners or local authorities share insights on common challenges, such as eligibility criteria, administrative procedures, and bottlenecks. This combination of expert guidance and local perspective helps participants understand both theoretical options and real-world constraints.

During the **Workshop Phase**, participants actively engage with the information and apply it to concrete project ideas. Guided exercises show how to search for calls, filter opportunities by eligibility or sector, and match project concepts with specific funding instruments. The facilitator provides structured support to help participants navigate online portals, identify relevant programs, and understand application criteria.

Finally, the **Follow-up Phase** consolidates learning by sharing resources, links, and guidance for ongoing exploration. This ensures that knowledge gained during the session can be translated into continuous action beyond the event.

Successful implementation requires a **diverse team of participants and contributors**. Facilitators should include experts in EU and national funding mechanisms with experience in sustainable and low-carbon projects. Representatives from municipalities, utilities, or other relevant institutions to provide local context and highlight practical considerations. Additional participants, such as educators, NGOs, or sector-specific specialists, can enrich discussions and offer cross-cutting perspectives.

The **expected outcomes** of the session include a better understanding of the funding landscape, the ability to locate and evaluate relevant financial opportunities, and increased capacity to turn project ideas into actionable funding strategies. Participants leave with practical knowledge, replicable search techniques, and a roadmap for aligning local solutions with available instruments.

Within the CO2 PACMAN Toolkit, this activity plays a key role **by bridging the gap between scenario development and tangible implementation**. Equipping stakeholders with the skills and knowledge to secure funding helps move innovative solutions and community-driven initiatives beyond the planning stage into **actionable pathways toward climate neutrality**. Its inclusion in the Toolkit underscores the importance of financial literacy and strategic planning as essential parts of a successful transition.

More details are available in D2.2.1 Citizen survey, Youth Think report, Financing the transition: evaluation report. Table 8.1 provides an overview of the main components and key features of this activity.

Table 8.1: Key components and features of Financing the transition activity

Component	Description/ Guidance
Purpose	Develop the ability to identify, assess, and access financial tools that support climate-neutral and low-carbon initiatives, ensuring that transition pathways can be turned into practical investments.
Step-by-Step Procedure	**1. Preparation Phase:** Identify relevant EU, national, and innovative funding programs; customize content to fit the island's context; select practical examples and resources. **2. Presentation & Discussion Phase:** Experts introduce funding options; local authorities share practical challenges and administrative insights. **3. Workshop Phase:** Participants review calls, filter opportunities, and align project ideas with appropriate funding mechanisms through guided exercises. **4. Follow-up Phase:** Distribute resources, links, and guidance to support ongoing independent efforts exploration.
Key Methods Used	Mapping the funding landscape; expert presentations; facilitated discussions; hands-on exercises for call searching and eligibility analysis; guided navigation of online portals; collaborative matching of ideas and instruments.
Who Should Be Involved	Funding experts; municipal representatives; utilities and sectoral operators; schools/universities (as relevant); NGOs and community groups; project partners facilitating technical or participatory components.
Roles and Responsibilities	**Facilitators and experts:** prepare content and lead exercises; **local authorities:** provide contextual insights and highlight practical constraints; **participants:** bring project ideas and implement finance-search methods; **project partners:** support coordination and collaboration.
Data Required (Inputs)	Map of available EU and national funding programs; sector-specific priorities; initial project ideas from Labs; links to key funding portals; examples of successful applications.
Data Produced (Outputs)	List of relevant funding opportunities; initial matching of project ideas and funding sources; participant-created roadmaps for exploring funding options; enhanced financial knowledge and research skills.
Tools & Materials Needed	Presentation materials; curated list of funding portals; templates for project–funding matching; internet access; examples of calls and application forms; guidance notes for continued learning.

Link with Other Toolkit Components	Supports the implementation of solutions emerging from Open Innovation, Landscape Analysis, and Living Labs ("The Island I Would Like"); facilitates operationalizing scenarios created with the CO2 PACMAN Tool; enhances the Testing the Toolkit phase by linking ideas to financial feasibility.
Expected Outcomes	Enhanced financial literacy; ability to recognize suitable funding sources; increased capacity to develop funding strategies; better preparedness to execute decarbonisation projects.
Value for Users / Why This Module Matters	Transforms planning into practical steps by equipping stakeholders with the skills to secure financial resources; lowers barriers to implementation; and supports the long-term sustainability of climate-neutral strategies.
Adaptability & replicability	Easily replicable with standardized preparation steps, adaptable examples, and reusable exercises; suitable for various island contexts and sectors; scalable for future training programs or multi-stakeholder workshops.

Technical Note 9: The Landscape Scenario, Design Prototyping & Virtual Reality and Visualization Tools

9.1 The Landscape Scenario and design prototyping

The landscape scenario and design prototyping are based on the outcomes of the assessment phase. Landscape scenarios are based on land uses and the RETs that combined to result in landscape suitability A, B, and C. These are further based on data reported in Table 9.1. Figure 9.1 shows were landscape scenarios and design prototyping are sited in the general framework.

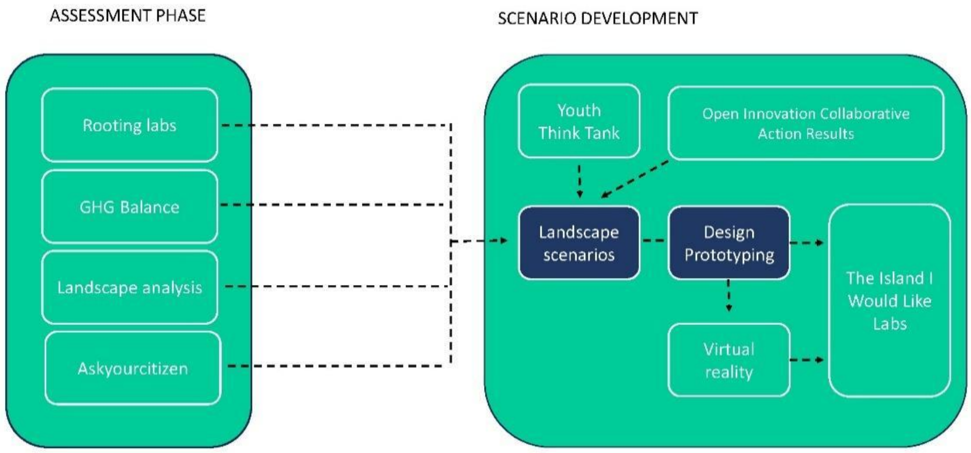


Figure 9.1: the landscape scenarios and design prototyping in the general framework.

Table 9.1: Data used for the landscape scenarios and design prototyping.

Data set	Format
Data set (D 1.3.1)	**Format**
State Base map	Raster maps
Technical regional map	Raster maps
Natural habitat	Vector maps
Water courses and bodies	Vector maps
Soil quality	Raster maps
Biodiversity	Raster maps
Landscape semiology	Original data
Additional literature search	
policy, planning, trend and state of the art related to agriculture	Scientific papers
policy, planning, trend and state of the art related to natural habitat conservation and enhancement	Scientific papers
policy, planning, trend and state of the art related to renewable energy.	Scientific papers

The landscape scenario reports the foreseen actors, land use, RET, energy and spatial scales and supporting policies (Figure 9.2). Landscape scenarios are descriptive and conceived for optimal communication during "*the Island I would like Labs*", formulated as questions to the local community for the island's future development.

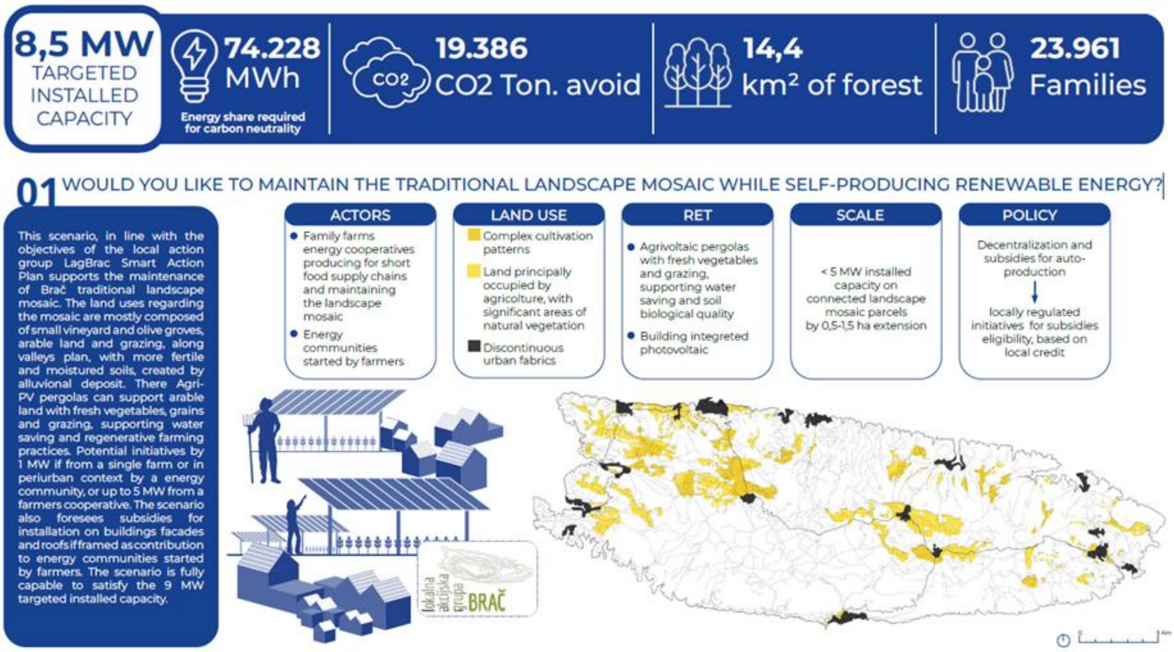


Figure 9.2: An example of one of the landscape scenarios conceived for the island of Brač, based on the landscape capability outcome of the assessment phase.

Within the scope of landscape scenarios, sample sites on the island are selected to prototype a landscape design that exemplifies, in a real landscape context, how the landscape would integrate the RET (Figure 9.3). Design prototyping is intended here as in European Council of Landscape Architecture Schools (ECLAS) Research Through Design: sample solutions in designing the landscape and relative visualizations capable to accommodate the complexity of multiple objectives and to foster collaboration among involved parties. Design Prototyping can support collaborative processes within transdisciplinary sustainability research (Peukert et al., 2021) and, in Cooperation research, can support the exchange of approaches and best practices to face sustainability goals in collaborative processes.

Figure 9.3: An example of one of the design prototypes conceived for the island of Brač, based on the landscape scenario 01: "Would you like to maintain the traditional landscape mosaic while self-producing renewable energy? The referent of the Local Action Group is engaged by looking at this prototype during "The Island I would like" lab.

The design prototypes are the input data for the Virtual Reality and Visualizations Tool applications.

9.2 Virtual Reality and Visualization Tools

The VR component functions as a visualization and engagement tool, designed to communicate renewable energy scenarios, enhance public understanding, and promote informed discussions on spatial changes. It supports four main goals:

- Educate citizens and stakeholders about renewable technologies, how they operate, and their visual integration into landscapes.
- Engage communities and decision-makers with immersive, spatially accurate environments.
- Increase participation through interactive exploration that fosters ownership and inclusion.
- Promote debate and transparency about potential impacts in sensitive coastal and agricultural areas.

VR development begins with data integration and geospatial workflows, combining spatial datasets from assessment and design phases. Inputs include RET shapefiles, scenario boundaries, technical parameters, photographic references, high-resolution DEMs, orthophotos, and environmental GIS layers. These are imported into the 3D Scene of the real-time game engine and aligned using georeferenced coordinate systems. A coordinate-translation script converts geographic coordinates into the engine's 3D space, ensuring meter-level accuracy. Next, the 3D terrain and scenario are reconstructed using the Cesium and Real World Terrain plugins and rendered as an interactive surface that supports vegetation layers, colliders, and blended textures. Larger landscape areas can be rendered at lower resolutions to provide realistic context and horizons. RET models are added with real-world dimensions, along with agricultural patterns, roads, buildings, vegetation, and other small features. Visual supervision, photographic comparison, and iterative feedback maintain fidelity to the real environment. Finally, the VR environment design and interaction are developed using professional tools, supporting immersive navigation (teleportation or free movement), controller or hand-tracking interaction, and information overlays such as labels and real-time distance indicators. Additional enhancements—Mediterranean vegetation, agricultural elements, small animated objects, and human figures — improve realism, scale perception, and intuitive understanding. The final VR environment reproduces each prototype at human scale, allowing users to explore proposed energy–landscape setups and compare scenarios during "The Island I Would Like" Labs. Table 9.2 provides an overview of the main components and key features of this activity.

Table 9. 2: Key components and features of the landscape scenario and design prototyping & virtual reality, and visualization tools

Component	Description/ Guidance
Purpose	Convert analytical findings into spatialized and narrative scenarios that facilitate dialogue, comparison, and collaborative decision-making in Living Labs.
Step-by-Step Procedure	**1)** Draft narrative landscape scenarios on the land uses with higher capability (A-C) **2)** Review island-specific landscape literature. **3)** Integrate materials from local partners and Rooting Labs. **4)** Refine narrative landscape scenarios. **5)** Select representative sample sites. **6)** Prototype site-specific designs (Research Through Design). **7)** Create multi-format visual representations. **8)** Transfer assets to the VR development workflow.
Key Methods Used	Landscape scenario development; research through design; geospatial data integration; 3D landscape reconstruction; narrative-driven communication.
Who Should Be Involved	Landscape architects, local partners, environmental experts, Living Lab facilitators, VR software engineers/3D Designers
Roles and Responsibilities	Landscape architects coordinate multi-disciplinary teams and conceive and develop landscape scenarios and design prototypes. Local partners: validate contextual knowledge. VR team: reconstruct terrain and build immersive scenes. Facilitators: prepare and use outputs in Living Labs.
Data Required (Inputs)	Land use classes capability (A–C); orthophotos and regional technical maps; Natural habitat, Water courses and bodies, Soil quality, Biodiversity, Landscape semiology maps; Additional literature search on policy, planning, trend, and state of the art related to agriculture, natural habitat conservation and enhancement, and renewable energy development. Rooting Lab insights: landscape design prototypes and CAD files for VR.
Data Produced (Outputs)	Narrative landscape scenarios; sample sites design prototypes per some scenarios; plan views; photorealistic top-down images; landscape sections; 3D prototype models; VR-ready assets.
Tools & Materials	GIS software, CAD software, Graphic software, 3D modelling tools, rendering/graphics tools, Matrix and maps of land use

Needed	capabilities, raster and vector maps, VR headsets and Real-Time Game Engine and plugins.
Link with Other Toolkit Components	Builds directly on the Assessment and Rooting Labs; provides core material for "The Island I Would Like" Labs; delivers spatial and visual assets to the VR module; ensures methodological continuity with Landscape analysis.
Expected Outcomes	Coherent landscape scenarios; realistic design prototypes; visual and immersive materials supporting community discussion and informed decision-making.
Value for Users / Why This Module Matters	Enables stakeholders to understand the spatial implications of RET deployment, compare potential futures, and participate transparently in planning processes.
Adaptability & replicability	Easily transferable to other islands or rural areas; adaptable to various datasets, RET types, and participatory methods formats.

Technical Note 10: The Island I Would Like

The Island I Would Like Labs marks the second phase of CO2 PACMAN Living Labs, when insights from the Rooting Labs are turned into shared visions for a climate-neutral island future. While the first round focused on engagement, diagnosis, and evidence gathering, this phase focuses on co-creation. Stakeholders—such as local authorities, utilities, businesses, tourism representatives, NGOS and civil society actors, academia and urban planners, citizens, and students—collaborate to explore potential solutions, test different scenarios, and start shaping an ambitious yet feasible transition roadmap.

Following a participatory planning approach, the Labs serve as a bridge between understanding current conditions and envisioning a future aligned with local priorities, constraints, and aspirations. Structured as a three-day workshop, the Labs reconnect participants with the project's accumulated knowledge and use it as a foundation for exploring pathways to decarbonisation. A key aspect is the introduction and hands-on use of the CO2 PACMAN Tool, which blends quantitative data with scenario visualization in an easy-to-use interface. Participants directly experiment with parameters, compare sectoral options, and observe the effects on greenhouse gas emissions and carbon absorption, thereby enhancing collective capacity for evidence-based decision-making.

The Labs also utilize 3D Virtual Reality experiences created within the project, allowing participants to immerse themselves in representations of future infrastructure, mobility systems, or land-use configurations. This experiential element aids understanding, encourages dialogue, and turns abstract ideas into intuitive, tangible images of possible futures. The participatory dimension of this second phase expands on the engagement initiated during the Rooting Labs. Public authorities revisit regulatory and infrastructural implications; utilities and businesses test operational feasibility; citizens consider social acceptability; and students from the Youth Think Tank contribute alternative visions and co-design proposals. Their involvement ensures intergenerational continuity and helps keep long-term scenarios aligned with the perspectives of younger residents.

At the end of the three-day event, the Labs produce a preliminary Climate-Neutral Transition Roadmap co-created with the community. This roadmap includes a shared vision for the island's desired future, a set of priority solutions, and a clearer understanding of synergies and trade-offs across sectors like mobility, energy, waste, water management, tourism, and land use. The Labs also foster cooperation among institutions, schools, businesses, and civil society, reinforcing trust and shared ownership as the project moves toward finalizing the island's roadmaps.

A typical three-day schedule includes:

- **Day 1**: public event, presentation of assessment activities and Rooting Lab results, interactive stations, landscape scenarios and VR exploration.
- **Day 2**: scenario simulations using the CO2 PACMAN Tool, group discussions, and co-design sessions.
- **Day 3**: presentation of outcomes to local authorities, feasibility assessments, and synthesis of roadmap components.

Through hands-on experimentation and multi-stakeholder dialogue, The Island I Would Like Labs builds a community-supported vision of the island's climate-neutral future and generates practical insights for policymaking and roadmap development. Table 10.1 provides an overview of the main components and key features of this activity.

Table 10.1: Key components and features of The Island I would like labs

Component	Description/ Guidance
Purpose	To co-create a shared, community-validated vision of a climate-neutral island by transforming findings from the Rooting Labs into future scenarios, priority solutions, and a preliminary Climate-Neutral Transition Roadmap. This serves as the project's main visioning and scenario co-design phase.
Step-by-Step Procedure	**1.** Reconnection with Phase 1 outputs: presentation of GHG baseline, AskyourcitizenonCaN, Vox Populi, Landscape Analysis, Open Innovation results, Youth Think Tank visions, VR exploration. **2.** Introduction and hands-on use of the CO2 PACMAN Tool: scenario simulation, adjusting parameters, exploring sectoral options. **3**. Co-creation workshops: debates, behavioural experiments, and co-design of roadmaps. **4.** Immersive exploration: VR-based visualization of future mobility, energy, and land-use solutions. **5.** Synthesis: discussion of feasibility, identification of priority actions, drafting of the preliminary Climate-Neutral Transition Roadmap. **6.** Public sharing: presentation to authorities and community.
Key Methods Used	Scenario co-design, cooperative planning, interactive simulation with the CO2 PACMAN Tool, VR-supported spatial visualization, multi-stakeholder deliberation, and behavioural and perception-based exercises.
Who Should Be Involved	Municipalities and public authorities; utilities and service providers; businesses and tourism actors; civil society organisations; citizens; Youth Think Tank students; project partners and technical experts; SMEs/startups from the Open Innovation process (where possible).
Roles and Responsibilities	**Local authorities**: assess feasibility, provide regulatory insights. **Citizens & NGOs:** express preferences, concerns, and acceptability conditions. **SMEs & utilities**: evaluate operational implications. **Students**: contribute youth scenarios and alternative visions. **Technical partners**: facilitate tool use, VR experiences, and scenario interpretation. **Project team**: coordinate sessions and synthesize outcomes.
Data Required (Inputs)	GHG baseline and sectoral data; results from AskyourcitizenonCaN and Vox Populi; Landscape Analysis outputs; Open Innovation Collaborative Action challenge–solution matches; Youth Think Tank scenarios; technical and socio-environmental

	constraints from Rooting Labs; VR models and geospatial data materials.
Data Produced (Outputs)	Preliminary Climate-Neutral Transition Roadmap; key actions and sectoral pathways; stakeholder preferences; a refined vision of the climate-neutral future; feasibility notes and acceptability insights; updated or improved tool-based scenarios; documentation of discussions for final roadmap development.
Tools & Materials Needed	CO2 PACMAN Tool; VR headset and 3D visualization files; workshop materials (maps, post-its, boards); facilitation guidelines; laptops and internet access; printed summaries of Rooting Labs results; scenario worksheets.
Link with Other Toolkit Components	Builds directly on Rooting Labs' insights and data, integrates Youth Think Tank proposals, incorporates Open Innovation Collaborative Action solutions, uses outputs from Landscape Analysis, relies on CO2 PACMAN Tool simulations, and feeds results into the final island roadmaps and the Testing the Toolkit phase.
Expected Outcomes	Community-validated vision of the island's climate-neutral future; identified priority solutions; shared understanding of trade-offs; increased acceptance and trust; better capacity to interpret decarbonisation scenarios; preliminary roadmap for the island.
Value for Users / Why This Module Matters	Transforms data into actionable visions; empowers communities to influence the transition; enhances cross-sector collaboration; makes climate scenarios tangible through VR and tool-based exploration; supports evidence-based decision-making; increases the realism and social legitimacy of proposed pathways.
Adaptability & replicability	Can be applied in any local setting; flexible workshop formats (1–3 days); compatible with various datasets; VR optional but scalable; repeatable structure for municipalities, islands, regions, or communities working on climate-neutral planning.

Testing the Toolkit: Insight

The 'Testing the Toolkit: Insight' section presents the full, expanded outcomes of the CO2 PACMAN Toolkit's validation phase across the three pilot islands—Brač, Crete, and Elba. While the main body of the Toolkit highlights key cross-cutting insights, this section offers a comprehensive, island-specific overview of how the methodology performed in real territorial contexts. The results are organized to reflect the core components of the Toolkit's assessment phase and include detailed findings from the Rooting Labs, GHG balances, Youth Think Tanks, the AskyourcitizenonCaN perception survey, and the Open Innovation Collaborative Action.

Across all three pilot islands, several recurring patterns emerged. First, the energy sector consistently accounts for the largest share of emissions, highlighting the need for integrated energy planning and renewable deployment. Second, environmental awareness is notably high among residents, although optimism about achieving climate neutrality remains moderate, indicating a need for ongoing education and communication. Third, youth engagement proved to be a powerful driver of continuity and innovation, enhancing long-term readiness. Finally, all islands demonstrated the importance of multi-level governance, as progress depended on coordinated action among local authorities, regional actors, SMEs, and civil society. Together, these patterns show that while each territory has unique characteristics, the CO2 PACMAN methodology effectively captures shared Mediterranean challenges and opportunities, supporting its transferability and replicability.

Brač

Rooting Lab

The Rooting Lab on Brač effectively grounded the project in the island's realities by engaging a wide range of stakeholders, including local, regional, and national authorities; infrastructure providers; SMEs; business support organizations; sectoral agencies; schools; universities; NGOs; and citizens. Participants confirmed the high relevance of sustainability topics and appreciated the interactive tools and open discussions. Students expressed strong climate concerns but had limited familiarity with neutrality concepts, highlighting the need for continued educational efforts. Overall, the Lab enabled data validation, captured local perceptions, and initiated early co-creation of decarbonisation ideas, providing a solid foundation for the next phases of the CO2 PACMAN process.

GHG balance

The energy sector is the top contributor to emissions, accounting for around 68% of total gross emissions (62.97 kt CO_2eq), followed by the AFOLU sector, which accounts for around 21% (20.15 kt CO_2eq), and the waste sector, which accounts for the remaining 11% (9.9 kt CO_2eq). The industrial sector accounts for 0 kt CO_2eq. According to IPCC guidelines, this category includes only process emissions from industrial production activities—specifically mineral, chemical, and metal manufacturing—none of which are present on the island of Brač. The small manufacturing and agro-food facilities operating locally do not perform industrial processes that generate direct material-production emissions. Consequently, their energy and fuel use is allocated entirely to the Energy sector, while any agricultural inputs or outputs associated with these activities are attributed to the AFOLU sector. Overall, gross emissions amount to 93.1 kt CO_2eq, of which approximately 92% (85.5 kt CO_2eq) are compensated by the island's carbon sinks. As a result, the island's net emissions total 7.5 kt CO_2eq.

Table I.1 presents the detailed GHG balance for Brač Island, disaggregated by sector—yellow for energy, blue for industrial processes, pink for waste, and green for AFOLU. Each row specifies the corresponding subsector and indicates the consumption category associated with the emissions. The table also reports total gross emissions, total carbon uptake, and the resulting net emissions. Data are provided both as absolute values (centre column) and as percentage contributions (right column).

Table I.1: GHG emissions by sector and sub-sector in Brač: values in $ktCO_2eq$ and their percentage contribution to total emissions

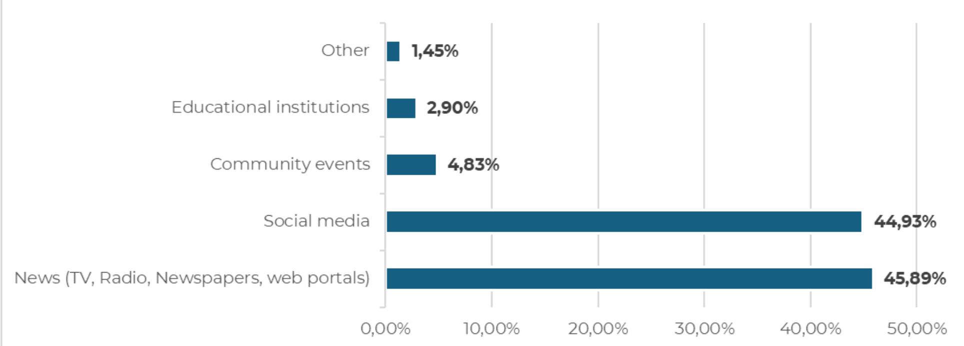
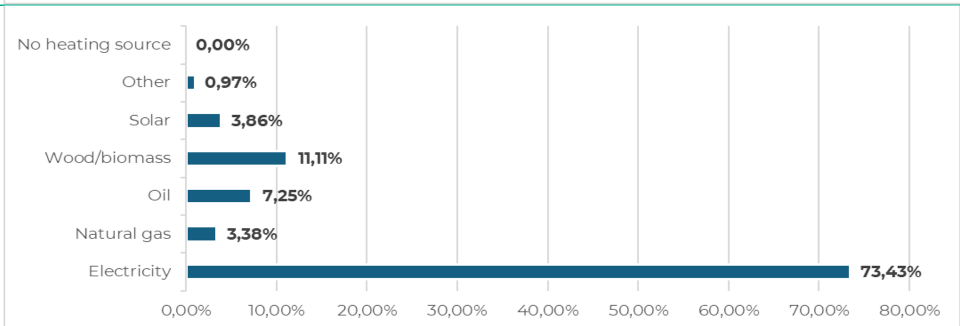
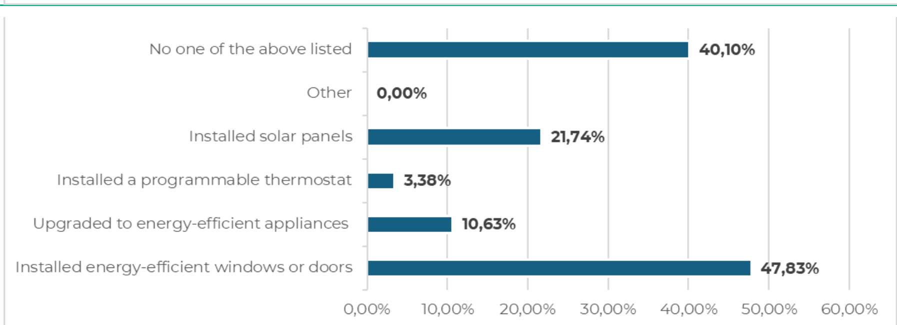
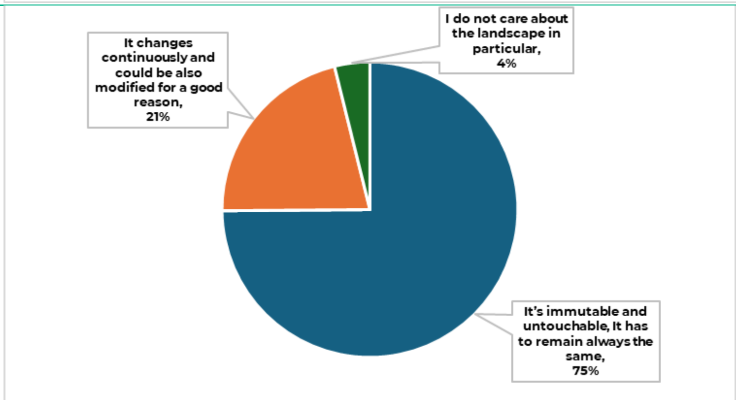
BRAČ EMISSIONS SECTORS AND SUB-SECTORS	VALUE ($ktCO_2eq$)	% ON TOTAL
ENERGY	**62.97**	**67.7 %**
ELECTRICITY PRODUCTION/CONSUMPTION (HOUSEHOLD AND SERVICES, PUBLIC TRANSPORT, INDUSTRIAL, AGRICULTURAL)	5.6	6 %
FUEL CONSUMPTION (HEATING FOR RESIDENTIAL, SERVICE, INDUSTRIAL, AGRICULTURAL)	10.2	10.9 %
MOBILITY (ROAD TRANSPORTATION, WATER-BORNE NAVIGATION, CIVIL AVIATION)	47	50.8 %
INDUSTRIAL PROCESSES	**0**	**0 %**
WASTE	**9.9**	**10.7 %**
WASTEWATER	0.2	0.2 %
SOLID WASTE (LANDFILLED, COMPOSTED, SELECTION PLANTS, RECYCLED)	9.7	10.4 %
AFOLU	**20.15**	**21.7 %**
FOREST FIRES	15.45	16.6 %
LIVESTOCK (WILD AND STABLED ANIMALS)	4.39	4.7 %
AGRICULTURAL PRODUCTION (CEREALS, ROOTS AND TUBERS, TEMPORARY FODDER, PERMAMENT FODDER)	0.3	0.3 %
TOTAL GROSS EMISSIONS	**93.1**	**100 %**
LAND USE (UPTAKE)	**-85.6**	**-92 %**
TOTAL NET EMISSIONS	**7.5**	**8 %**

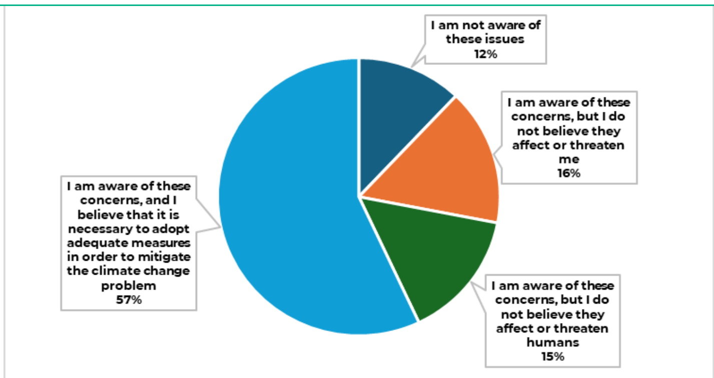
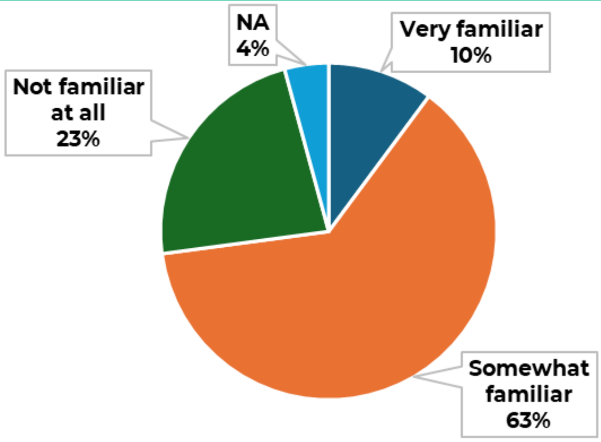
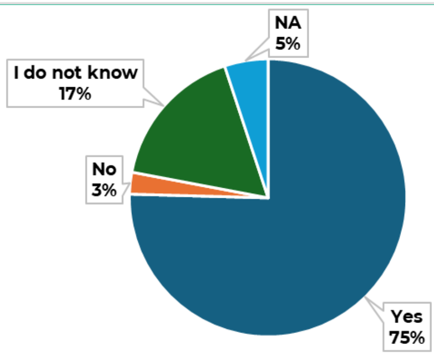
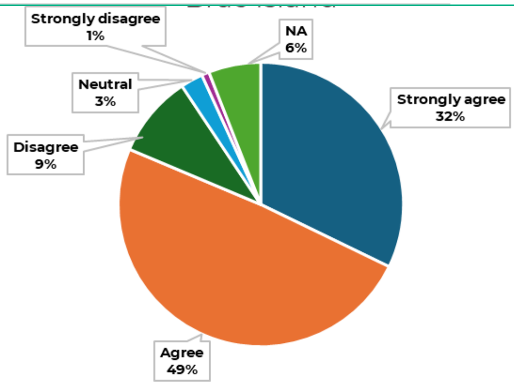
For methodological details, refer to Technical Note 2: GHG balance, and Deliverable 1.3.1 (CO2 PACMAN Datasets and Tools).

AskyoutcitizenonCaN survey

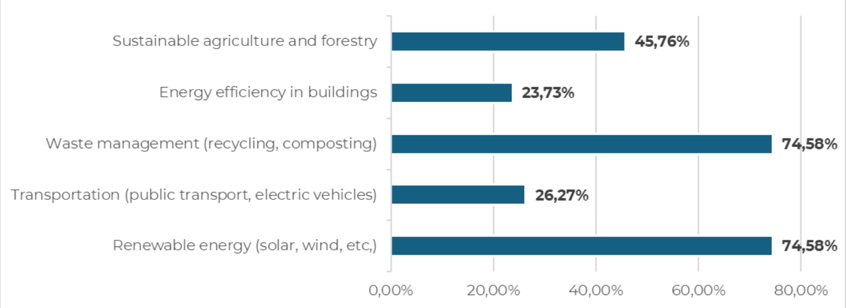
The survey results highlight strong environmental awareness among Brač residents: 88% of respondents are aware of climate change, and 57% believe it is necessary to adopt adequate measures in order to mitigate it. However, only 32% are optimistic about achieving this goal by 2040, showing both engagement and realism in public perception. Respondents identified renewable energy and waste management (both 75%) as top priorities for reducing environmental impacts, followed by sustainable agriculture (46%), improvements in transportation (26%), and energy efficiency in buildings (24%). These findings demonstrate a community that is aware, willing to act, yet mindful of the structural challenges ahead. Table I.2 reports the selected survey results for Brač: in the first column, a sample of questions; in the second, the survey results.

Table I.2: Selected results of AskyourcitizenonCaN for Brač

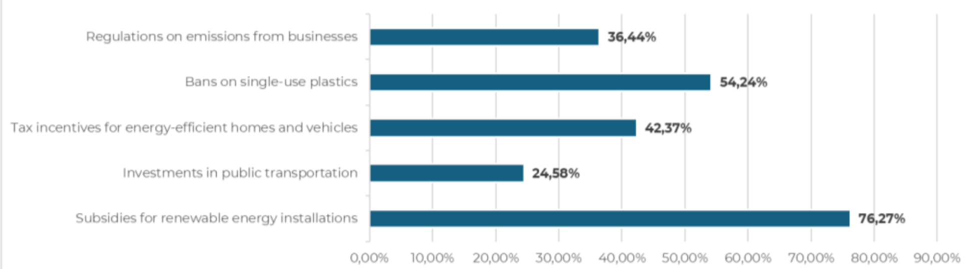
Question	Brač results
Where do you get most of your information about environmental issues?	
What is your primary source of energy for heating your home?	
Have you made any of the following home improvements to increase its energy efficiency?	
What do you think about the landscape of your island?	

Are you aware of the concerns related to climate change?	
How familiar are you with the concept of Climate neutrality (REDUCE EMISSIONS UP TO NET 0)?	
Do you believe that achieving Climate neutrality is important for the island?	
Do you agree with the sentence: the island should aim to reduce emissions up to net 0 (Climate neutrality) by 2030?	

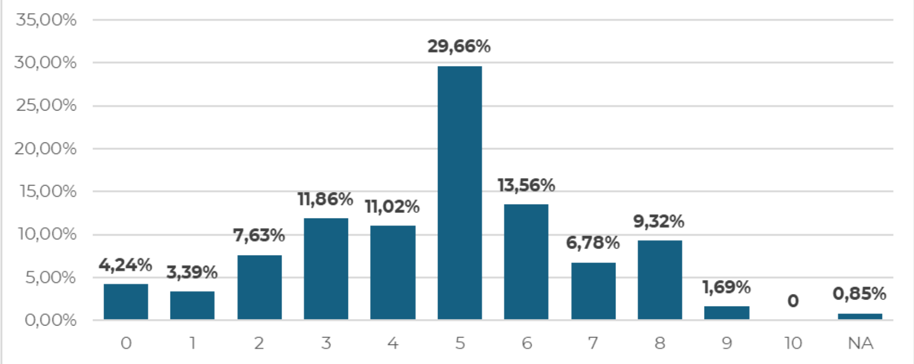
In order to achieve the Climate Neutrality, on which topic should the island focus on?



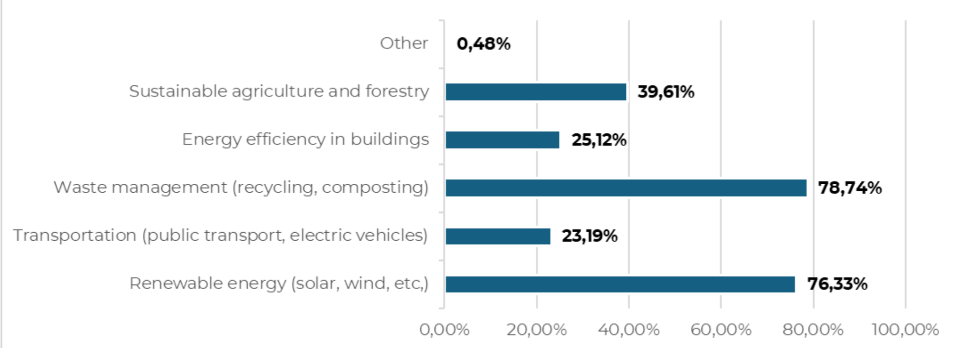
Which of the following policies would you support to help achieving Climate Neutrality?



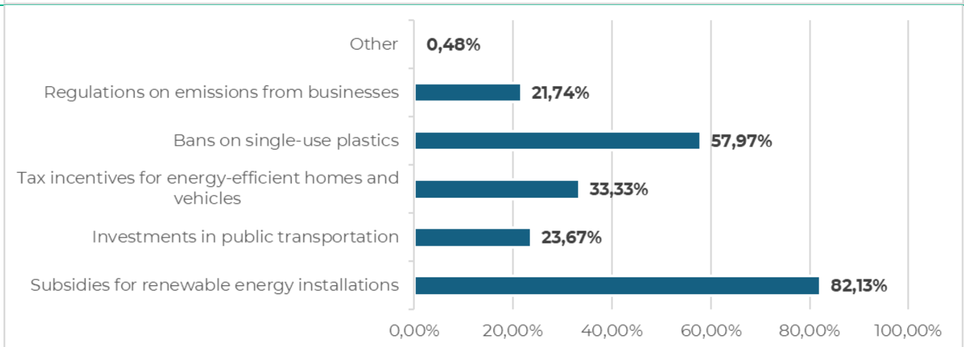
On a scale of 0 to 10, how optimistic are you that the island will achieve Climate neutrality by 2040?



In order to reduce environmental impacts, on which topic should the island focus on?



Which of the following policies would you support to help reducing environmental impacts of the island?



For methodological details, see Technical Note 4: AskyourcitizenonCaN. The report on the citizen survey "AskyourcitizenonCaN" details the methodology and results, which are also available online: askyourcitizenoncan.unisi.it.

Youth Think Tank

In September 2024, during the Brac Rooting Lab, the first Youth Think Tank on Brač Island brought together local students to discuss climate change and sustainable lifestyles. Most participants (63%) expressed concern about the climate crisis, and over half were unfamiliar with the term climate neutrality. When asked to identify priorities for their island, they ranked behavioural change, renewable energy, and tree planting as the most effective solutions. Nearly 60% said they felt more hopeful after the session, confirming that participatory learning can turn awareness into motivation for real change.

A year later, in September 2025, a second Youth Think Tank took place in Bol, uniting high school students from Bol High School and university students from the University of Split – Faculty of Civil Engineering, Architecture, and Geodesy. Building on previous experience, the session expanded the discussion with geospatial analysis, participatory dialogue, and a hands-on session with the CO2 PACMAN Tool. The comparison of Slido[1] results before and after using the tool confirmed a consistent hierarchy of priorities: renewable energy (4.9 → 4.5) and sustainable mobility (4.1 → 4.1) remained the top solutions, followed by behavioural change (3.0 → 3.3) and tree planting (3.3 → 3.1). These results show that students already had a solid understanding, and the interactive approach helped reinforce rather than drastically change their perceptions.

Open Innovation Collaborative Action

On Brač, open innovation focuses on waste management (Komunalno društvo GRAD d.o.o. & Michelli Tomić d.o.o.), water stewardship (Vodovod Brač), and safety (Fire Brigade). Three solvers were selected to address these priorities: LIS Data Solutions (an AI-based waste-routing system), Fibsen (real-time fiber-optic water-leak detection), and the University of Central Lancashire (the E-FAST initiative for electric-vehicle fire safety and training). A potential pilot collaboration between Fibsen and Vodovod Brač is currently being discussed.

Brač faces key challenges related to fragmented local data, the energy sector's dominance in emissions, and varying levels of climate-neutrality awareness among stakeholders. However, strong stakeholder engagement, early youth participation, and the island's high

[1] Slido is an online live-polling and audience interaction platform

carbon sink capacity present significant opportunities for a low-carbon transition and nature-based solutions. Overall readiness is medium to high, supported by motivated institutions, an active citizenry, and clear pathways for incorporating renewable energy, enhancing waste management, and encouraging behavioral changes.

Crete

Rooting Lab

The Rooting Lab in Crete anchored the CO2 PACMAN process within the local community of Rethymno by mobilizing a broad and diverse group of stakeholders, including local and regional authorities, SMEs, infrastructure and service providers, business support organizations, schools, higher education institutions, NGOs, interest groups, and the general public. The Lab stood out for its strong communication and outreach efforts: an intensive media campaign covering social networks, online portals, local newspapers, TV, and radio increased the project's visibility and encouraged more participation. Interactive workshops, open-air co-design activities, surveys, and public events enabled local stakeholders, planners, decision-makers, residents, students, and enterprises to discuss climate neutrality. At the same time, targeted dissemination materials ensured that key messages reached audiences across multiple platforms. Overall, the Lab promoted awareness, boosted community engagement, and laid a solid foundation for ongoing collaboration as the island co-creates climate-neutral roadmaps.

GHG balance

The energy sector is the largest source of emissions, accounting for 64% of total gross emissions (1,877.67 kt CO_2eq), followed by the AFOLU sector (23%, 684.84 kt CO_2eq) and the waste sector (13%, 395.2 kt CO_2eq). According to IPCC guidelines, this category includes only process emissions from industrial production activities—specifically from mineral, chemical, and metal manufacturing—none of which are present on the island of Crete. Therefore the industrial sector in the context of the CO2 PACMAN toolkit accounts for 0 kt CO_2eq. A strong agro-food industry sector exists in Crete, as well as a smaller building materials industry; however, these activities do not perform industrial processes that generate direct material-production emissions. Consequently, their energy and fuel use is allocated entirely to the Energy sector, while any agricultural inputs or outputs associated with these activities are attributed to the AFOLU sector. Total gross emissions reach 2,958 kt CO_2eq, with roughly 41% (1,218.2 kt CO_2eq) offset by carbon sinks on the island, resulting in net emissions of 1,737 kt CO_2eq in Crete.

Table I.3 presents the detailed GHG balance for Crete Island, disaggregated by sector—yellow for energy, blue for industrial processes, pink for waste, and green for AFOLU. Each row specifies the corresponding subsector and indicates the consumption category associated with the emissions. The table also reports total gross emissions, total carbon uptake, and the resulting net emissions. Data are provided both as absolute values (centre column) and as percentage contributions (right column).

Table I.3: GHG emissions by sector and sub-sector in Crete: values in kt CO_2eq and their percentage contribution to total emissions

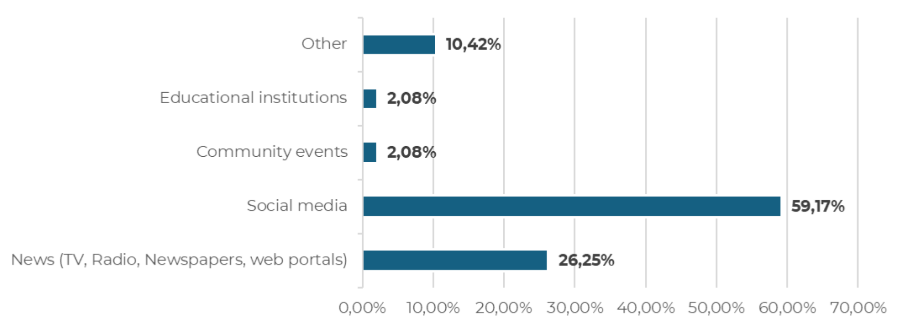
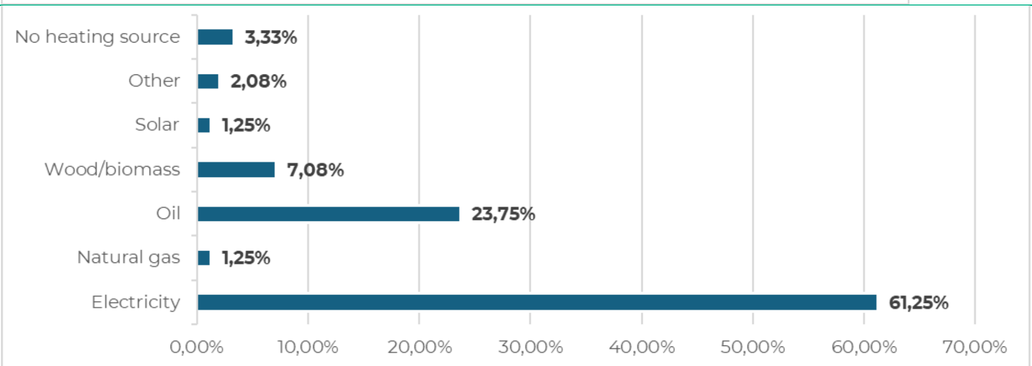
CRETE EMISSIONS SECTORS AND SUB-SECTORS	VALUE (ktCO_2eq)	% ON TOTAL
ENERGY	**1877.67**	**63.5 %**
ELECTRICITY PRODUCTION/CONSUMPTION (HOUSEHOLD AND SERVICES, PUBLIC TRANSPORT, INDUSTRIAL, AGRICULTURAL)	**505**	**17.1 %**
FUEL CONSUMPTION (HEATING FOR RESIDENTIAL, SERVICE, INDUSTRIAL, AGRICULTURAL)	**228**	**7.7 %**
MOBILITY (ROAD TRANSPORTATION, WATER-BORNE NAVIGATION, CIVIL AVIATION)	**1145**	**38.7 %**
INDUSTRIAL PROCESSES	**0**	**0 %**
WASTE	**395.17**	**13.4 %**
WASTEWATER	**50.17**	**1.7 %**
SOLID WASTE (LANDFILLED, COMPOSTED, SELECTION PLANTS, RECYCLED)	**345**	**11.7 %**
AFOLU	**684.84**	**23.2 %**
FOREST FIRES	**16**	**0.5 %**
LIVESTOCK (WILD AND STABLED ANIMALS)	**606**	**20.5 %**
AGRICULTURAL PRODUCTION (CEREALS, ROOTS AND TUBERS, TEMPORARY FODDER, PERMAMENT FODDER)	**64**	**2.1 %**
TOTAL GROSS EMISSIONS	**2958**	**100 %**
LAND USE (UPTAKE)	**-1221**	**-41 %**
TOTAL NET EMISSIONS	**1737**	**59 %**

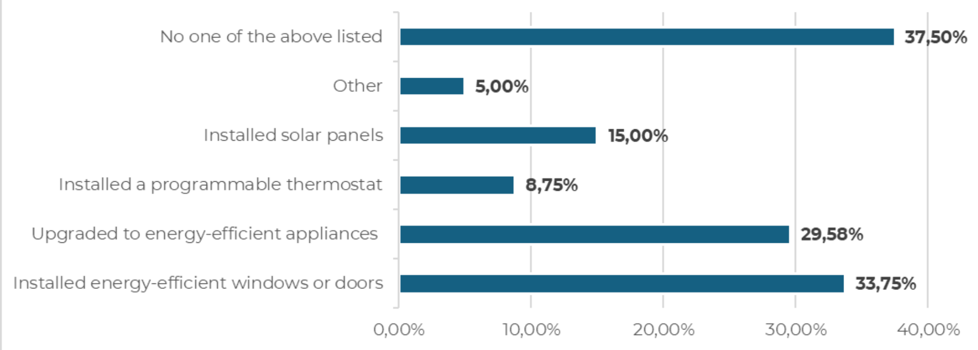
For methodological details, refer to Technical Note 2: GHG balance, and Deliverable 1.3.1 (CO2 PACMAN Datasets and Tools).

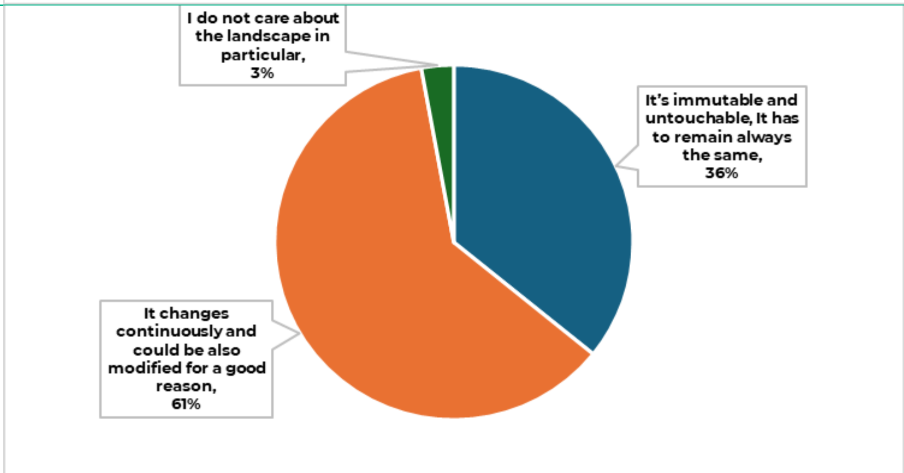
AksyourcitizenonCaN

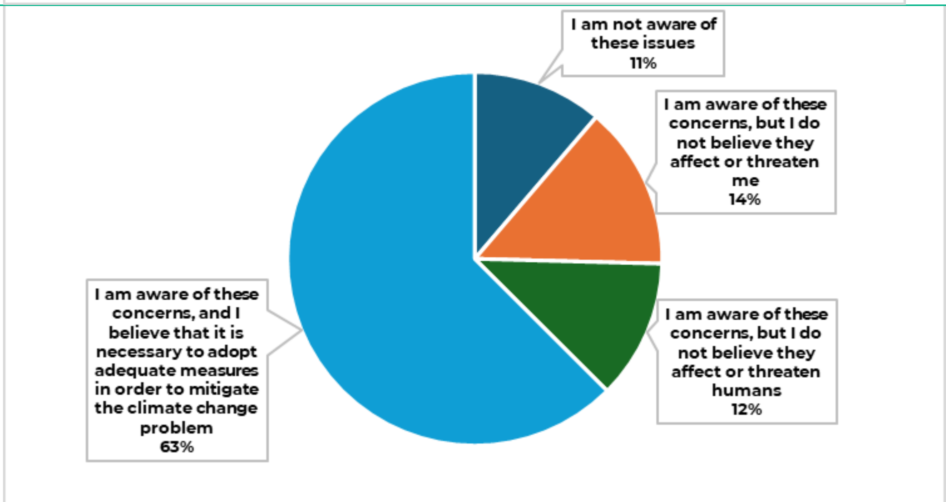
The survey results show that many Crete residents are environmentally aware: 89% of respondents are aware of climate change and 63% believe it is necessary to adopt adequate measures in order to mitigate it. Indeed, 83% support that the island should aim to reduce emissions up to net 0 (Climate neutrality) by 2030. However, only 37% feel optimistic about achieving climate neutrality by 2040, suggesting the need for both attention and immediate action. 69% of the respondents listed waste management (69%) as the top priority for reducing environmental impacts, followed by renewable energy (65%), transportation (60%), energy efficiency in buildings (53%), and sustainable agriculture and forestry (42%). These findings highlight a population conscious of the climate challenge and supportive of concrete actions to enhance local sustainability. Table I.4 reports the survey results for Crete: in the first column, a sample of questions; in the second column, the survey results.

Table I.4: AskyourcitizenonCaN result for Crete

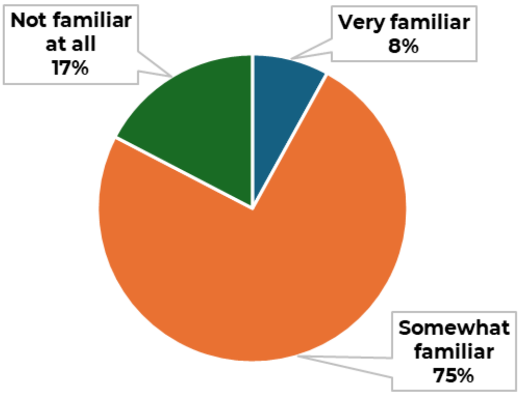
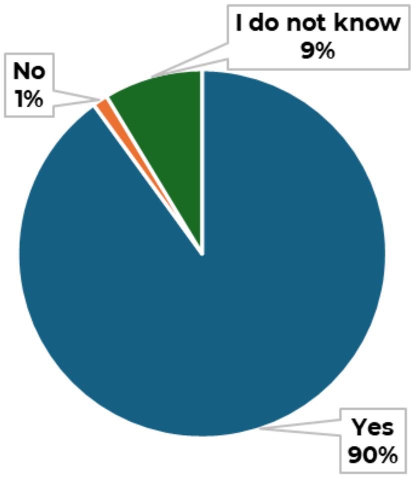
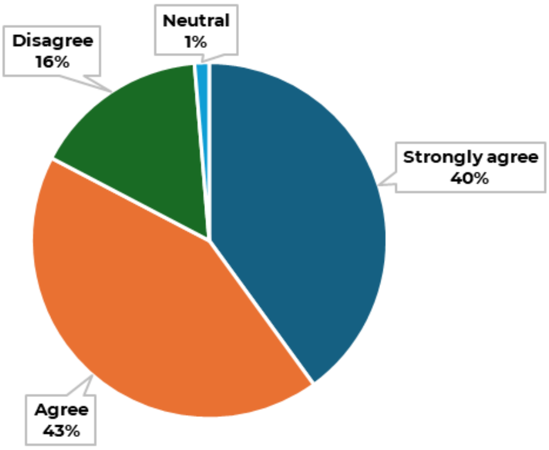
<table>
<tr><th>Question</th><th>Crete results</th></tr>
<tr><td>Where do you get most of your information about environmental issues?</td><td>
</td></tr>
<tr><td>What is your primary source of energy for heating your home?</td><td>
</td></tr>
</table>

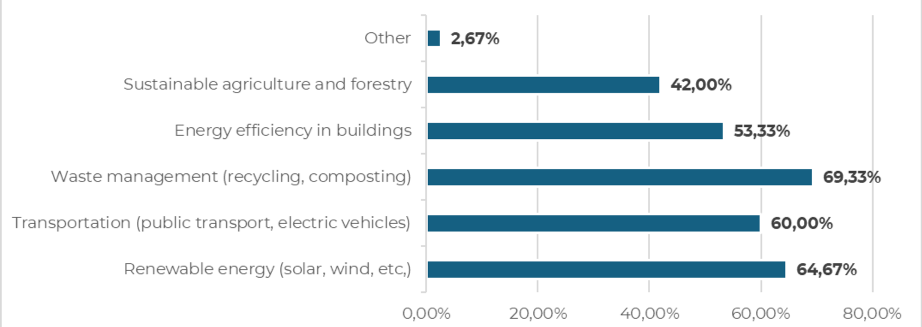
<table>
<tr><td>Have you made any of the following home improvements to increase its energy efficiency?</td><td>


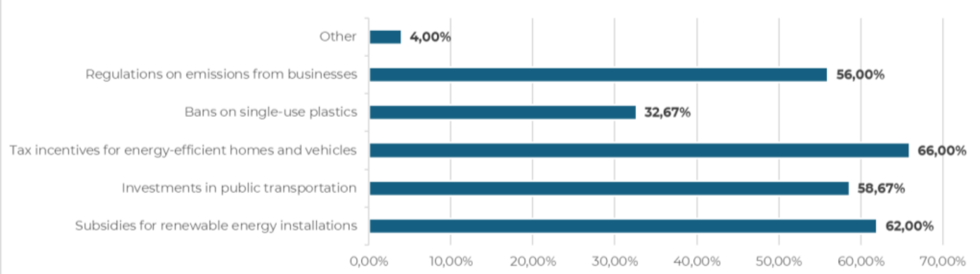
</td></tr>
<tr><td>What do you think about the landscape of your island?</td><td>


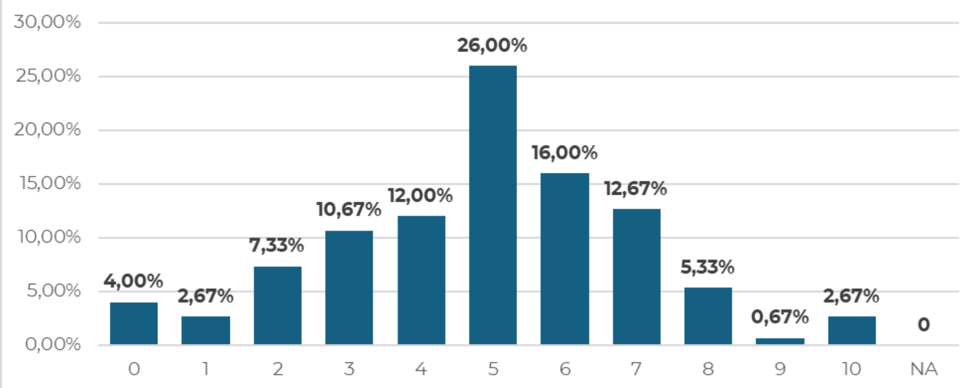
</td></tr>
<tr><td>Are you aware of the concerns related to climate change?</td><td>


</td></tr>
</table>

How familiar are you with the concept of Climate neutrality (REDUCE EMISSIONS UP TO NET 0)?	
Do you believe that achieving Climate neutrality is important for the island?	
Do you agree with the sentence: the island should aim to reduce emissions up to net 0 (Climate neutrality) by 2030?	

<table>
<tr>
<td>In order to achieve the Climate Neutrality, on which topic should the island focus on?</td>
<td>


</td>
</tr>
<tr>
<td>Which of the following policies would you support to help achieving Climate Neutrality?</td>
<td>


</td>
</tr>
<tr>
<td>On a scale of 0 to 10, how optimistic are you that the island will achieve Climate neutrality by 2040?</td>
<td>


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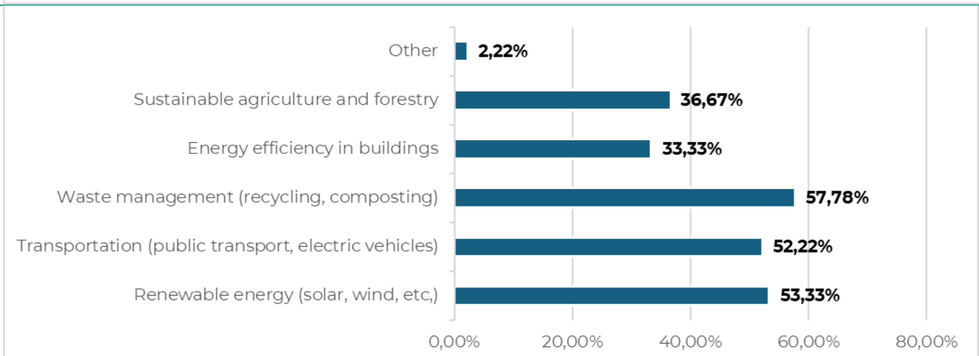
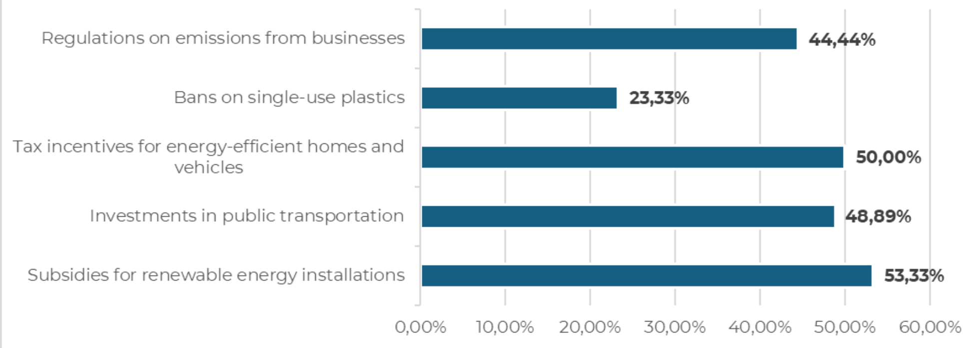
</tr>
<tr>
<td>In order to reduce environmental impacts, on which topic should the island focus on?</td>
<td>


</td>
</tr>
</table>

<table>
<tr>
<td>Which of the following policies would you support to help reducing environmental impacts of the island?</td>
<td>
</td>
</tr>
</table>

For methodological details, see Technical Note 4: AskyourcitizenonCaN. The report on the citizen survey "AskyourcitizenonCaN" details the methodology and results, which are also available online: askyourcitizenoncan.unisi.it.

Youth Think Tank

In October 2024, the Renewable and Sustainable Energy Lab of the Technical University of Crete launched the first youth-focused activities of CO2 PACMAN, engaging students in participatory exercises designed to raise awareness and strengthen their role in the island's climate transition. These initial efforts paved the way for a more evolved Youth Think Tank held in May 2025, when 25 undergraduate students from the School of Chemical and Environmental Engineering participated in the two-day workshop "The Island I Would Like."

Using a combination of scientific analysis and creative visioning, students collaborated in teams to develop climate-neutral roadmaps for Crete, addressing solutions across energy, transport, waste, water, tourism, and food systems. Guided by the Sustainable Energy Planning Toolbox and the CO2 PACMAN methodology, they simulated real decision-making processes, evaluated local challenges, and crafted integrated proposals tailored to the island's unique characteristics. A team of active 'Ambassadors for a Climate Neutral Crete' was initiated. This experience highlighted the strong interest of Cretan students in climate issues. It demonstrated how hands-on, participatory methods can empower young people to envision and co-create credible pathways toward a carbon-neutral island.

Open Innovation Collaborative Action

In Crete, open innovation targeted priority areas identified by local stakeholders, including circular materials (Intermunicipal Solid Waste Management Company), waste management (Rethymno Hoteliers Association), and sustainable mobility (Municipality of Rethymno). Three solvers were chosen to address these priorities: SilviBio (Circular peat alternatives from organic waste streams, supporting sustainable agriculture and resource efficiency), Effiwaste (promoting Zero Waste strategies in hotels and tourism-related businesses, integrating waste reduction with operational improvements), and LIS Data Solutions (AI-Driven Urban Mobility Data Platform, to optimize sustainable transport planning and improve modal split analysis).

Crete's main challenges arise from its large territorial size, high energy demand, and the relatively significant share of net emissions, all of which require ambitious, multi-sector mitigation efforts. However, the island's strong institutional commitment, high public awareness, rich educational system, and effective communication outreach provide major opportunities to accelerate decarbonization. Crete shows a high level of readiness, supported by active universities, engaged stakeholders, and a socio-political climate open to innovative mobility, circular solutions, and renewable energy integration.

Elba

Rooting Lab

The Rooting Lab on Elba strengthened the project's integration into the island's social and institutional fabric by engaging a wide range of stakeholders, including local and regional authorities, national agencies, sectoral organizations, SMEs, infrastructure and service providers, NGOs, interest groups, and the general public. The Lab encouraged renewed cooperation with regional partners such as the Tuscany Region and ARRR (Regional Agency for Resource Recovery of Tuscany Region), while establishing new connections with local initiatives, including the CER of Elba, which became a key catalyst for further collaboration. Participants appreciated the various engagement formats, from technical exchanges to informal outreach events, demonstrating how accessible communication can increase public understanding of climate neutrality. Along with the Youth Think Tank and visits to local businesses, the Lab helped strengthen networks, boost shared commitment, and set the foundation for co-developing community-driven pathways toward decarbonisation.

GHG balance

The energy sector is the largest contributor to emissions, accounting for around 93% of total gross emissions (183.2 kt CO_2eq). The waste sector follows, accounting for almost 5% (9.5 kt CO_2eq), and the AFOLU sector accounts for around 2% (4.5 kt CO_2eq). The industrial sector accounts for 0 kt CO_2eq. According to IPCC guidelines, this category includes only process emissions from industrial production activities—specifically mineral, chemical, and metal manufacturing—none of which are present on the island of Elba. The small manufacturing and agro-food facilities operating locally do not perform industrial processes that generate direct material-production emissions. Consequently, their energy and fuel use is allocated entirely to the Energy sector, while any agricultural inputs or outputs associated with these activities are attributed to the AFOLU sector. Total gross emissions come to about 197 kt CO_2eq, with roughly 32% (62 kt CO_2eq) offset by carbon sinks on the island. As a result, Elba's net emissions are 135 kt CO_2eq.

Table I.5 presents the detailed GHG balance for Elba Island, disaggregated by sector—yellow for energy, blue for industrial processes, pink for waste, and green for AFOLU. Each row specifies the corresponding subsector and indicates the consumption category associated with the emissions. The table also reports total gross emissions, total carbon uptake, and the resulting net emissions. Data are provided both as absolute values (centre column) and as percentage contributions (right column).

Table I.5: GHG emissions by sector and sub-sector in Elba: values in ktCO_2eq and their percentage contribution to total emissions

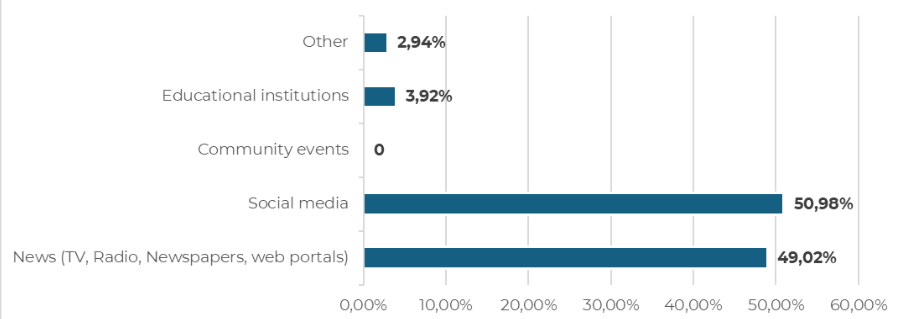
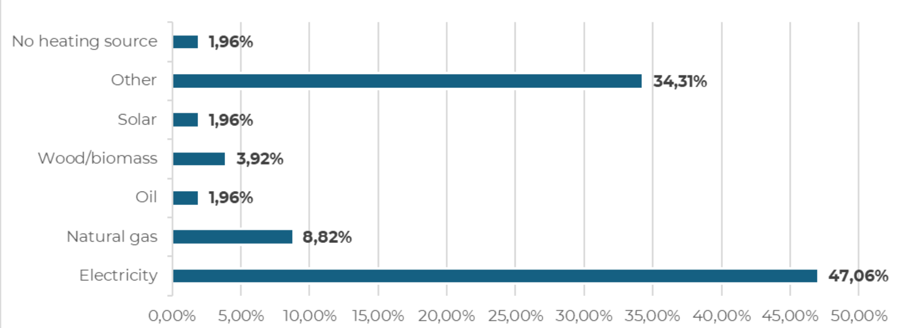
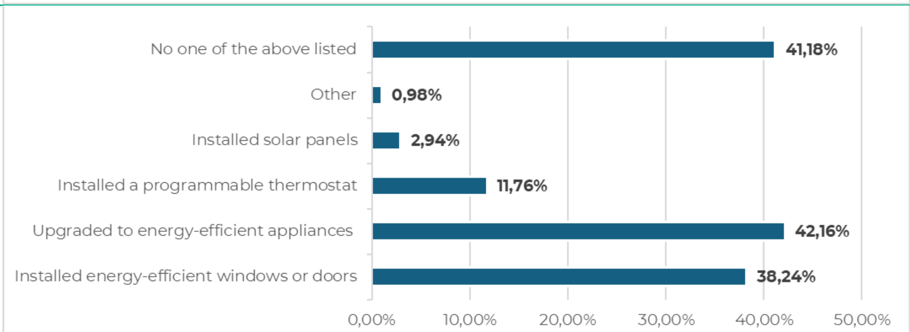
ELBA EMISSIONS SECTORS AND SUB-SECTORS	VALUE (ktCO_2eq)	% ON TOTAL
ENERGY	**183.2**	**92.9 %**
ELECTRICITY PRODUCTION/CONSUMPTION (HOUSEHOLD AND SERVICES, PUBLIC TRANSPORT, INDUSTRIAL, AGRICULTURAL)	48	24.5 %
FUEL CONSUMPTION (HEATING FOR RESIDENTIAL, SERVICE, INDUSTRIAL, AGRICULTURAL)	16	8.2 %
MOBILITY (ROAD TRANSPORTATION, WATER-BORNE NAVIGATION, CIVIL AVIATION)	119	60.2 %
INDUSTRIAL PROCESSES	**0**	**0 %**
WASTE	**9.5**	**4.8 %**
WASTEWATER	2.3	1.2 %
SOLID WASTE (LANDFILLED, COMPOSTED, SELECTION PLANTS, RECYCLED)	7.2	3.7 %
AFOLU	**4.52**	**2.3 %**
FOREST FIRES	4.48	2.3 %
LIVESTOCK (WILD AND STABLED ANIMALS)	0	0 %
AGRICULTURAL PRODUCTION (CEREALS, ROOTS AND TUBERS, TEMPORARY FODDER, PERMAMENT FODDER)	0.04	0.02 %
TOTAL GROSS EMISSIONS	**197.22**	**100 %**
LAND USE (UPTAKE)	**-62**	**-32 %**
TOTAL NET EMISSIONS	**135**	**68 %**

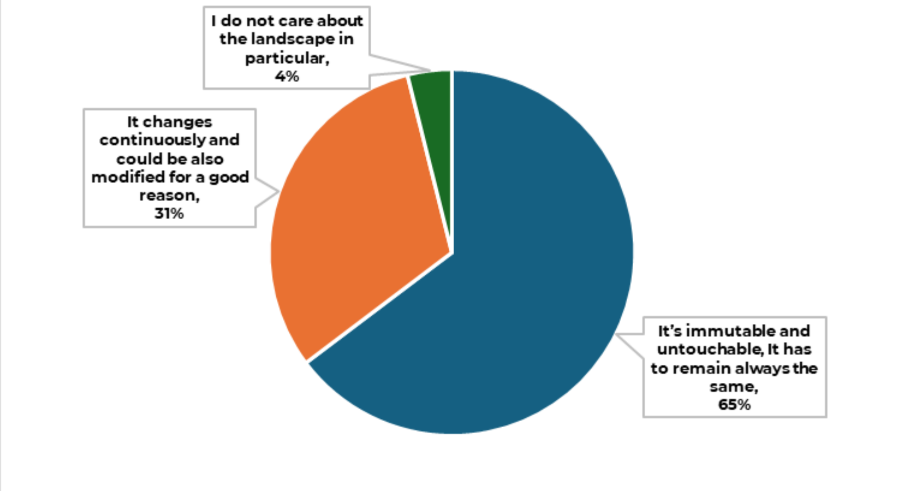
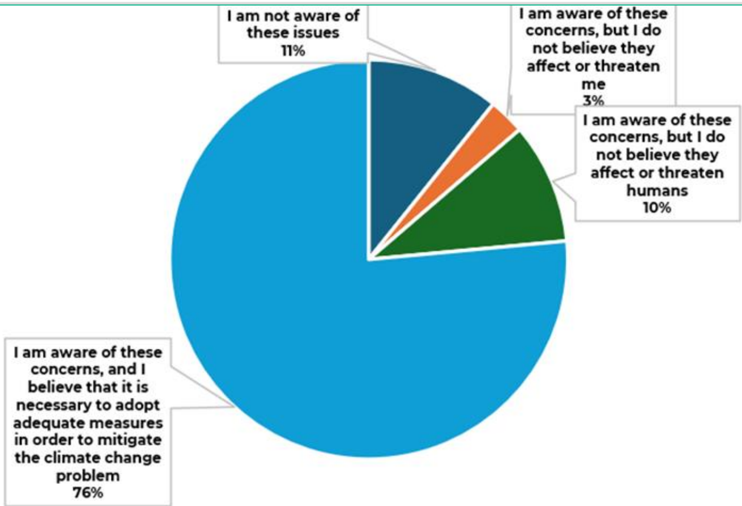
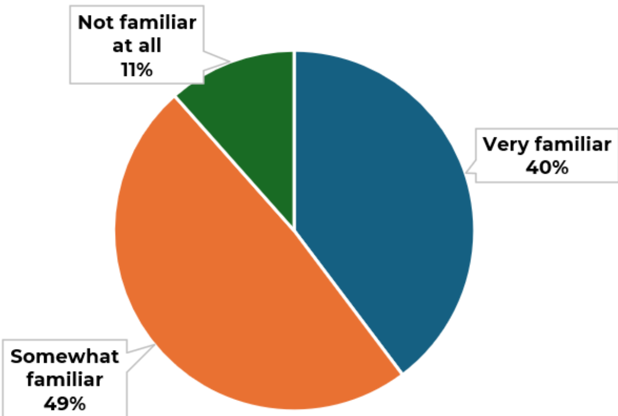
For methodological details, refer to Technical Note 2: GHG balance, and Deliverable 1.3.1 (CO2 PACMAN Datasets and Tools).

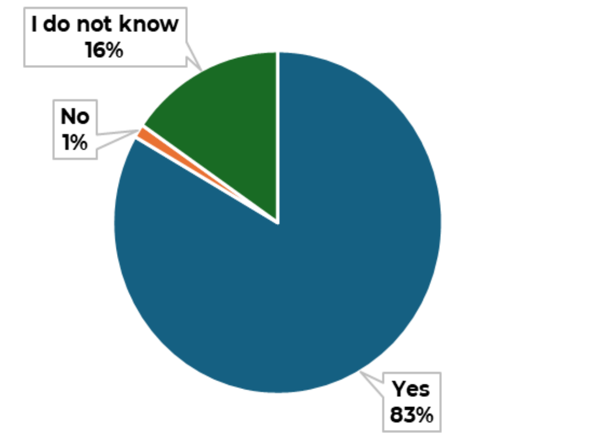
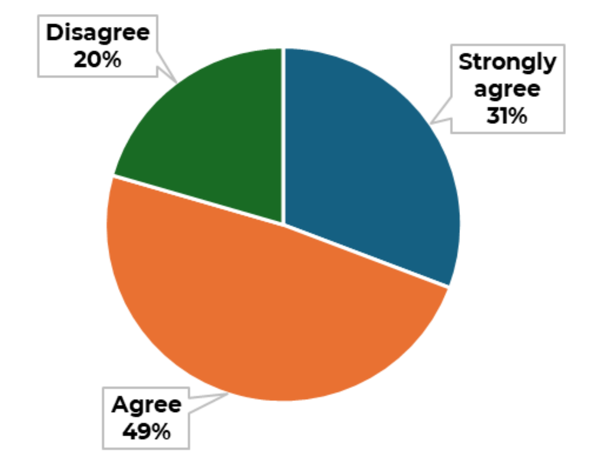
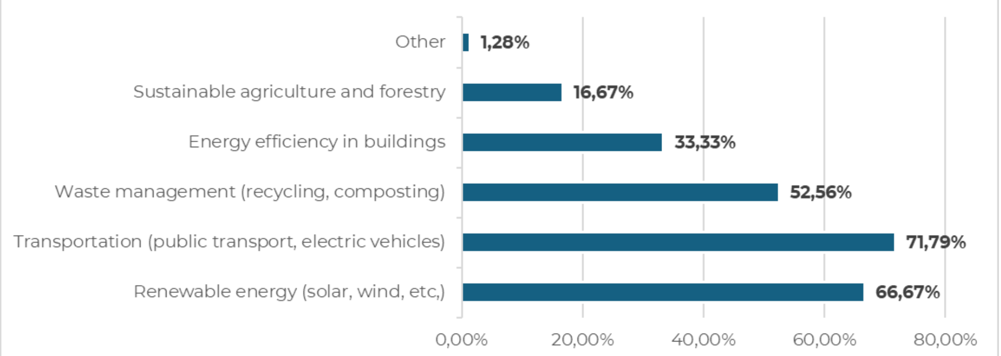
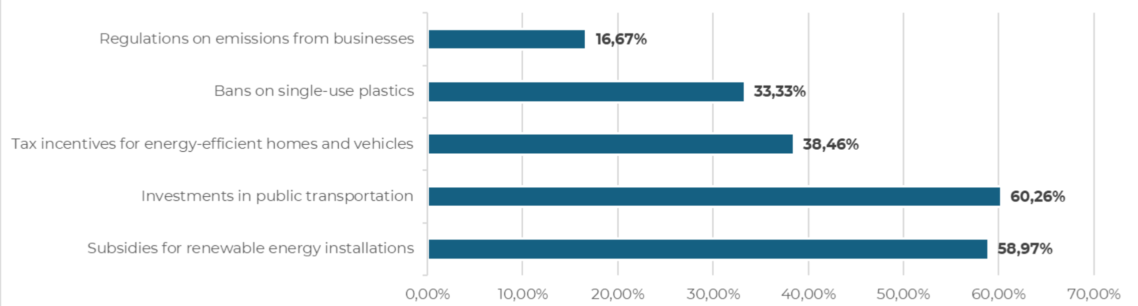
AskyourcitizenonCaN

Survey responses from Elba Island reveal a similarly high awareness of climate change, with 89% of participants recognizing the need for immediate action. However, only 37% believe climate neutrality can be achieved by 2040, indicating cautious optimism tempered by local constraints. Citizens prioritized transportation (72%) and renewable energy (67%) as the most urgent areas for intervention, followed by waste management (53%), energy efficiency in buildings (33%) and sustainable agriculture and forestry (17%). The results depict a community aware of environmental issues and willing to engage, while acknowledging the structural and socio-economic barriers to transition. Table I.6 reports the survey results for Elba: in the first column, a sample of questions; in the second, the survey results.

Table I.6: AskyourcitizenonCaN result for Elba

Question	Crete results
Where do you get most of your information about environmental issues?	
What is your primary source of energy for heating your home?	
Have you made any of the following home improvements to increase its energy efficiency?	

What do you think about the landscape of your island?	
Are you aware of the concerns related to climate change?	
How familiar are you with the concept of Climate neutrality (REDUCE EMISSIONS UP TO NET 0)?	

Do you believe that achieving Climate neutrality is important for the island?	
Do you agree with the sentence: the island should aim to reduce emissions up to net 0 (Climate neutrality) by 2030?	
In order to achieve the Climate Neutrality, on which topic should the island focus on?	
Which of the following policies would you support to help achieving Climate Neutrality?	

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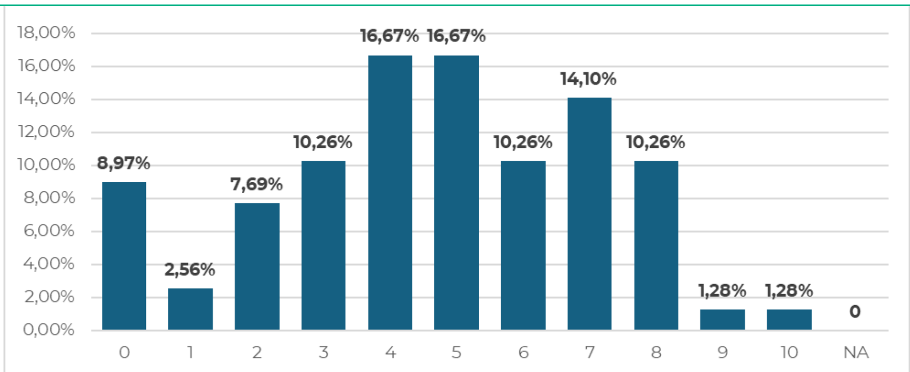
<tr>
<td>On a scale of 0 to 10, how optimistic are you that the island will achieve Climate neutrality by 2040?</td>
<td>
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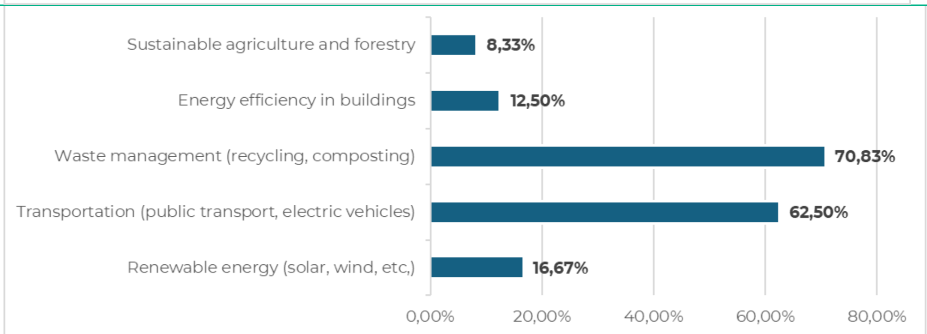
<tr>
<td>In order to reduce environmental impacts, on which topic should the island focus on?</td>
<td>
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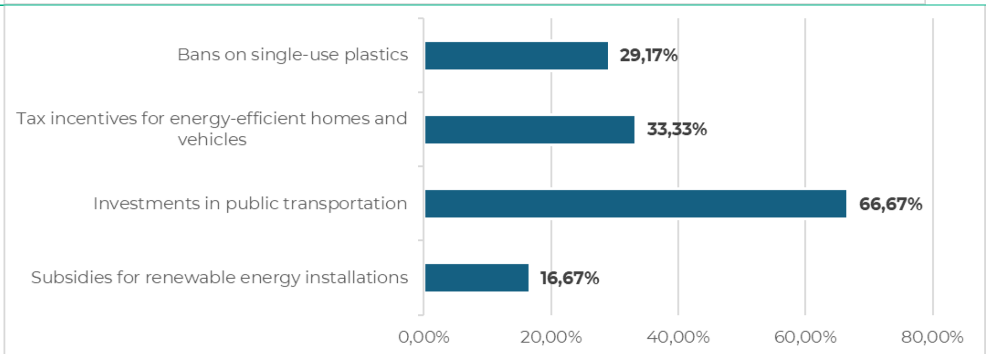
<tr>
<td>Which of the following policies would you support to help reducing environmental impacts of the island?</td>
<td>
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Youth Think Tank

In December 2024, the first Youth Think Tank session was held on Elba Island, organized with Raffaello Foresi High School in Portoferraio. The workshop showed a mix of awareness and curiosity: over half of the students expressed concern about climate change, while many were still unfamiliar with the concept of carbon neutrality. When asked to identify the most effective actions for their island, they prioritized renewable energy, behavioural changes, and sustainable mobility, demonstrating a strong understanding of the human side of the transition. A few months later, during the Rooting Lab activities in March 2025, students participated in two educational games (the Fish Game and the COOL Game, specifically designed to engage students in the climate neutrality process), exploring cooperation, resource limits, and everyday climate choices. The response was enthusiastic: over 70% reported a better understanding of sustainability, and 90% described the experience as highly engaging and motivating. In November 2025, another Youth Think

Tank session was held with the same classes at Raffaello Foresi High School, this time focused on testing the CO2 PACMAN Tool. After an introduction to Elba's updated greenhouse gas balance and the historical link between ecological change and local landscapes, students worked in groups to design their own climate-neutral scenarios. The activity enhanced their ability to interpret data, compare policy options, and visualize long-term impacts on their island. Their reflections emphasized the urgency of tackling key challenges—such as transportation, renewable energy deployment, and forest management—and the importance of accessible planning tools to support informed decision-making. The session also proved crucial in preparing students for the upcoming co-design phase, allowing them to refine their ideas and become more active participants in the transition process.

Open Innovation Collaborative Action

The main challenges identified in Elba relate to agroecology (Arrighi), hydrogen-enabled mobility (CER Elba), and sustainable events (Acqua dell'Elba). The solvers chosen to address these challenges are: DEVINE (Smart Monitoring & Decision Support for Vineyard-Forest Integration), GreenShift Elba (Reducing Vehicular Traffic through Sustainable Multi-Modal Mobility and Green Tourism), and Bluease (Digital Platform for Sustainable and Low-Carbon Event Management).

Elba's main challenges include reliance on the energy sector for most of its emissions, limited capacity to absorb carbon, and structural barriers related to its island setting and tourism seasonality. However, active collaboration with regional authorities, strong youth involvement, the rise of local energy communities (CER Elba), and a motivated small and medium enterprise (SME) ecosystem create favorable conditions for climate action. Readiness is rated as medium, with strong institutional interest and community awareness, but ongoing capacity-building is needed to support renewable energy, agroecological innovation, and improved mobility solutions.

Added Value, Transferability, and Legacy of the CO2 PACMAN Toolkit

The development and testing of the CO2 PACMAN Toolkit represent a significant step toward empowering territories in the Mediterranean and beyond to design and implement credible pathways to climate neutrality. The work presented in this document demonstrates the Toolkit's strong **relevance** because, rather than merely documenting project results, the CO2 PACMAN Toolkit positions itself as a practical, transferable framework that directly addresses the core challenges faced by insular and peripheral regions, including fragmented data availability, diverse stakeholder needs, and the complexity of translating climate ambition into operational strategies.

Compared with existing approaches, the Toolkit offers clear **added value** by integrating scientific assessment, participatory engagement, digital modelling, VR-supported scenario exploration, and open innovation within a single, coherent framework. This unique combination helps bridge the gap between evidence and action, enabling communities to understand their current emissions profiles, explore alternative futures, and co-design actionable roadmaps that reflect local constraints, opportunities, and governance realities.

Through its modular structure, IPCC-based methodologies, harmonised datasets, and adaptable engagement formats, the CO2 PACMAN Toolkit demonstrates a **high level of transferability well beyond insular narrow contexts** (i.e., specific pilot contexts). Experiences from Brač, Crete, and Elba confirm that the methodology can be applied across territories with different scales, institutional arrangements, and socio-environmental characteristics, while maintaining methodological consistency and comparability. In this sense, the Toolkit contributes to broader European and Mediterranean objectives by offering a replicable pathway for operationalising climate neutrality at the local level.

Finally, this document has been designed to function as a practical reference, combining a clear structure, detailed technical notes, visual and immersive tools, and operational guidance tailored to both experts and decision-makers. As the project moves forward, the CO2 PACMAN Toolkit provides a solid foundation for continued refinement, shared learning, and cross-territorial cooperation.

Output 1.1 should therefore be understood not as a final product, but as an evolving reference framework — one that strengthens the capacity of territories to navigate the transition toward climate neutrality with confidence, inclusiveness, and scientific rigour. Through continued application and adaptation, CO2 PACMAN is positioned to support resilient, socially grounded, and future-proof climate strategies across the Mediterranean and beyond.

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List of figures

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