Report on the evaluation of ecosystem services in Reunion Island focusing on the bio-corridor of Saint-Philippe

Deliverable nº D.3.4

May 2023

Citation: MOVE-ON project (2023), European Commission Directorate General Environment Grant Agreement no. 07.027735/2019/808239/SUB/ENV.D2. Deliverable 3.4 (Report on the evaluation of ecosystem services in Reunion Island focusing on the bio-corridor of Saint-Philippe)

Coordinated by:

Partners:

Supported by:

This project has received funding from the European Union represented by European Commission Directorate - General Environment, under grant agreement Nº 07.027735/2019/808239/SUB/ENV.D2

Project Acronym	**MOVE-ON**
Project Title	**From case studies to Anchor Projects - setting the ground to advance MAES in Europe's overseas.**
Grant Agreement nº	07.027735/2019/808239/SUB/ENV.D2
Start of the project	May 2020
Duration	36 months
Project coordinator	Regional Fund for Science and Technology, Regional Government of the Azores (Portugal)
Website	www.moveon-project.eu

Deliverable title	**Report on the evaluation of ecosystem services in Reunion Island focusing on the bio-corridor of Saint-Philippe**
Deliverable nº	**D.3.4**
Activity title	Methods integration and implementation in regional projects
Task title	Assessing ecosystems' functionality and services of a bio-corridor on Reunion Island
Task Leader(s)	*NEXA*
Lead authors	*Cathleen Cybèle, Ina Sieber,* José Bénédicto
Contributing authors	Rekha Grimoire, Anne-Lise Herold
Due date of deliverable	31/03/2023
Actual submission date	12/05/2023
Dissemination Level:	Public

Version	Status	Date	Author(s)
1.0	Draft	14/02/2023	Cathleen Cybèle, Ina Sieber, José Bénédicto, Rekha Grimoire, Anne-Lise Herold
1.2	Draft	28/03/2023	Cathleen Cybèle, Ina Sieber, José Bénédicto, Rekha Grimoire, Anne-Lise Herold
1.3	Revision	31/03/2023	Cathleen Cybèle, Ina Sieber, José Bénédicto, Rekha Grimoire, Anne-Lise Herold
1.4	Final revision	27/04/2023	Tara Pelembe, Carolina Parelho

Summary

The MOVE-ON project aims at advancing the MAES methodology's implementation in European ORs and OCTs. The project also intends to create and strengthen the scientific and technical MAES communities in those territories, demonstrating the benefits of ecosystems conditions assessments and related ecosystem services to support decision-making.

MOVE-ON Activity 3 aims at integrating and implementing methods in Anchor Project sites. Activity 3 is based on recommendations and support of Activity 2 and Activity 4, within which each individual need of each Anchor Project site is tailored in terms of methods, technical support or networking for stakeholders.

The Anchor Project of Reunion Island region is the Biological corridor of Mare Longue Nature Reserve of the municipality of Saint-Philippe located in the southern area of the island. The MAES process has been undertaken to map Ecosystem Services, especially cultural benefits and services supplied by the ecosystems in the area, not only the Biological corridor of Mare Longue Nature Reserve at municipal scale but also at the scale of Reunion island itself. Task 3.4 has been put in place in as follows:

- Sub-task 3.4.1 - Identification of stakeholders and establishment of the Anchor Project governance
- Sub-task 3.4.2 – The "Bio-corridor forum"
- Sub-task 3.4.3 – Implementation of the MAES framework for the corridor

List of abbreviations

BISE	Biodiversity Information System
CICES	Common International Classification of Ecosystem Services
ES	Ecosystem Services
ESMERALDA	Enhancing ecoSysteM sERvices mApping for poLicy and Decision mAking
FG	Focus Groups
OPENESS	Operationalisation Of Natural Capital And Ecosystem Services
OPERAs	Operational Potential of Ecosystem Research Applications
EU	European Union
IUCN	International Union for Conservation of Nature
MAES	Mapping and Assessment of Ecosystems and their Services
MOVE	Mapping and Assessing the State of Ecosystems and their Services in the Outermost Regions and Overseas Countries and Territories: Establishing links and pooling resources
MOVE-ON	Mapping and Assessing the State of Ecosystems and their Services in the Outermost Regions and Overseas Countries and Territories: From Case Studies to Anchor Projects - Setting the ground to advance MAES in Europe´s overseas
NGO	Non Governmental organisation
OCT	Overseas Countries and Territories
OR	Outermost Region
PGIS	Participatory GIS mapping
PSP	Participatory Scenario Planning

Table of Contents

List of Figures

List of Tables

1 INTRODUCTION

The EU Biodiversity strategy 2020, through the Action 5 of the 2nd target, urged its member states in each national territory to map and assess the state of ecosystems and their services (European Commission, 2011). Furthermore, the recent EU Biodiversity Strategy for 2030 also lay emphasis on the importance of ecosystems and their services with key targets. In the execution of the EU Biodiversity strategy 2020, MAES is a method that has been applied since the past decade in continental Europe with a view to assess then evaluate ecosystems services.

The inception of ES was put ahead by Constanza et al. (1997) describing the role of ecological systems and the natural capital mainly as stock of materials and information, listing ES, and their functions. The value of ES being of utmost importance shows a need to preserve nature as well as the society. Figure 1 expresses the link between ecological services, social and economic systems, in which biophysical structures (through a given habitat) or processes, and their functions (for instance biomass, water) lead to the supply of services that are beneficial to social and the economic system notably for human well-being.

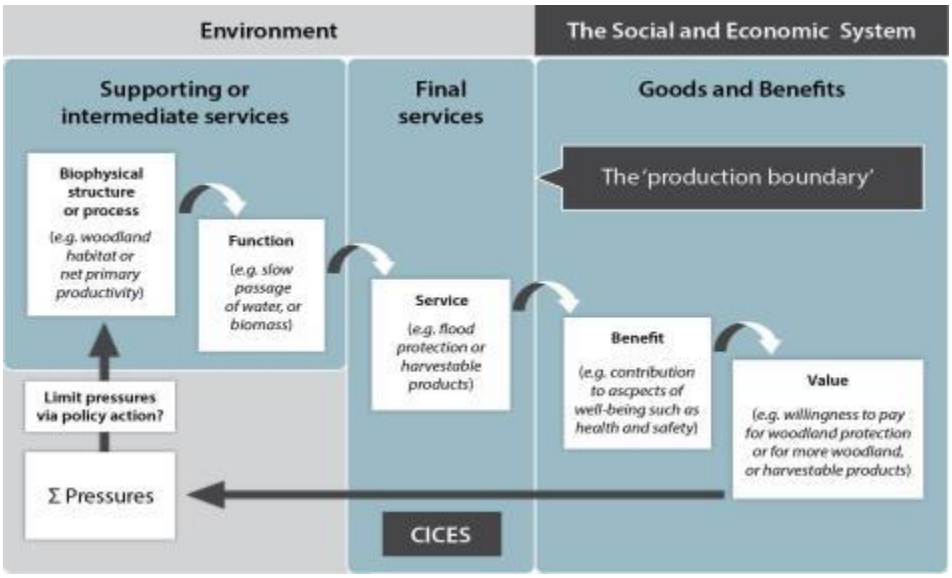


Figure 1: The concept of Ecosystem Services Part of: Burkhard B, Maes J (Eds) (2017) Mapping ecosystem services. Advanced Books. https://doi.org/10.3897/ab.e12837

Numerous research projects have been implemented to develop and emphasize on the MAES approach, for example, the ESMERALDA project (Enhancing

ecoSysteM sERvices mApping for poLicy and Decision mAking) has delivered a database of sets and tools to implement the MAES approach to support policy and decision making. Despite the fact that 80% of Europe's biodiversity is located in Europe's Outermost Regions (ORs) and Overseas Countries and Territories (OCTs) (Petit and Prudent, 2008), there is a dearth in the assessment of ES within the overseas region (Sieber et al. 2018).

The Directorate-General for Environment of the European Commission has dedicated funding mechanism to apply the MAES methodologies in its overseas territories through two projects. First the MOVE pilot project (GA. No.07.027735/2018/776517/SUB/ENV.D2) from 2018 to 2020 has been put in place showcasing first ES assessments in form of case-studies, followed by more recently the MOVE-ON project.

The MOVE-ON pilot project "From case studies to Anchor Projects setting the ground to advance MAES in Europe's overseas" highlights Anchor Projects as a setting ground of MAES. One of the MOVE-ON Anchor Projects sites, amongst others, is located in the Indian Ocean, more specifically in Reunion Island (French OR) and carried out by the Agency for Investment, Development and Innovation (NEXA) and the University of Reunion Island. The selected area for the Anchor Project site is located in the southern area of Reunion Island, in the municipality of Saint-Philippe, within the Mare Longue Nature reserve, hosting the last remnants of pristine forests of the island.

Figure 2: Worldwide location of Reunion Island in the Indian Ocean, within which Mare Longue Nature Reserve is located in the municipality of Saint-Philippe in the southern area of the island (Google 2023)

2 OVERVIEW OF THE STUDY AREA

2.1 Reunion Island

Reunion Island, commonly called "La Réunion", French outermost territory, is located within the Mascarene Archipelago of the Indian Ocean. The tropical island covers 2512 km$^{2.}$ with the active Volcano, Piton de la Fournaise, Reunion Island displays a complex topography and a high diversity of native habitats distributed along sharp elevation gradients from sea level to 3070 m above sea level (a.s.l). The island biota is characterized by a high level of endemism reaching almost 100% for native animals or plants living in alpine vegetation. Native biota are highly

threatened by biological invasions despite permanent efforts to control major invasive species especially plants impacting ecosystem at global scale, namely strawberry guava, lantana, kahili ginger etc. Due to habitats and native species vulnerability, 40% of Reunion Island is now protected as a National Park that recently received by UNESCO the status of natural world heritage site.

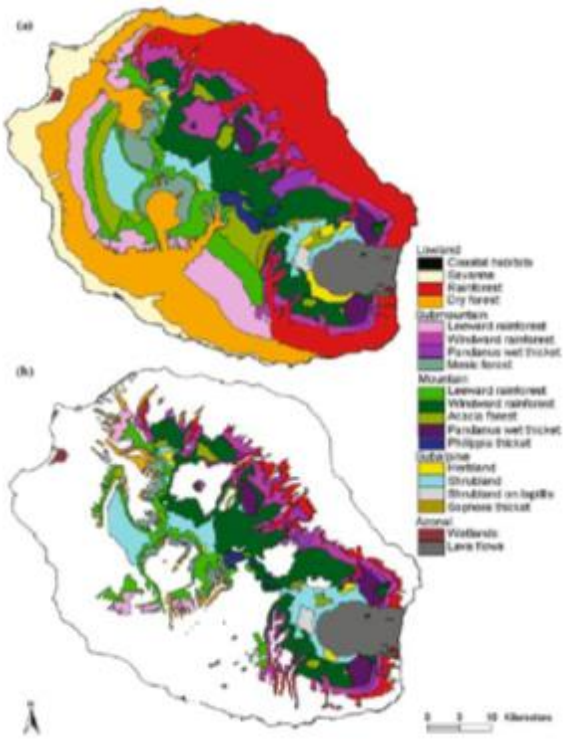


Figure 3: Habitat types in Reunion Island Island: (a) original extent; (b) current extent (excluding areas transformed by agriculture and urbanisation or highly invaded areas) (Strasberg et al. 2005)

According to the French national institute for statistics and economic studies (INSEE) the population on Reunion Island reached 863 100 people in 2020. People are mainly localised in large towns all along the coast, with the exception of two areas lying on the lower slopes of the active volcano, the municipalities of Saint Philippe and Sainte Rose in the Southern east of Reunion. It partly explains why Saint-Philippe presents one of the least populated municipalities with an estimate of 5256 people in 2020; the population size of Sainte Rose is roughly similar with about 6300 people.

2.2 The Anchor Project site: the municipality of Saint-Philippe, home to the Mare Longue Nature Reserve as bio-corridor in Reunion Island

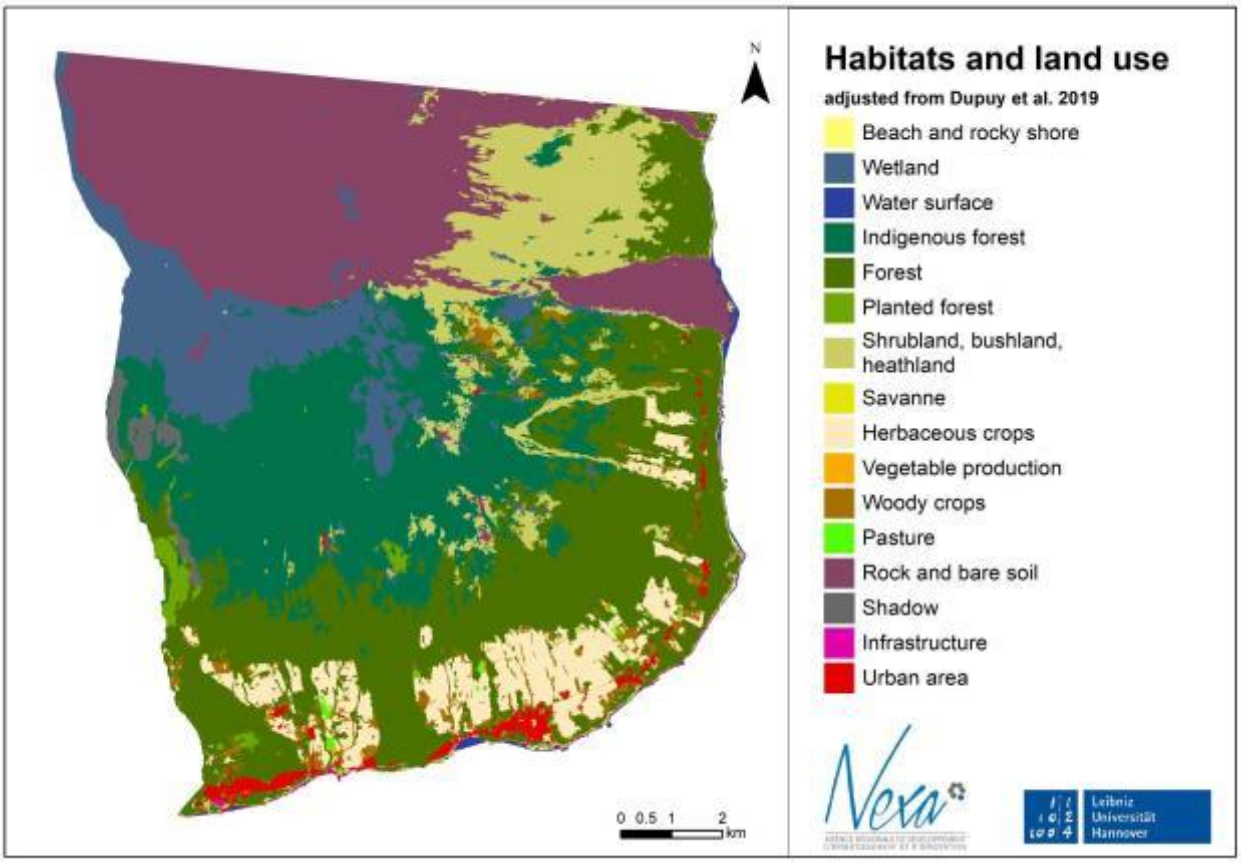


Figure 4: The land use in Saint-Philippe on the base the GABIR Project,available on CIRAD-AWARE platform[1]

The Mare Longue Nature reserve is known for its high level of endemism as a high biodiversity area of the island. It composes a heterogeneous landscape stretching from the seashore to the highest peak of the volcano area (Figure 2). Within the nature reserve the last remnants of hygrophilous forest are located at low altitudinal level of the island. Invasive alien species, habitat fragmentation and anthropogenic activities pose the main threats to this high biodiversity area. This nature reserve and the municipality itself is an area of research study for such exceptional natural features, endemic flora and fauna. Land use in the buffer zone to the nature reserve is characterized by agroforestry, as common practice, along with tourism and recreational activities. Figure 4 shows the land use in Saint-Philippe on the base the GABIR Project, available on CIRAD-AWARE platform. The map shows that human

[1] http://aware.cirad.fr/

settlements and built up areas agglomerate in the coastline. Agricultural activities, especially sugarcane cultivation, take place in the lower slopes. Woody crops include the cultivation of fruit orchards, and vanilla, major emblematic and economic activities of the area. The majority of the area is covered by indigenous forest, secondary forest as well as lava flows. Small spots of humid forest can be found on higher altitude.

Several categories of ES are delivered by Mare Longue Nature Reserve and it necessary to highlight that the Anchor Project site found in Saint-Philippe within Reunion Island as a European Union Outermost Region, and as part of the Mascarene Islands. Mare Longue Nature Reserve is a remnant of the pristine forests of Reunion Island sharing the Madagascar and the Indian Ocean Islands biodiversity hotspot. Due to the high biodiversity value of Mare Longue Nature Reserve , it is mandatory to select this site as an Anchor Project site for MAES implementation within the Outermost regions.

3 ANCHOR PROJECT OBJECTIVES AND RESEARCH QUESTIONS

3.1 The governance of the Anchor Project site

In terms of governance, the Mare Longue Nature Reserve as a whole is divided into several zones with diverse management authorities, namely the National Park of La Réunion, the Forestry Services and the Municipality of Saint-Philippe.

The Mare Longue Nature Reserve was the first biological reserve created in 1958 in Reunion Island. The National Park of La Réunion, first created in early 21st century, included part of Mare Longue Nature Reserve under the National Park area.

The National Park aimed at the co-creation of shared governance between institutional, scientific and economic stakeholders of the Mare Longue Nature Reserve and its vicinity. The objective of a shared governance of the nature reserve allows the National Park to not only be a facilitator but also a coordinator in favour of actions that will be carried out by the stakeholders of the Mare Longue Nature Reserve area. A concerted action plan[2] (CAP) has been set-up with implementation from 2019 to 2030. The co-creation of a management plan and a CAP is a response to the prevailing conservation challenges despite the action undertaken by biodiversity conservation experts for a few decades. In addition, the Mare Longue Nature Reserve has witnessed an expansion of socio-economic

[2] https://documentation.reunion-parcnational.fr/index.php?lvl=notice_display&id=8123

stakeholders as well as academics, farmers and landowners, in relation to the policy in place to protect such pristine area. The advent of the MOVE-ON project in 2019 allowed the Anchor Project site to be included as an operational activity within the Mare Longue Nature Reserve CAP actions. In fact, the Anchor Project site has been integrated within the vision of the CAP during the 1st CAP technical committee as follows:

"The Mare Longue forest is alive and preserved, sheltering an exceptional biodiversity on the scale of the Mascarene Islands and providing the populations with a precious space for resourcing and activities of wealth creation."

3.2 The Anchor Project research questions

At the initial phase of the project's implementation, three main questions were formulated in the Anchor Project site, setting the objective for the Anchor Project on Reunion Island, as stated in the deliverable D.2.2b. These three questions cover socio-economic business questions on the sustainable expansion of touristic activities, a policy-oriented demand for uptake of ES into local management plans. From a societal perspective, the question of maintenance and enhancement of the local community's sense of belonging and protection of the Anchor Project site through socio-economic activities was identified. Thus, the Anchor Project site focus on the business question and in some ways the societal question (Figure 5).

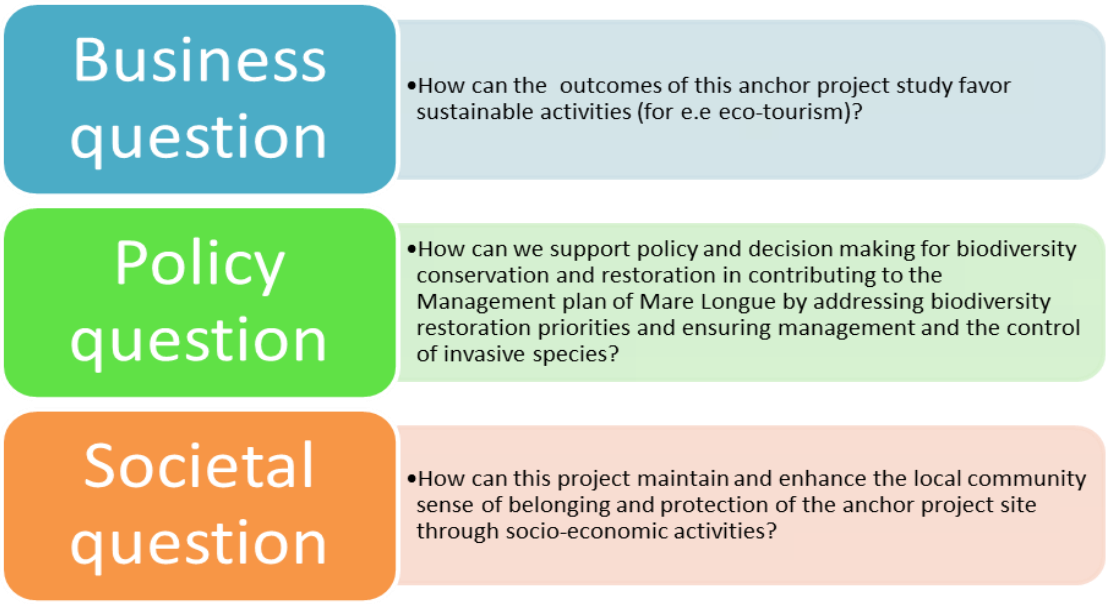


Figure 5 : The 3 core questions established in Deliverable 2.b of the MOVE-ON project regarding the Anchor Project site of Reunion Island

4 METHODS AND MATERIALS FOR ECOSYSTEM SERVICES MAPPING AND ASSESSMENT

4.1 Following the guidance of the EU MAES explorer tool

The EU has funded and produced several reports to encourage Member States on the methods of mapping ES. The mandate for the MAES is anchored Action 5 of the EU Biodiversity Strategy which expects each Member State to map and assess ES in their national territory, for application to policy and decision making. In our Anchor Project study, the work previously conducted and collected in the ESMERALDA Database served as an initial overview. We first looked into the EU MAES explorer tool based of ESMERALDA project and selected the first four of the seven steps to be applied in Reunion Island (Figure 6).

Figure 6: EU MAES explorer guidance tool tailored to the needs of member states of the EU

We took into account the framework for integrated MAES developed by Burkard *et al. 2018*. This framework for integrating the MAES process (Figure 6), to devise a sequential approach (Figure 10) for describing our Anchor Project activities by implementing step 1 to step 4 of this approach. In addition, the MAES approach aims to enable "stakeholders" to know and measure the effects of the decisions and actions they undertake on natural ecosystems and on the services provided by these ecosystems that underpin their own activities.

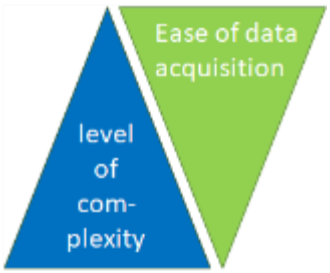
4.2 Governance method in stakeholder's involvement

In the identification of relevant stakeholders, linked with a common focal issue at ecological scale, we first conducted informal meetings with key stakeholders. Through informal meetings, we prepared the insights for the step-wise approach in the governance of the Anchor Project site.

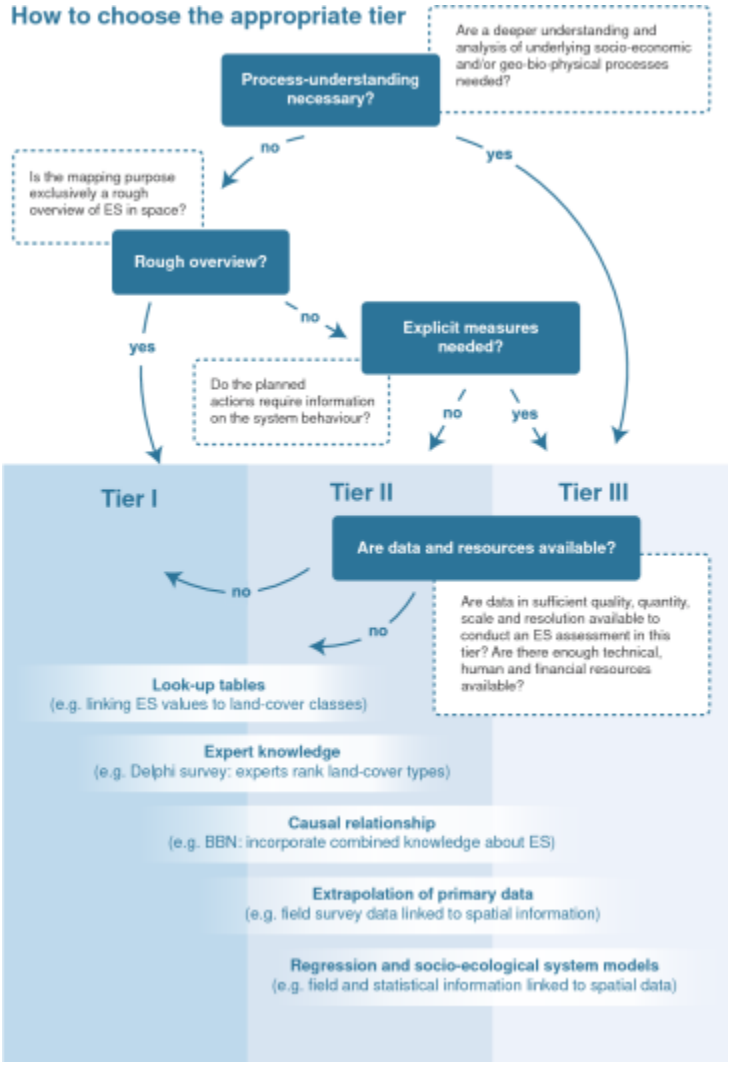
Figure 7: The step-wise approach to set-up a governance to building-up steering committee meeting and "Ecosystem Sentinel" Community

The aim of joining an existing steering committee meeting and to set-up an "Ecosystem Sentinel" Community was to better understand the ecological dynamic and human impact. Such governance also aimed to reduce the gap between research results and practioners needs. In addition, the "Ecosystem Sentinel" Community, aimed at assisting in the design and implementation of ecosystems monitoring and assessment activities with the help of academics and public authorities. The "Ecosystem Sentinel" Community contributed to the Anchor Project site as from the first step with regards to stakeholders' involvement (Figure 10).

4.3 Utilizing a multi-tiered approach



When multiple ES mapping and assessment methods are combined to present a comprehensive overview of ES distribution, it is called a tiered-approach. Such a tiered approach allows consistent, yet flexible mapping of ES. The different tiers build upon each other and increase in level of complexity, however, at a cost of ease of data acquisition. Tier 1 approaches entail Lookup tables, linking ES to habitats or Land Use Land Cover (LULC). High Tiers include complex regression and socio-ecological systems models with high data demand (Grêt-Regamey et al. 2017).



The tiered approach (Figure 8) needs to be operationalized for the assessment of ES based on four steps: (1) definition the goal of the assessment, e.g. the policy, business or societal question; (2) identification of the components of the system in a meta-analysis of individual case studies or new research—selection of the variables used for mapping; (3) selection of the appropriate levels of a multi-Tier framework considering the variables needed to best answer the policy question. In a fourth step (4) selection of appropriate methods takes place based on a literature review (Grêt-Regamey et al. 2015).

Figure 8: The multi-tiered approach as guidance for selecting the appropriate, yet flexible ES method in response to concise policy and stakeholder questions (Grêt-Regamey et al. 2017)

Considering the driving questions for this Anchor Project, cultural ES of ecotourism, sense of belonging and societal valuation of ecosystems seem to be key aspects to be assessed in this Anchor Project.

Therefore, a tripartite research methodology was selected. First, a Participatory Scenario Planning (PSP) then Participatory mapping approach (PGIS) were applied to find out where current socio-economic and socio-cultural activities, including eco-tourism, are located in the municipality of Saint-Philippe. In a second step, the capacity of ES to supply cultural ES was assessed taking a participatory expert-based matrix assessment, linking ES to land use classes and habitats. In a third step (Figure 9), the actual use of ES, especially tourism, was estimated applying the InVEST model (recreation).

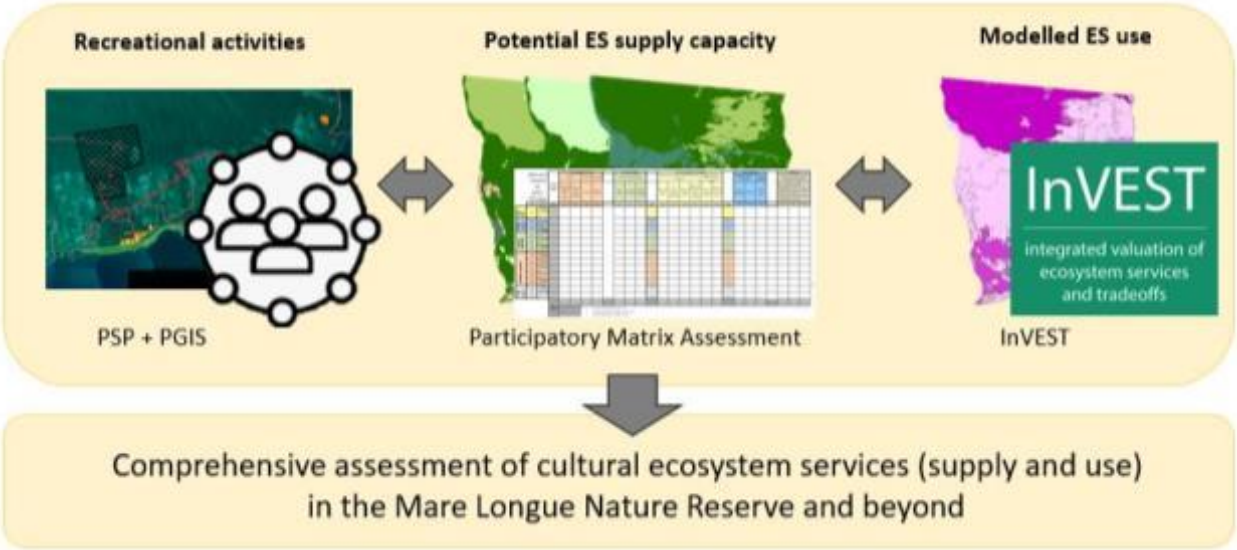


Figure 9: Schematic representation of the use of the Multi-Tiered approach applied to a comprehensive assessment of cultural servies

4.4 Participatory GIS-mapping

MAES methods are diverse and numerous. Among them, participatory methods offer the opportunity to deepen the knowledge of ES produced thanks to traditional, non-institutional knowledge, to identify knowledge gaps, to set up a socio-historical approach that allows to understand long-term dynamics, but also to reinforce the stakeholders' sense of belonging and the group dynamics around a common good.

The participatory approach provides an opportunity to give voice to residents and value their views while promoting inclusion and cooperation. This approach also

allows access to information. It is an opportunity for empowerment and to develop a sense of ownership of the areas to be preserved (Reed 2008).

Based on the method factsheet of the Operationalisation Of Natural Capital And ES project (OpenNess), GIS-based participatory mapping (PGIS) refers to the set of participatory mapping activities involving the use of GIS technology in a process that involves local people. PGIS can:
- Examine the distribution of ES at the local scale,
- Identify sites where land users indicate that greater conservation is desired,
- Spatially reference perceived landscape values that could be incorporated into planning,
- Identify potential environmental risks, including climate risks.

Thus, PGIS activities have the potential to assist in land and landscape management decision making, analysis of stakeholder (land user) preferences, considering land-related welfare factors, and generation of information that can be used to anticipate conflict. In the framework of the MOVE-ON pilot study in Reunion Island, three participatory MAES methods were selected. For our Anchor Project study, the main output of these activities will be maps indicating the ES generated in the different areas of interest.

We first looked into the existing network related to habitats and biodiversity in our Anchor Project site, identified the pertinent institutions/stakeholders to involve in the process. We joined relevant networks in the form of a steering committee while contributing to it and on the other hand, we created a sub-group called "Ecosystem Sentinel" community.

4.5 Participatory Scenario planning

Complementary to the PGIS, participatory scenario planning (PSP) consists of modeling different options for the future, namely socio-economic, climatic or environmental. PSP allows for the evaluation of the social and environmental impacts of future development and changes in the use of the territory studied. It allows the inclusion of the temporal factor but also of elements that cannot be mapped (although maps can complement and illustrate the scenarios).

In the framework of the Mare Longue Nature Reserve pilot study, the use of narrative scenarios was relevant (they could be accompanied by maps or illustrations; for example, maps representing use conflicts and their potential evolution). These are future scenarios presented in the form of simple but engaging texts, which describe

alternative futures. The objective of these scenarios is to fuel the debate on development options, their benefits and risks for a given place. The comparison of different scenarios is therefore an opportunity to bring out a better option. Scenarios should be plausible and have an internal logic. During PSP activities, participants should:

- Identify drivers of change,
- Identify relevant ES,
- Create the scenarios,
- Characterize the scenarios (impact assessment),
- Propose relevant actions for the scenarios considered best.

4.6 Stakeholders involvement in participatory mapping

The overall methodology chosen for the Mare Longue Nature Reserve study is based on the adaptation of Palomo-Campesino et al. (2018). It is an iterative process that facilitates the circulation of information between actors and between categories of actors: structural partners (person representing an institution with decision-making capacity on the territory) as well as other stakeholders (any person having an activity in the studied territory: inhabitant, tourist, socio-economic stakeholders). The exercise offers an opportunity for collective social learning. The use of PGIS and PSP tools is integrated in a global iterative approach. We undertook a sequential approach in stakeholders' engagement, in the form of semi-structured interviews, focus groups meetings, workshops and forums as a platform of discussion and sharing, illustrated in the following figure 10:

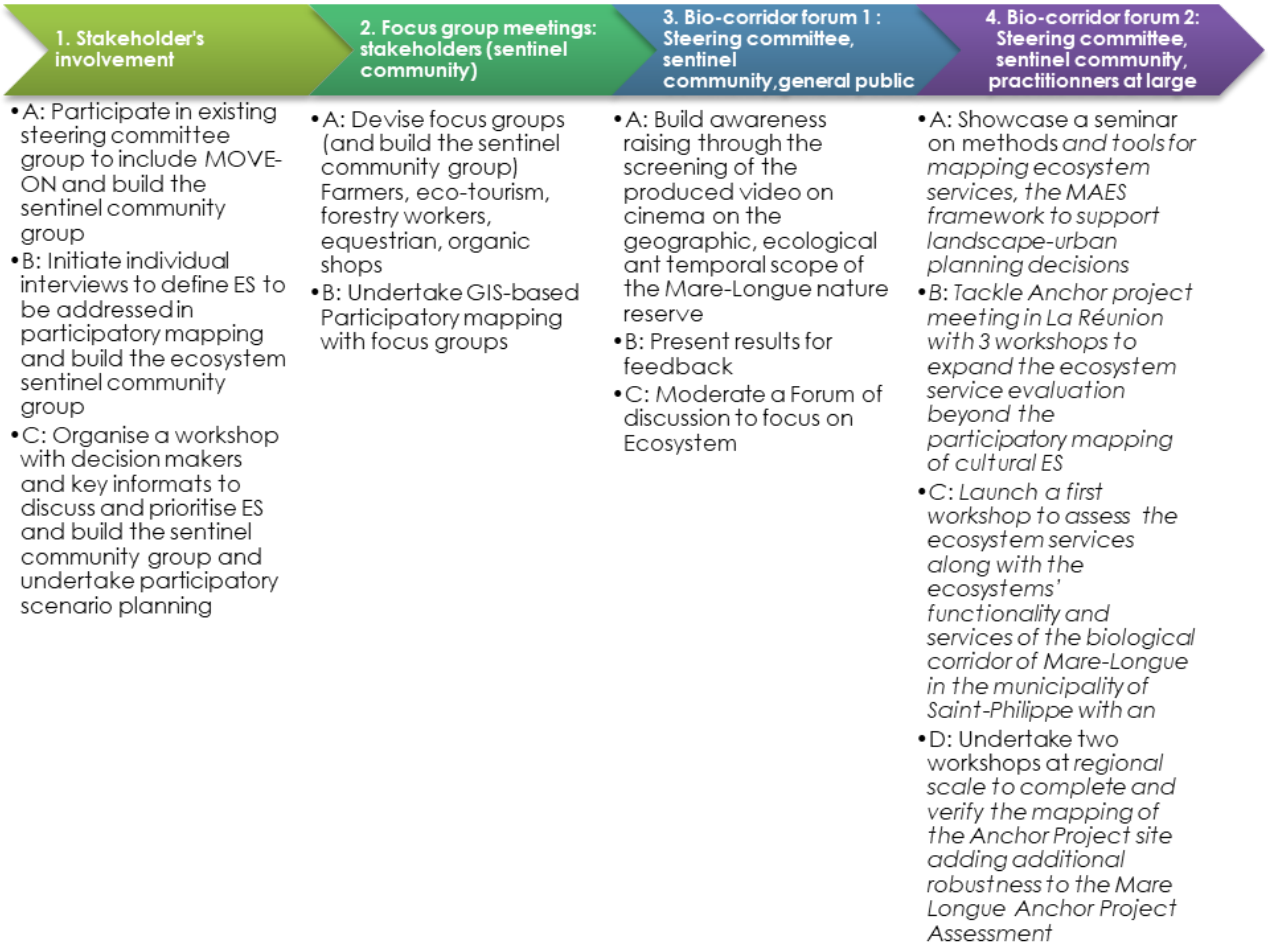


Figure 10: The various steps in the implementation of the Anchor Project site in the municipality of Saint-Philippe

First the MOVE-ON project with Anchor Project site the Mare Longue Nature Reserve, have been incorporated within the shared governance of the Mare Longue Nature Reserve lead by the National Park of La Réunion. The committee meetings organised by the National Park in the context of the setting-up on a concerted action plan for the management of the Mare Longue Nature Reserve, included the MOVE-ON project anchor site. Thus, the MOVE-ON "steering committee "has been initiated through the committee meetings of the concerted action plan for the management of the Mare Longue Nature Reserve (1.A in Figure 10). The committee meetings, through a shared governance with the National Park of La Réunion as facilitator and coordinator, allowed the MOVE-ON project to be understood by the institutional, scientific as well as socio-economic stakeholders.

With a view to assess priority ES of stakeholders, semi-structured interviews have been undertaken to be able to evaluate which category of ES would be mapped (whether the group of Provisioning, regulating or cultural services).

Based on the group of chosen ES, participatory PGIS and PSP were undertaken in the form of thematic focus group meetings (Figure 10).

4.7 Evaluating the capacity of habitats to supply ecosystem services

To assess the capacity of habitats to supply ES, an ES capacity matrix method has been applied. Such a capacity matrix is a comprehensive and flexible method in the form of a look-up table combining ecosystem types and ES (Burkhard et al. 2009). At the base, geospatial units such as Land Use/ Land Cover (LULC) data can be used to delineate the ecosystem types. These geospatial units are then linked to ES of relevance for the study region (Figure 11). At the intersections in the matrix table, the supply of ES within the particular geospatial units (e.g. LULC types) can be assessed on a scale from 0 (no or very weak capacity) to 5 (very strong/maximum capacity). The normalization to such a relative scale from 0 – 5 allows us to compare different ES (that are usually assessed by different indicators and units). Such an approach is well-suited to express values from different domains, including biophysical, socio-cultural, non-monetary as well as monetary values of multiple ES.
One approach to conduct such a matrix assessment is via expert knowledge. Expert estimations deliver a good overview by integrating different sources of expertise, while at the same time being a strong capacity building tool. As all expert-based assessments, the scoring values strongly depend on the experience, knowledge as well as objectivity of the evaluators (Burkhard et al. 2012). Yet, numerous applications show the robustness and effectiveness of the method (Campagne and Roche. 2018, Sieber et al. 2021).

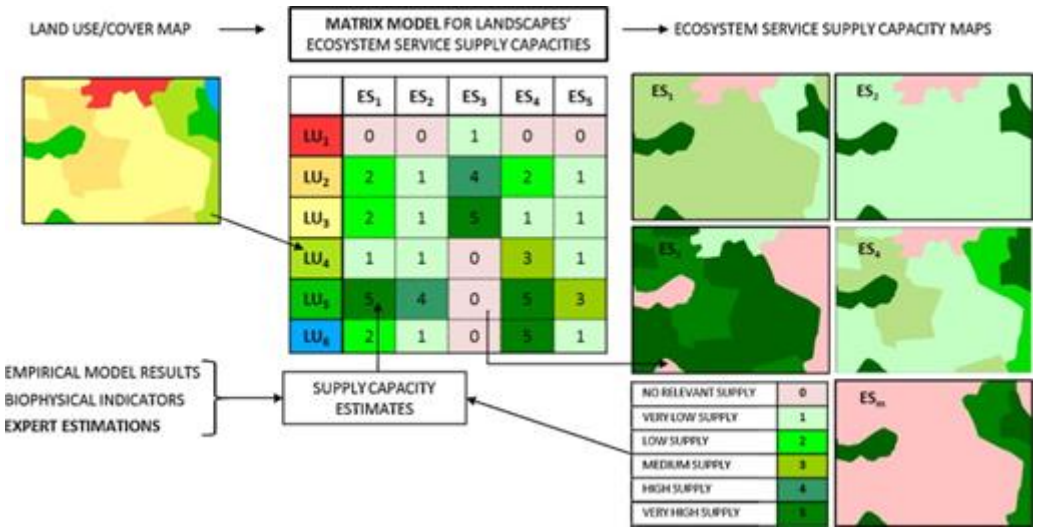


Figure 11: Schematic representation of the ecosystem services Matrix method (after Burkhard et al. 2009, in Jacobs et al. 2015)

For this assessment, a workshop was organized at the municipality of Saint-Philippe on 27th of January 2023. The matrix included 13 habitats and 19 ES, including supporting functions of biodiversity, nutrient cycling and carbon sequestration. Also, the matrix entailed 3 cultural ES were of importance for this assessment. In addition, a level of confidence was included to capture the expert's ease to fill the matrix per habitat and ecosystem type. Experts filled the matrix individually during the workshop and online. Altogether, 10 matrices were obtained.

The expert panel consisted of experts from government officials, land use planners, national park authorities and environmental specialists. Notably, 30% of the experts were female. The majority of experts mentioned their expertise related to forests (40%), followed by agriculture (30%), marine and urban (20%) habitats. Only 1 expert from aquatic ecosystems was present (10%). The expert panel covered 40% management authorities, 30% environmental agents and 20% decision-makers.

4.8 Modeling the actual use of ES

To model the actual use of ES in the Community of Saint-Philippe, the InVEST model suit has been selected. The model allowed us to quantify the value of natural environments based on the distribution of person-days of recreation, based on the locations of ecosystems, land uses and other features that factor into people's decisions about where to recreate. The model applied a proxy for visitation and recreation and draws upon geotagged photographs uploaded to the website flickr. This way the model is able to specify the spatial patterns of recreation (Sharp et al. 2014).

We ran the InVEST model for a timeframe from 2005 to 2017, with a cell size of 30x30m to obtain the precise location of human activities. Similarly, the model was run on the basis of LULC data (Dupuy and Gaetano, 2019) to obtain information on the location and land use in which photos were taken. Validation of model results was obtained through cross checking the content of the uploaded photos.

4.9 Data analysis

All the methods applied in this report require the use of Geoinformation Systems to process geospatial data. Data processing was conducted using ArcMap 10.8 and QGIS 3.26.1.

LULC data for the Reunion Island were obtained from Dupuy and Gaetano (2019), available on the AWARE platform by CIRAD[3]. This LULC dataset was created as part of the GABIR Project in 2017 and contains 35 land use classes on level N3, with a strong focus on agricultural land uses. For simplification, land use classes were regrouped to 16 broader classes. Even though data with higher resolution is available (e.g. Le Mézo et al. 2021), the level of detail goes beyond the scope of this assessment.

This regrouped and simplified LULC served as input for both the ES supply capacity assessment and the modeling with InVEST. For the participatory mapping, the communal area of Saint-Philippe was visualized using base-layer information from QGIS. Further, the delineation of communal boundaries for Saint-Philippe was obtained from OpenDataSoft[4].

[3] https://aware.cirad.fr/layers/geonode:classif_gabir_2017_postclas_code3_cor0

[4] https://public.opendatasoft.com/explore/dataset/georef-france-commune/information

5 RESULTS

5.1 Creation of the "Ecosystem Sentinel" Community

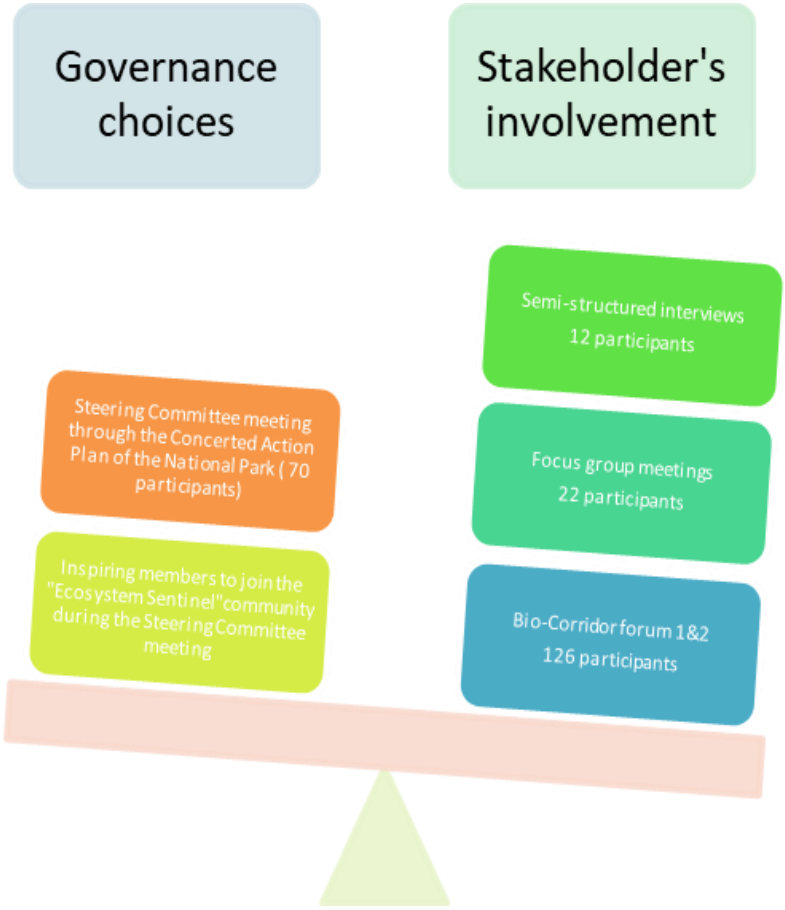


Figure 12: The choices of governance of the Anchor Project site through the participation of ongoing Steering Committee meetings to inspire stakeholder's involvement, showing more participation by members later within the activities of the MOVE-ON project

The governance choices of the Anchor Project site, in accordance with existing working groups, through the CAP of Mare Longue Nature Reserve, have generated successful results in terms of stakeholders' participation. Indeed, local institutions participated in the various events of the projects in semi-structured interviews, focus group meetings, and bio-corridor forums. The main stakeholders are the National Parks, Forestry Services, Departmental Council, tourism office as well as socio-economic stakeholders from the economic club of Saint-Philippe, organic farmers, vocational rental place usually in the form of Bread & Breakfast called "gite", tourist guides for hiking and speleology (Figure 13). The governance option enabled the

full participation of stakeholders on board of the participatory mapping processes (Figure 12).

Figure 13: Timeline showing the main activities of the Anchor Project site.

5.2 Stakeholders participation to Semi-structured interviews

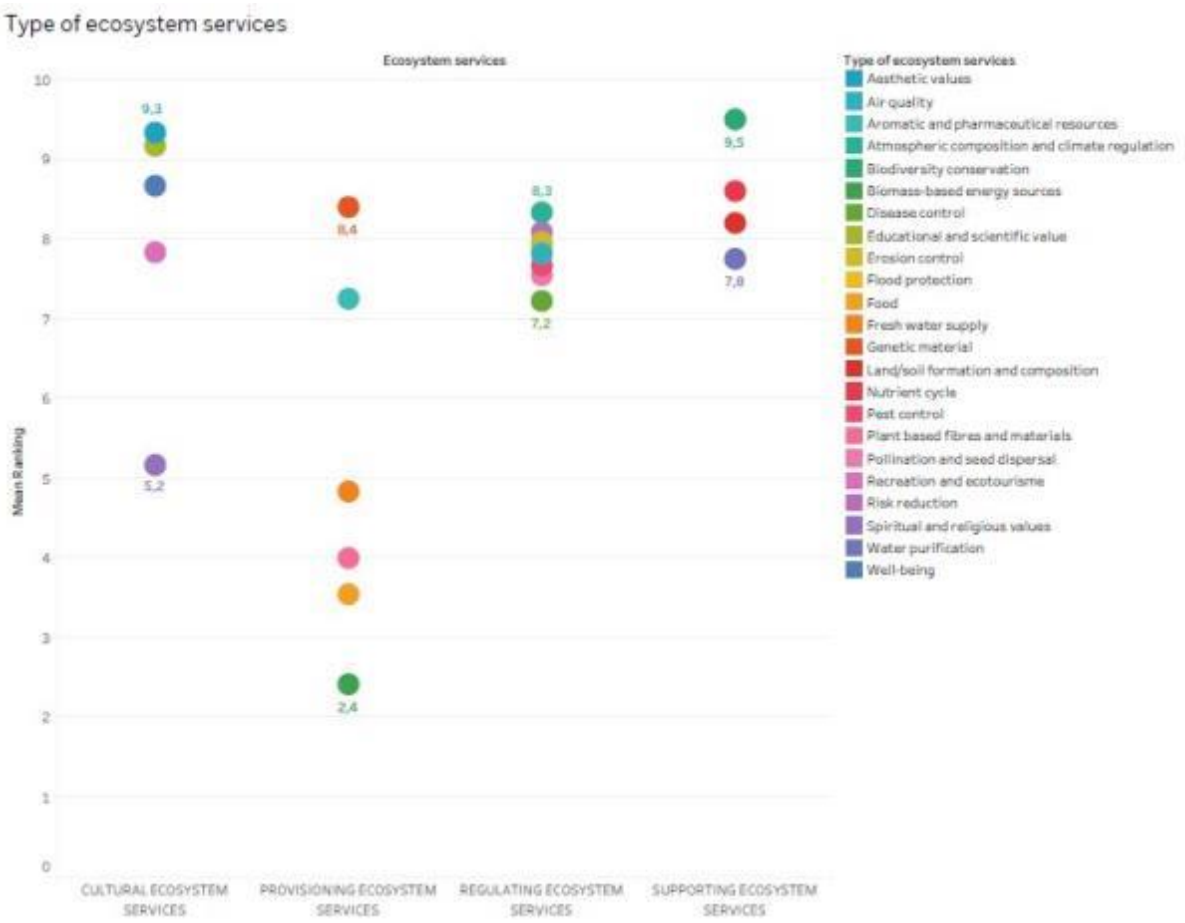


Figure 14: The mean ranking of per category of ecosystem services per priority by stakeholders

Following the semi-structured interviews, the institutional stakeholders composed of socio-economic actors, local institutions with administrative roles, NGOs and scientists, all expressed their priority for the cultural services though biodiversity services was also highly ranked. These experts recognized the high biodiversity value of the Mare-Longue Nature reserve as part of the municipality of Saint-Philippe, and on the other hand they expressed their willingness for the cultural category of ES (Figure 13). Thus, the necessity to conduct an evaluation of cultural ES was prioritized by the stakeholders.

Figure 15: The mean ranking from the list of selected ecosystem services prioritized by stakeholders

5.3 Participatory Scenario Planning

A workshop was held with the National Park to present the results of the PSP, where out of the 3 scenarios named scenario 1, scenario 2 and scenario 3 developed on the future management of the Mare Longue Nature reserve scenario 3 has been selected by the participants (Table 1). Indeed, biodiversity conservation is the imperative action for stakeholders (see Annex 2 on the three scenarios). In addition, a sustainable development has been opted through agroforestry and agriculture with eco-tourism.

Scenario	Description	Selection
Scenario 1	Maintain a standard economic growth model and the continuity of existing activities.	X
Scenario 2	Prioritize the development of tourism	X
Scenario 3	Build a community model that relies on 3 main pilars: biodiversity conservation, agroforestry and agri eco-tourism	√

Table 1 : The selected scenario by the institutional stakeholders for the future management of the Mare Longue Nature Reserve

5.4 Participatory-GIS Mapping through Focus group meetings

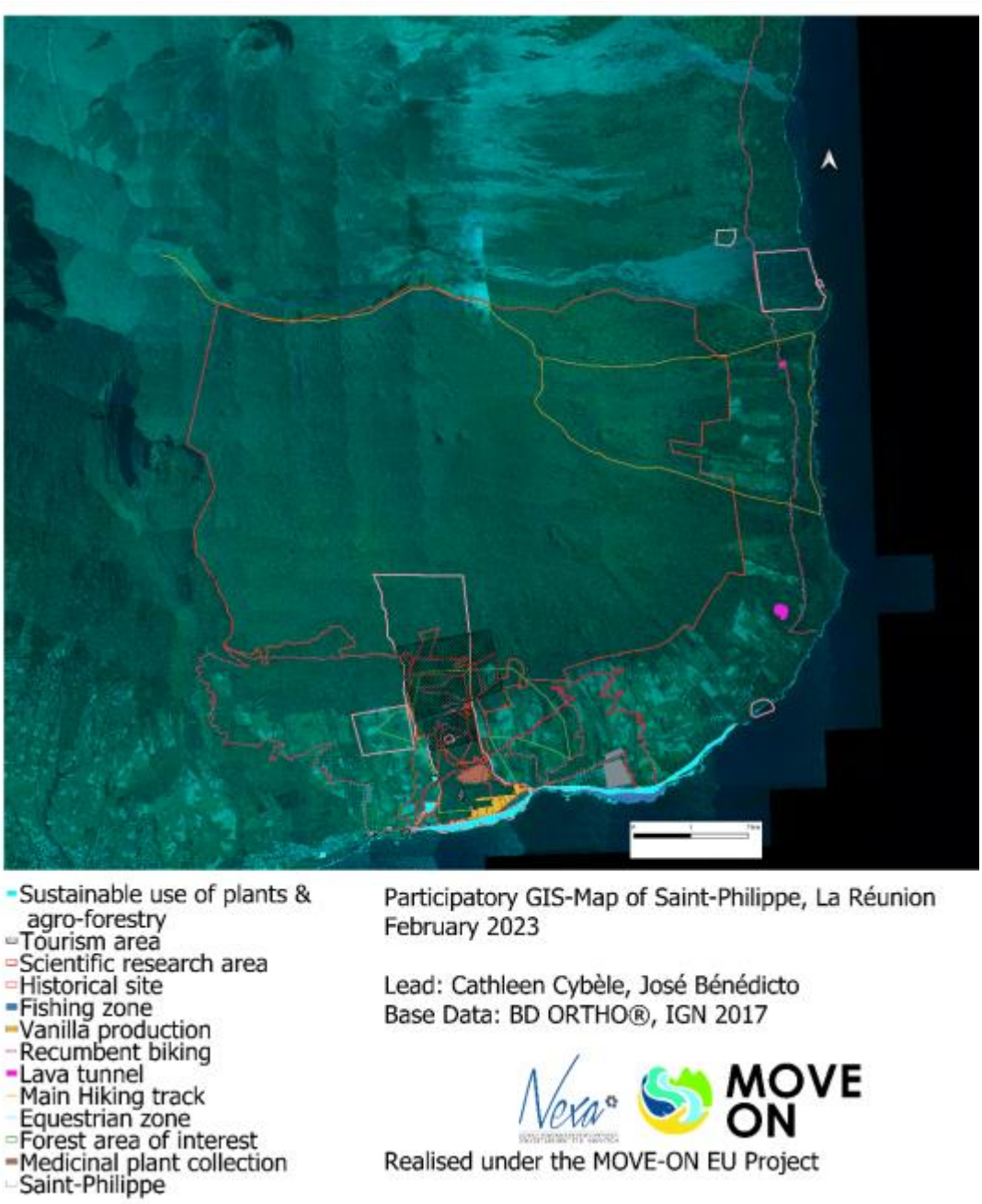


Figure 16: Participatory GIS-Mapping of Saint-Philippe, Reunion Island

The participatory-GIS mapping exercise was undertaken through 7 focus group thematic meetings, where mainly socio-economic stakeholders wrote on the A0-size prints maps, their cultural activities, identified as cultural ES namely forest and coastal areas as emblematic, aesthetic and recreational sites (Figure 15). Moreover, hiking, lava-flow tunnel with speleology, site-viewing particularly the last lava-flows, visit of vanilla, local ancient fruits and vegetables "*fruits et légumes longtemps*", organic farm, artisanal fishing, recumbent biking and equestrian track through the landscape and the forest, as well as historical site "ancient cemetery thought to be lost but recently found out", the ancient well, ancient bread oven was noted. In addition, the stakeholders expressed the historical importance of Saint-Philippe from a geological perspective, since part of small villages are on the last remnants of lava flow, and on basaltic rock. The stakeholders also explained, while undertaking the GIS-Mapping exercise that the forest of Mare Longue has been preserved due to its geological characteristics, of basaltic lava-flow with holes commonly called "*Barille*". These forests were in the early 19th-20th century, considered not appropriate for agriculture, and were thus conserved. The Mare Longue Nature Reserve is highly visited for research work, hiking and a botanical path.

5.5 Results of the Expert Based Matrix approach

The workshops obtained an overall of 10 matrices for the communal area of Saint-Philippe. Experts represented a diverse group from different fields of work. Table 1 shows the average from all 10 participants, including the level of confidence.
Overall, the capacity of 13 habitats to supply ES was assessed. Experts scored the ability of indigenous forest (C7) ecosystems highest, with strong to very strong overall supply capacity. Agroforestry (C6) and mixed forest (C8) showed slightly lower supply capacities. Lowest overall supply capacities were found among urban areas (C12) and Infrastructure and roads (C13). Agricultural areas show overall weak to moderate capacities for supporting and cultural ES, however, their contribution to provisioning ES, especially food provision, is unprecedented.
Ecosystem functions and supporting services were assessed across the habitats. Especially natural habitats were ranked with good to strong capacities to comprise biodiversity (S1). Forested habitats (C6-C9) showed moderate to strong capacities to provide nutrient cycling (S2) and to sequester carbon (S3).
Cultural ES were scored for all habitats. Especially Rocks and bare soil (C11), containing the lava flows from the Piton de la Fournaise and the recent lava flow from 2007, partly overgrown, are of high cultural valuation. These areas show high emblemic values (C1) as well as a strong landscape aesthetic (C2). For recreational

activities, this habitat received the second highest score, surpassed only by Rocky shores and ocean (C1), with a score of 4.4 out of 5.
Overall, experts felt most at ease with forested habitats and rivers (overall 2.2.) and the cultural ES (2.2 each).

Matrice à l'échelle de Saint-Philippe			Supporting Ecosystem Services			Cultural Ecosystem Services		
			Ecosystem functions			REPRESENTATIONS-subjective		USAGES-objective
			Biodiversity	Nutrient cycling	Carbon sequestration	Emblemic or symbolic	Landscape aesthatics	Recreatio-nal activities incl. (eco-) tourism
Code	HABITAT	Confiance	S1	S2	S3	C1	C2	C3
C1	Rocky shores and ocean	2.1	4.35	2.1	2.75	4.65	4.9	4.5
C2	Rivers	2.2	4	2.8	1.7	3.4	3.6	3.3
C3	Wetlands	2.0	4.6	4.1	4.3	3.1	3.4	2.3
C4	Agricultural areas - herbaceous crops	1.9	1.4	2.2	2.7	3.5	3.2	2
C5	Agricultural areas - woody crops	1.9	2.2	2.7	3.3	3.4	3	2.5
C6	Agroforestry	1.9	3.8	3.6	4.3	3.9	3.6	3.1
C7	Indigenous forest	2.2	4.9	4.4	4.9	4.8	4.8	4.3
C8	Mixed and planted forest	2.2	3.9	3.9	4.4	3.8	4.3	3.7
C9	Shrubland, bushland, heathland	2.1	3.1	3.1	3.4	2.7	2.7	3.3
C10	Savanne	1.8	3.4	2.6	2.6	2	2.9	2.5
C11	Rocks and bare soil	1.9	2.7	1.4	1.1	5	5	4.4
C12	Urban areas	2.0	1.6	0.6	0.4	2.3	2.7	3.9
C13	Infrastructure and roads	1.8	0.4	0.2	0.1	1.5	1.8	2.6
			2.4	1.5	1.8	2.2	2.2	2.2

Table 2: Result of the matrix of capacity of ES for the Municipality of Saint-Philippe

The ES supply capacities of Maintenance of water quality (regulating ES), Carbon sequestration (S3) and landscape esthetics (C2) are visualized in Table 2. In dark green, the high supply capacities of forests to supply ES are visible throughout the maps.

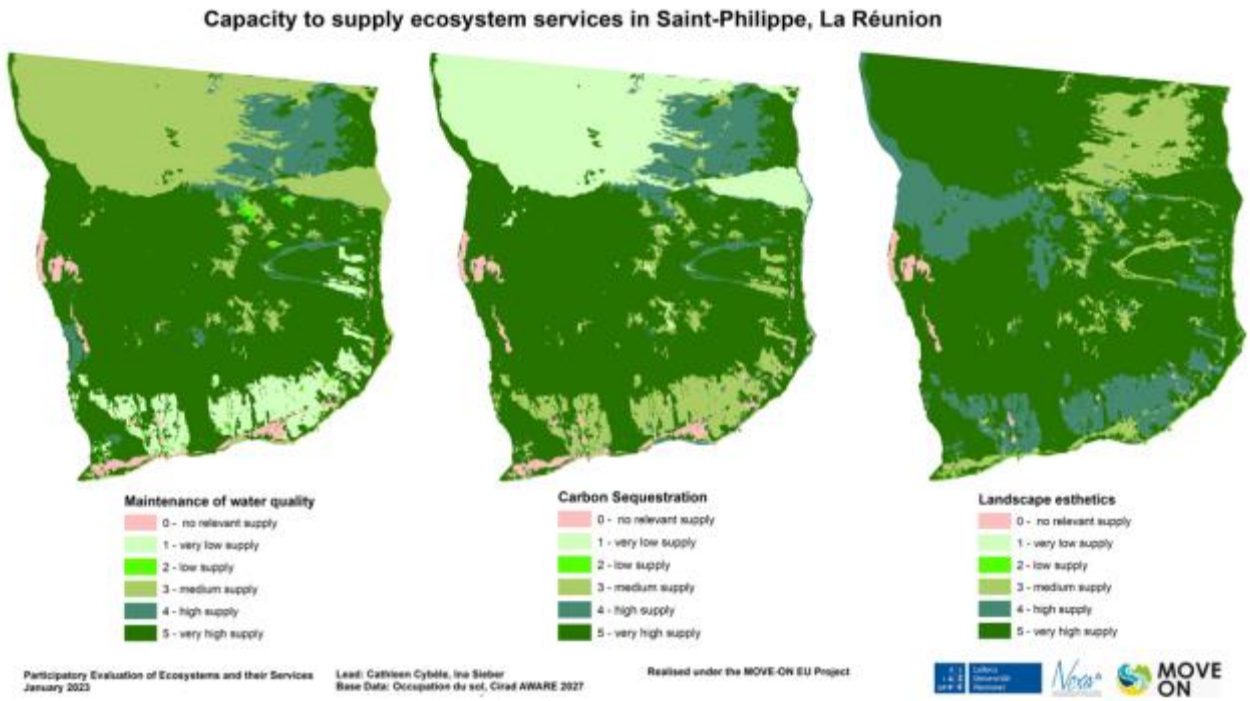


Figure 17: ES supplied in the communal area of Saint-Philippe, visualized on the basis of the matrix assessment (Feb. 2023)

The mapped resulted from the matrix of capacity of Saint-Philippe (Figure 16) demonstrate a high supply of landscape aethetic then carbon sequestration and of water quality.

5.6 Results of the modeling with InVEST

The actual use of cultural ES was calculated for the timeframe of 2005 - 2017 for the communal area of Saint-Philippe. A total of 996 georeferenced Photos was uploaded in the given time frame.

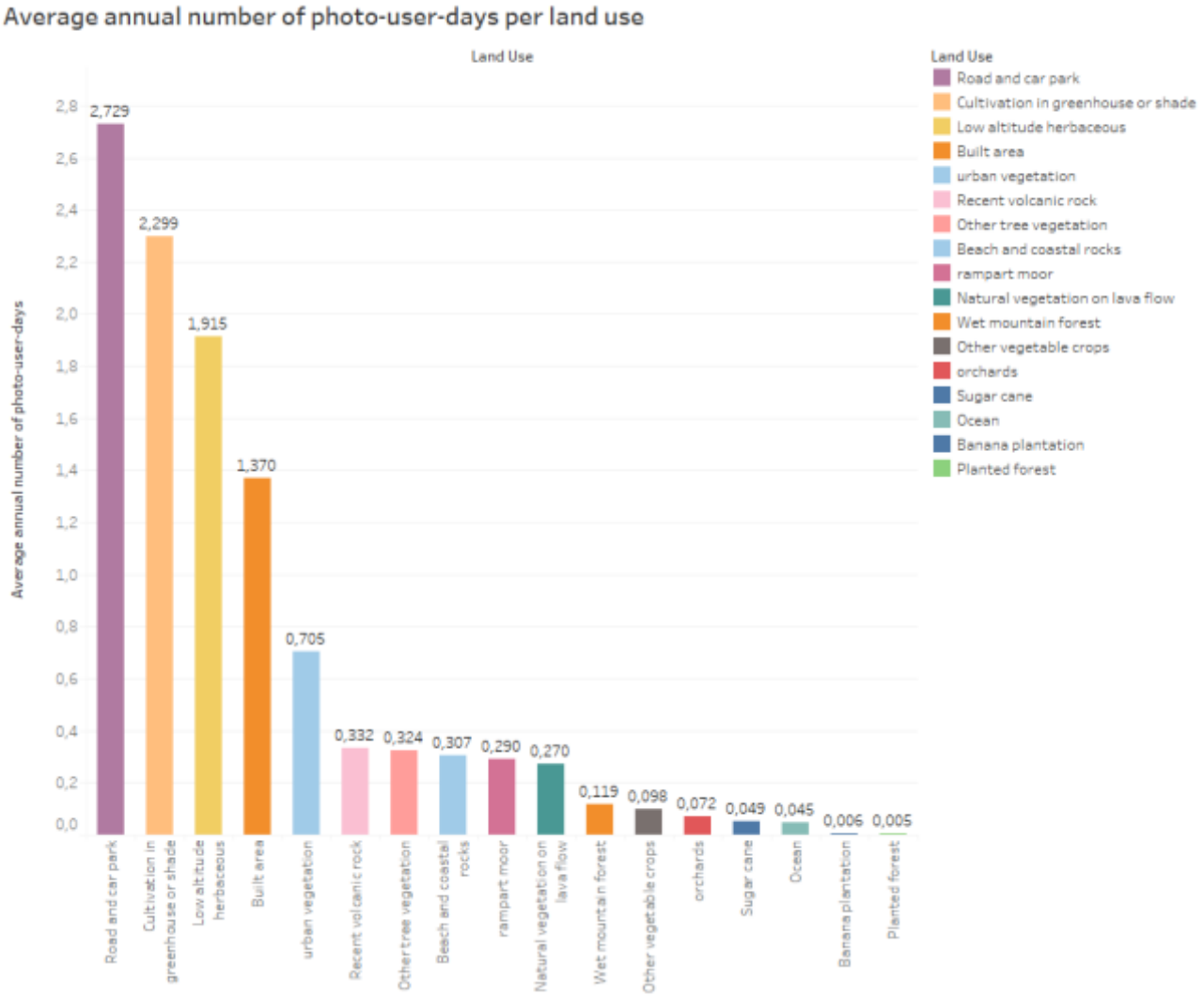


Figure 18: Based on the InVEST result model for Recreation, the annual number of Photo User Days for various land use types of the municipality of Saint-Phillippe, Reunion Island

Figure 17 shows the mean annual upload of Photos, ranging from 0 to almost 20 georeferenced Photo User Days a year. With 351 uploaded pictures, a maximum is found on the *Massif du Piton de la fournaise*, the volcanic crater and its lava flow of 2007, followed by the large forested areas (243 Photos). With 85 uploaded Photos, agriculture seems to play an important role in landscape aesthetics and recreation - with many pictures of large sugar cane fields uploaded on Flickr. 76 Photos of urban areas were found, with snapshots of historical buildings, restaurants, and people shot outside - integrating the urban area in its surrounding nature. Notably, photos were taken in the vicinity of trails and roads (48), only few pictures can be found in the middle of the different polygons. A detailed analysis of the individual Photo uploads shows that the majority of photos indeed shows landscapes.

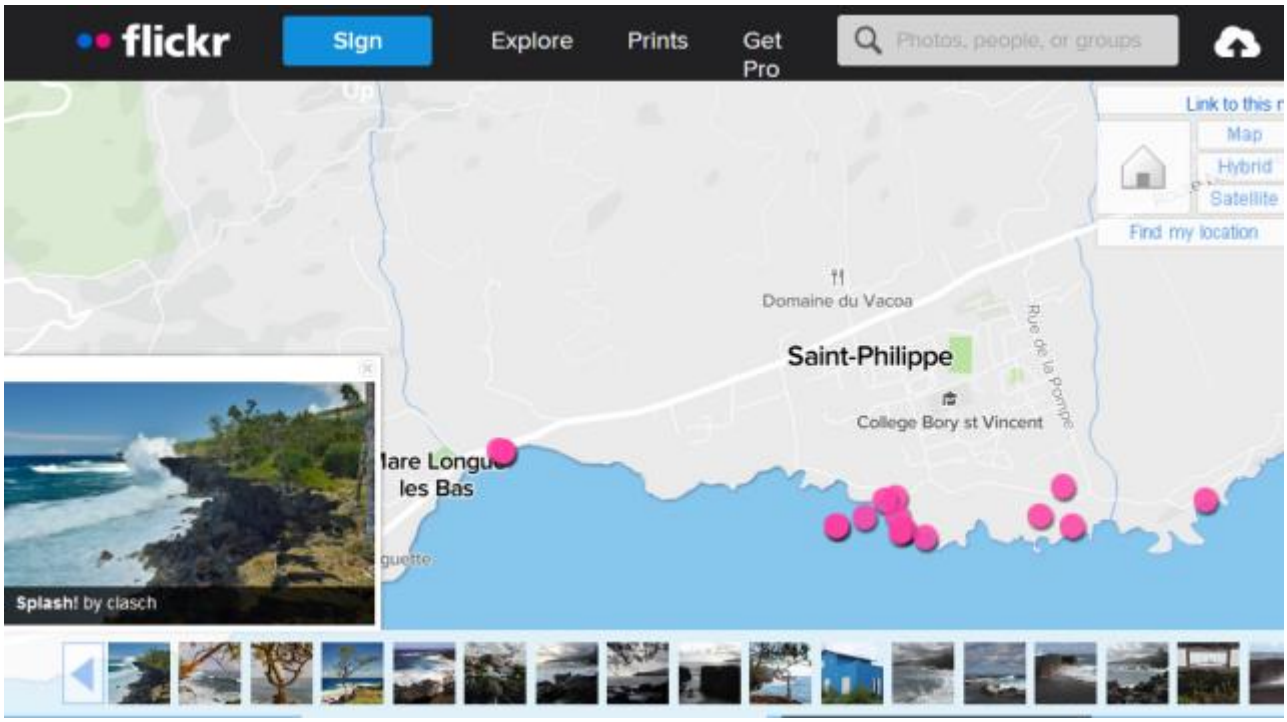


Figure 19: Selection of pictures uploaded only in the coastline of Saint-Philippe and Mare Longue les BasSelection of pictures uploaded only in the coastline of Saint-Philippe and Mare Longue les Bas

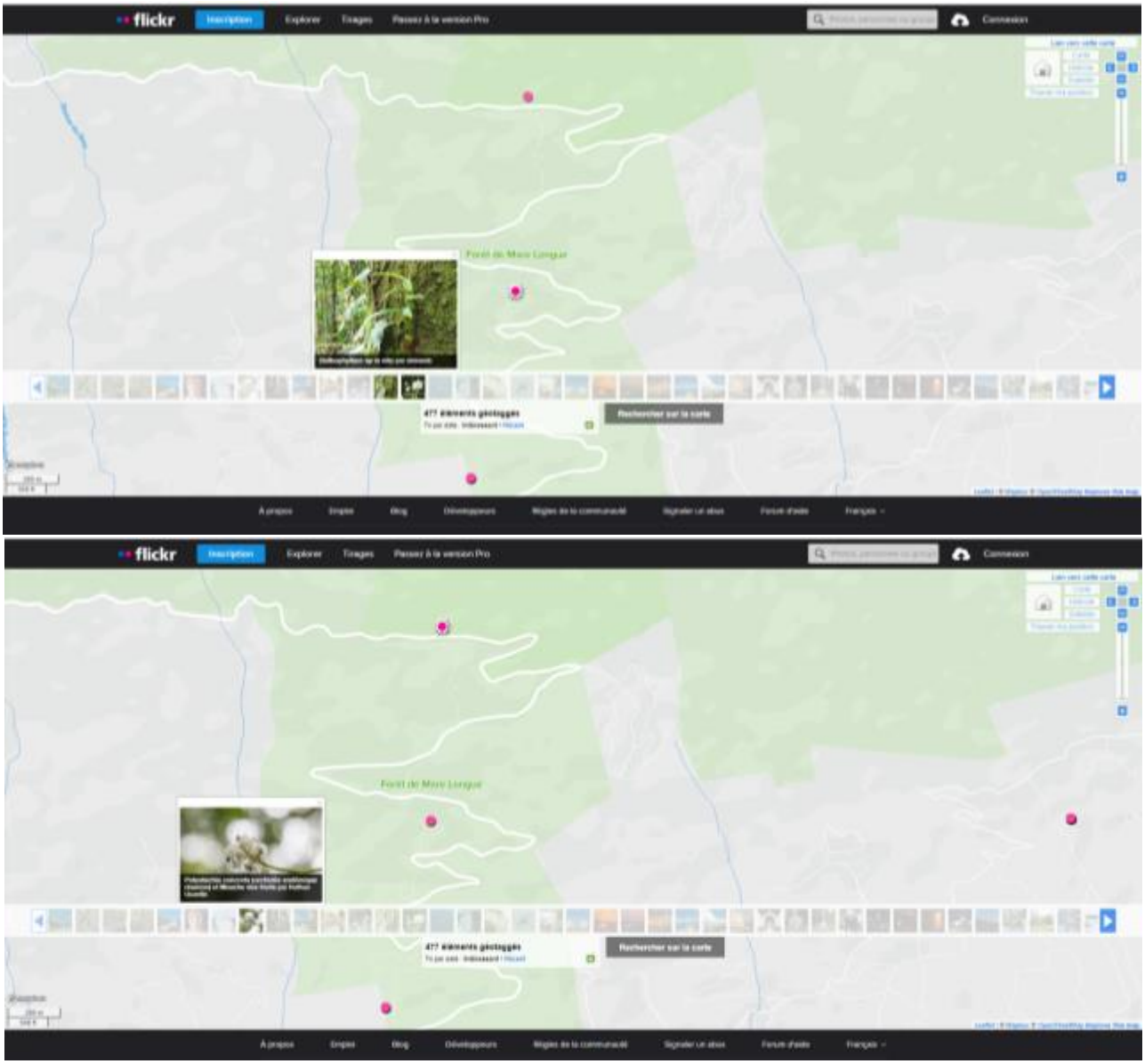


Figure 20: Selection of pictures of botany uploaded only in the Mare Longue Nature Reserve, in Saint-Philippe

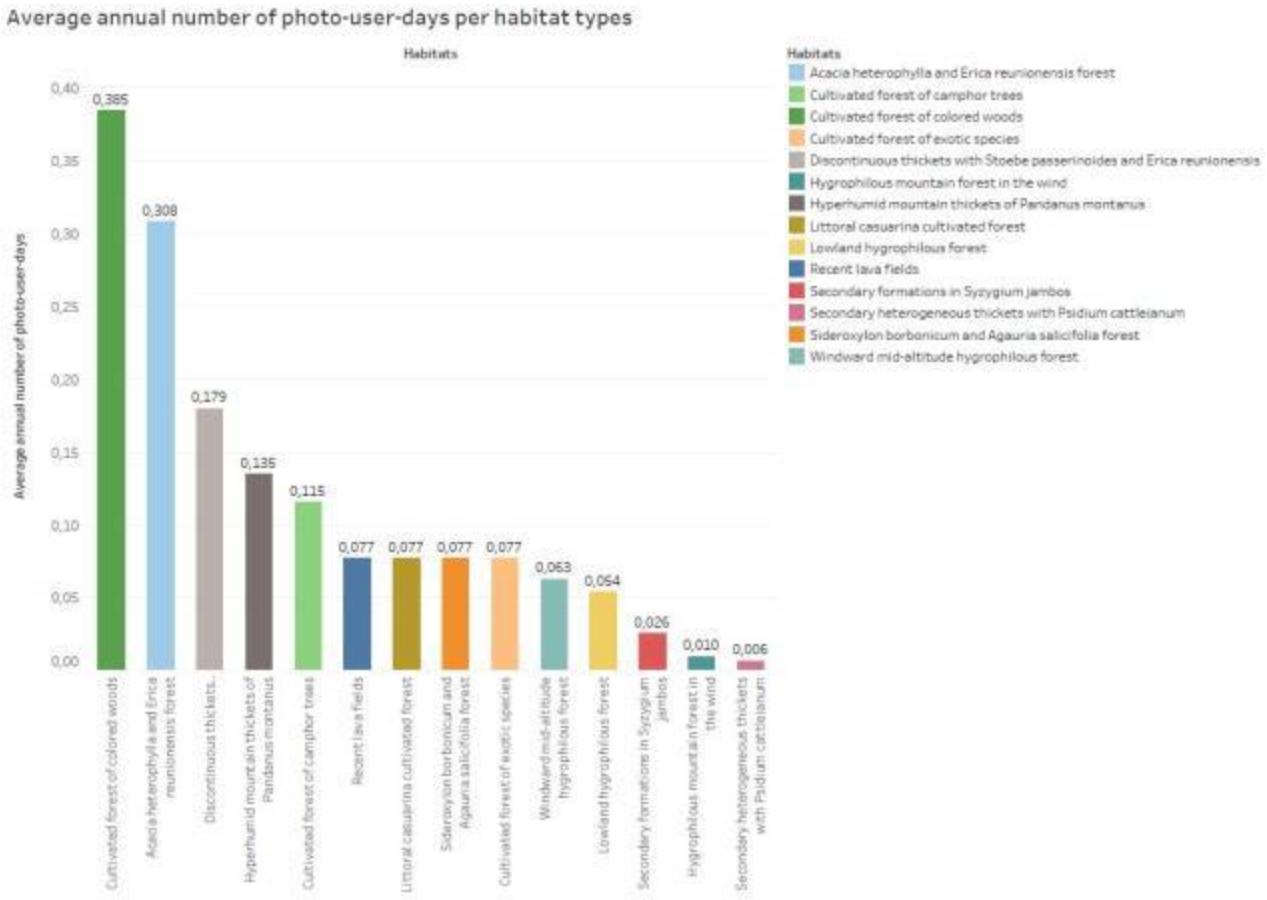


Figure 21: The mean annual number of photo taken per day from (2005 to 2017) from Flickr, in relation to habitat types of Saint-Philippe, Reunion Island

The colored forest "forêt de couleurs", located at the lower altitudinal level, of the Anchor Project site and within its lower part is the most visited habitat (Figure 20). The habitat at higher altitudinal level with the endemic species *Acacia heterophylla* and *Erica reunionensis* and discontinuous thickets have a high number of photos taken per day. Habitats with invasive alien species or secondary forest with *Syzygium jambos* are less visited.

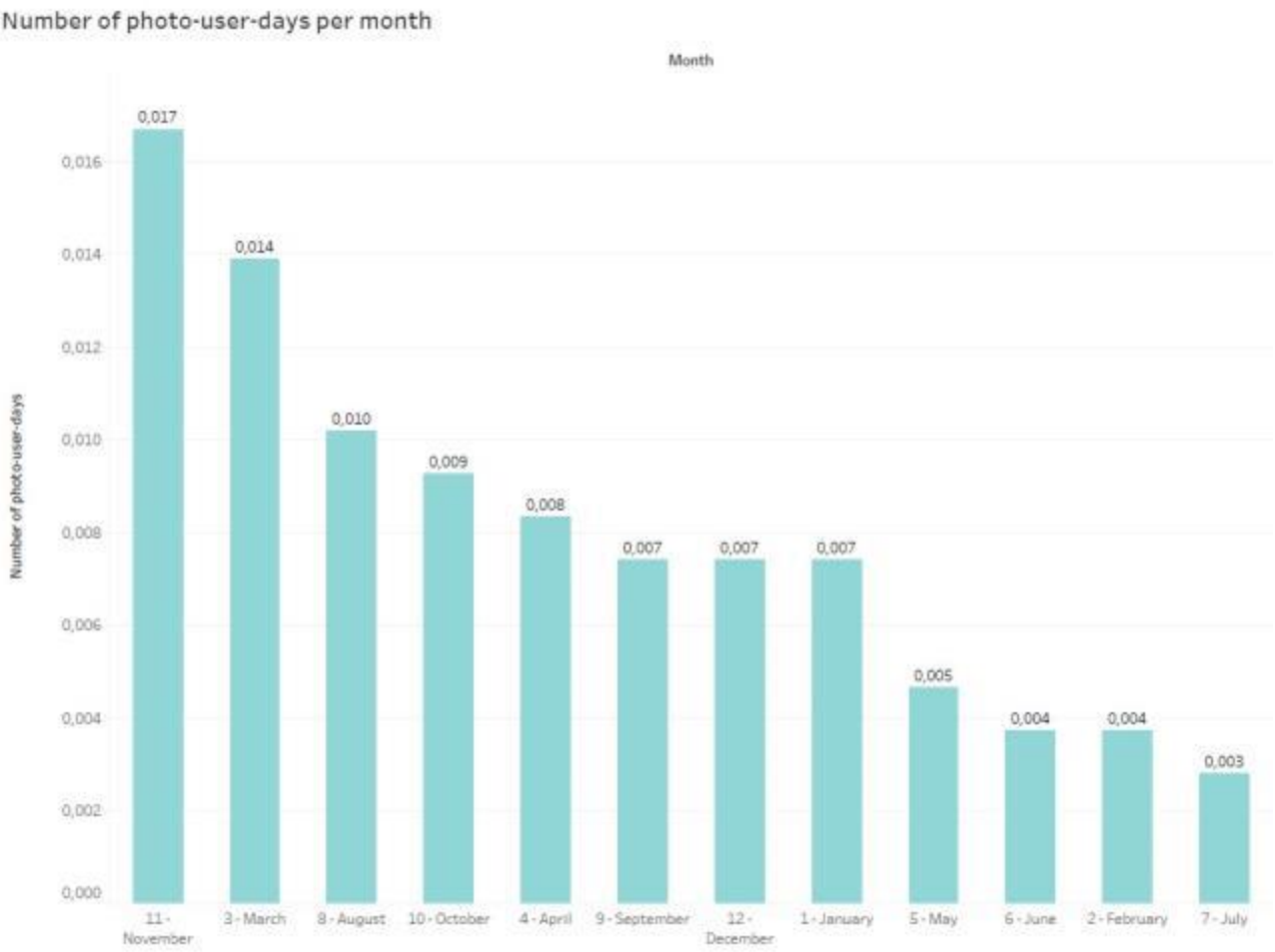


Figure 22: The number of photo taken in a month by user per day from 2005 to 2017 from Flickr, in Saint-Philippe, Reunion Island

November, March and August are the most visited months, with the maximum number of photos taken per month in the municipality of Saint-Philippe. The months with the least number of photos taken are June, February and July. February falls in the rainy season and along with June are non-holiday period. The beginning of winter holidays starts as from mid-July in Reunion Island however expressing less visits, with a peak visit in August.

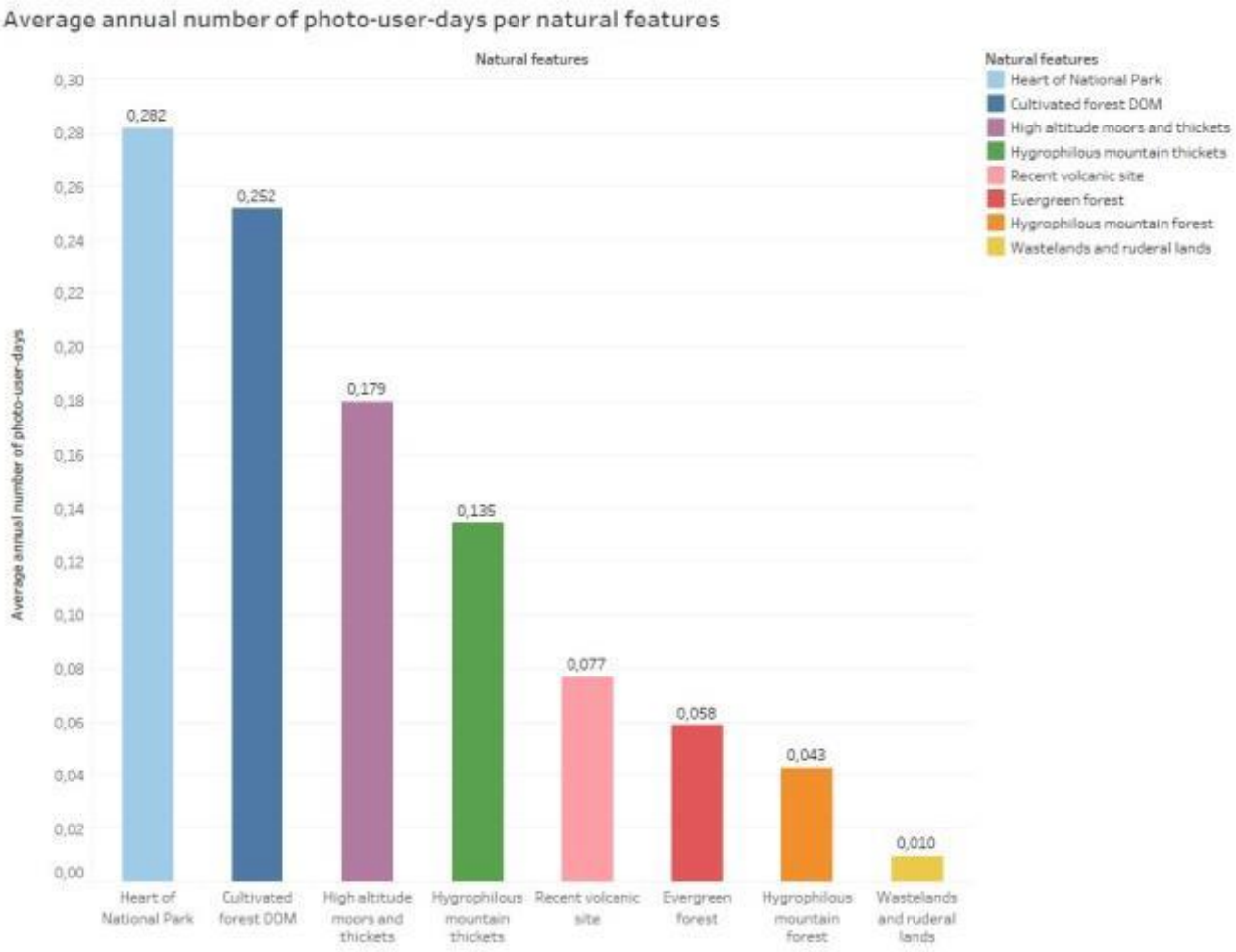


Figure 23: The number of photo annually by user per day in relation to natural characteristics from 2005 to 2017 from Flickr, in Saint-Philippe, Reunion Island

Mapping this information from InVEST results in the map shown in Figure 22. The spatial distribution of Photo User Days is shown for the communal area and described in relation to natural features. The commonly called "heart of the national park" is an area within the National Park of La Réunion, where part of the Anchor Project site is located. The cultivated forest under the management of the departmental council is located at lower attitudinal level and accessible to visitors. The recent volcanic site, characterized by the last lava flows, are less taken into picture than the nature reserve areas in the vicinity of the "heart" of the National Park (Figure 23).

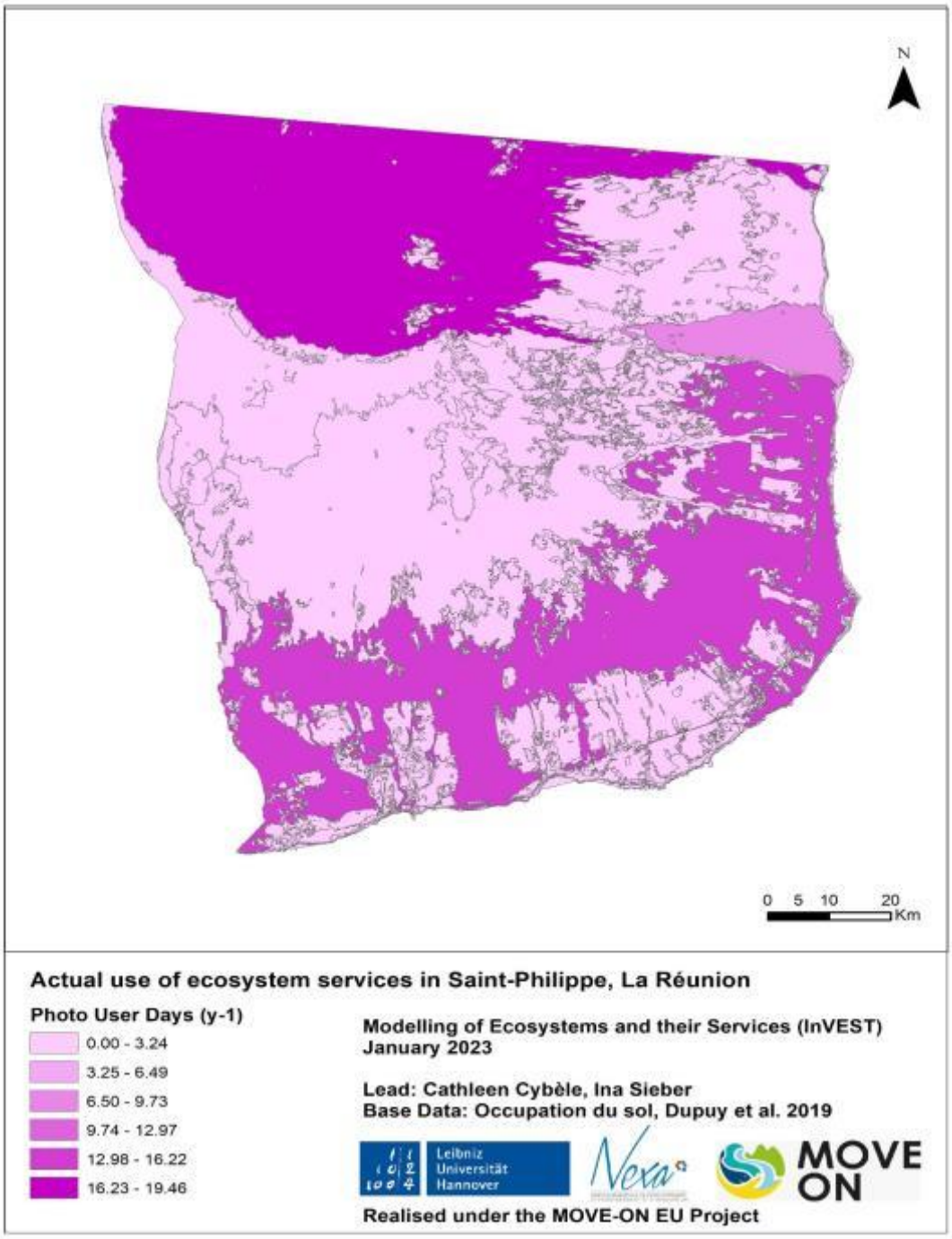


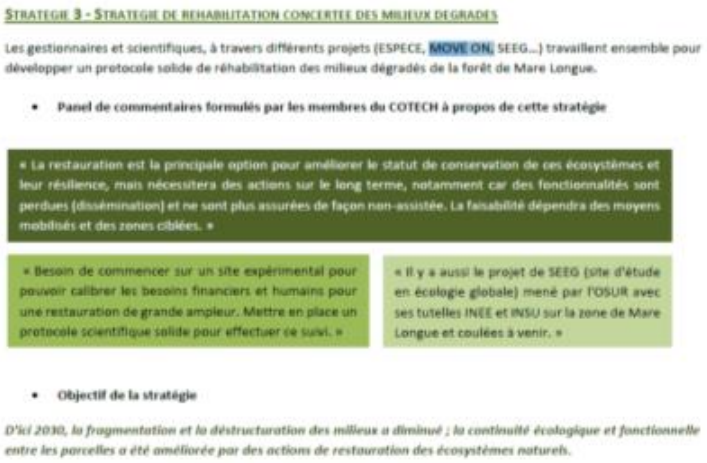
Figure 24: The number of Photo User Days per year of the Actual use of ecosystem services using the InVEST model, in Saint-Philippe, Reunion Island

6 STAKEHOLDERS INVOLVEMENT

6.1 Participation in existing steering committee group to include MOVE-ON

In the creation of a steering committee meeting for the MOVE-ON project, committee groups were created for Mare-Longue Nature Reserve by the National Park of La Réunion (Table 3). To ensure coordination and secure participation of stakeholders, the MOVE-ON project has been included in the National Park committee meetings. Indeed, the MOVE-ON project has been embedded in the elaboration of the concerted action plan for the Mare Longue Nature Reserve, merging events in the implementation of the MOVE-ON steering committee meeting. The Anchor Project has been contributing to the socio-economic group of the concerted action plan of the National Park. A presentation on MOVE-ON within the Mare-Longue Nature reserve was undertaken during the first committee meeting of the concerted action plan of Mare Longue.

Figure 25: NEXA's participation in the steering committee meeting of the Concerted Action plan of the Mare Longue Nature Reserve organized by the National Park of La Réunion



STRATEGIE 3 - STRATEGIE DE REHABILITATION CONCERTEE DES MILIEUX DEGRADES

Les gestionnaires et scientifiques, à travers différents projets (ESPECE, MOVE ON, SEEG...) travaillent ensemble pour développer un protocole solide de réhabilitation des milieux dégradés de la forêt de Mare Longue.

- **Panel de commentaires formulés par les membres du COTECH à propos de cette stratégie**

« La restauration est la principale option pour améliorer le statut de conservation de ces écosystèmes et leur résilience, mais nécessitera des actions sur le long terme, notamment car des fonctionnalités sont perdues (dissémination) et ne sont plus assurées de façon non-assistée. La faisabilité dépendra des moyens mobilisés et des zones ciblées. »

« Besoin de commencer sur un site expérimental pour pouvoir calibrer les besoins financiers et humains pour une restauration de grande ampleur. Mettre en place un protocole scientifique solide pour effectuer ce suivi. »

« Il y a aussi le projet de SEEG (site d'étude en écologie globale) mené par l'OSUR avec ses tutelles INEE et INSU sur la zone de Mare Longue et coulées à venir. »

- **Objectif de la stratégie**

D'ici 2030, la fragmentation et la déstructuration des milieux a diminué ; la continuité écologique et fonctionnelle entre les parcelles a été améliorée par des actions de restauration des écosystèmes naturels.

Figure 26: Caption of a strategy within the Concerted Action Plan of the Mare Longue Nature Reserve including the MOVE-ON anchor site project

Moreover, the concerted action plan generated 20 strategies, in which the MOVE-ON Anchor Project corresponds to the strategy 3 on the concerted rehabilitation of degraded habitats (Figure 24).

Through the ongoing meetings, stakeholder's have built awareness of the MOVE-ON Anchor Project site for collaboration throughout the MOVE-ON project.

Events	Purpose	Date	Place (in-person /visio)	Total number of participants
Steering Committee 1	Co-construction of a concerted action plan for the Mare-Longue Nature Reserve: presentation of the MOVE-ON project	10/10/2019	Plaine des Palmistes	23
Steering Committee 2	Participate to the "socio-economic" technical group	27/08/2020	Mare Longue	28
Steering Committee 3	Select strategies to be implemented within the action plan (1st workshop)	24/09/2020	Visio	15

Steering Committee 4	Finalization of the willingness of stakeholder's (workshop closure)	28/09/2020	Visio	4

Table 3: The Steering Committee meetings along with the number of participants within the management of the Mare Longue Nature Reserve of Saint-Philippe, Reunion Island.

Figure 27: The illustrations of the various Steering Committee Meetings in-person and through visio conference (National Park)

6.2 Semi-structured interviews

During the world COVID pandemic with sanitary measures ahead, the logistics for the semi-structured interviews were modified. The semi-structured interviews were conducted via visio-call. A given interviewee received prior to the visio call various documents; 1. The description of Mare Longue Nature Reserve, 2. The Concerted Action Plan of Mare Longue, 3. ES and 4. The MOVE-ON project. The interviews were

held individually and a series of questions were asked to the interviewees which were then summarized in table for analysis. The main interviewees, in total 12, members of the steering committee represented local institutions, with socio-economic activities, the research field, NGOs (See Annex1)

Figure 28 : Socio-economic stakeholders of the Steering Committee meeting of the PAC of Mare Longue Nature Reserve, Reunion Island (National Park)

6.3 Workshop with interviewees

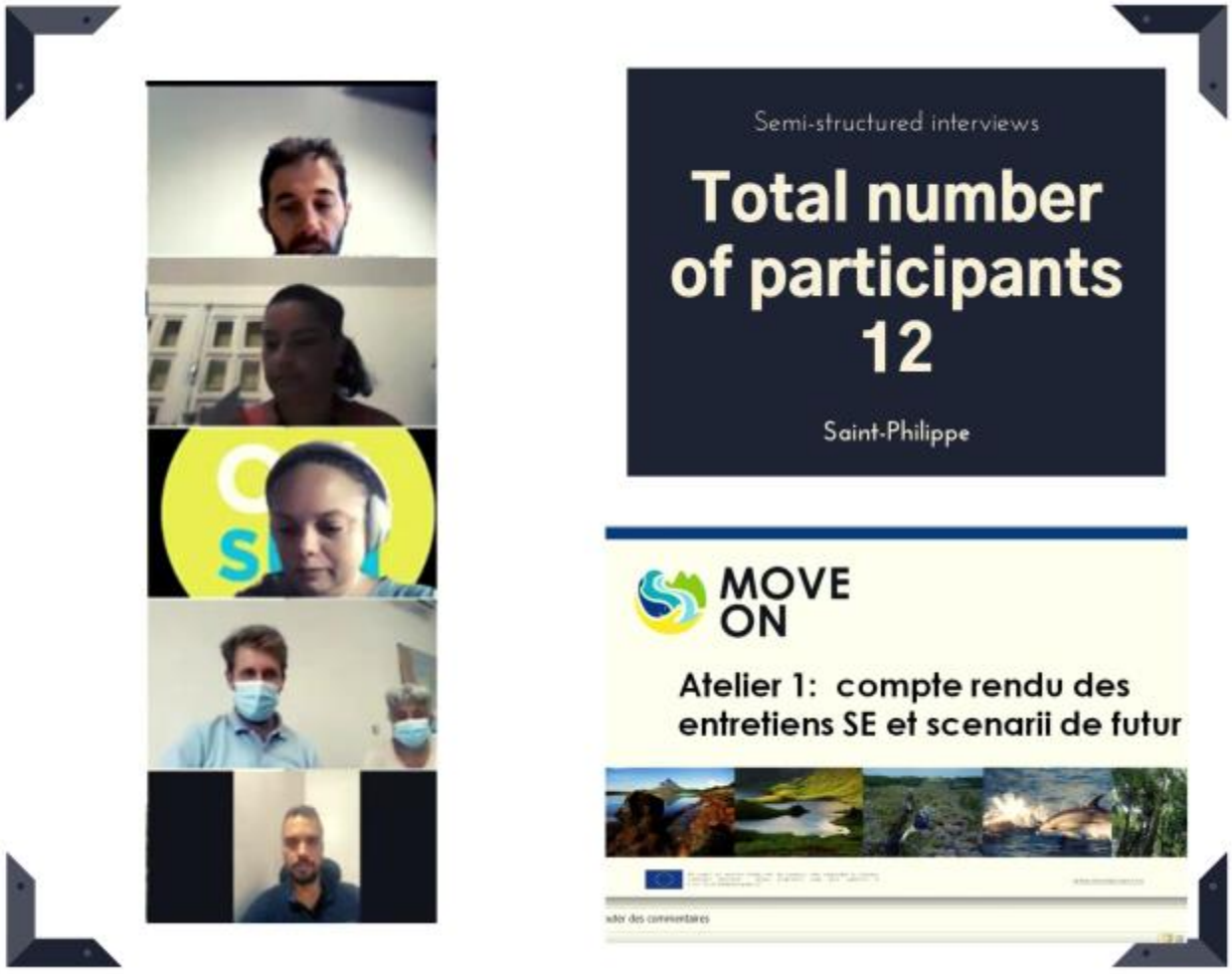


Figure 29: Online Workshop to showcase results of the Semi-structured interviews

Following the semi-structured interviews, an online workshop has been held among the interviewees (amongst which are present members of the steering committee group) to showcase the results for validation, notably the prioritized list of ES to be mapped throughout the MOVE-ON project. Moreover, during this online workshop, were presented the next steps ahead of the project through GIS-Participatory mapping in focus groups, also showcasing the maps that will be used during the GIS-Participatory mapping exercise.

6.4 Focus group meetings

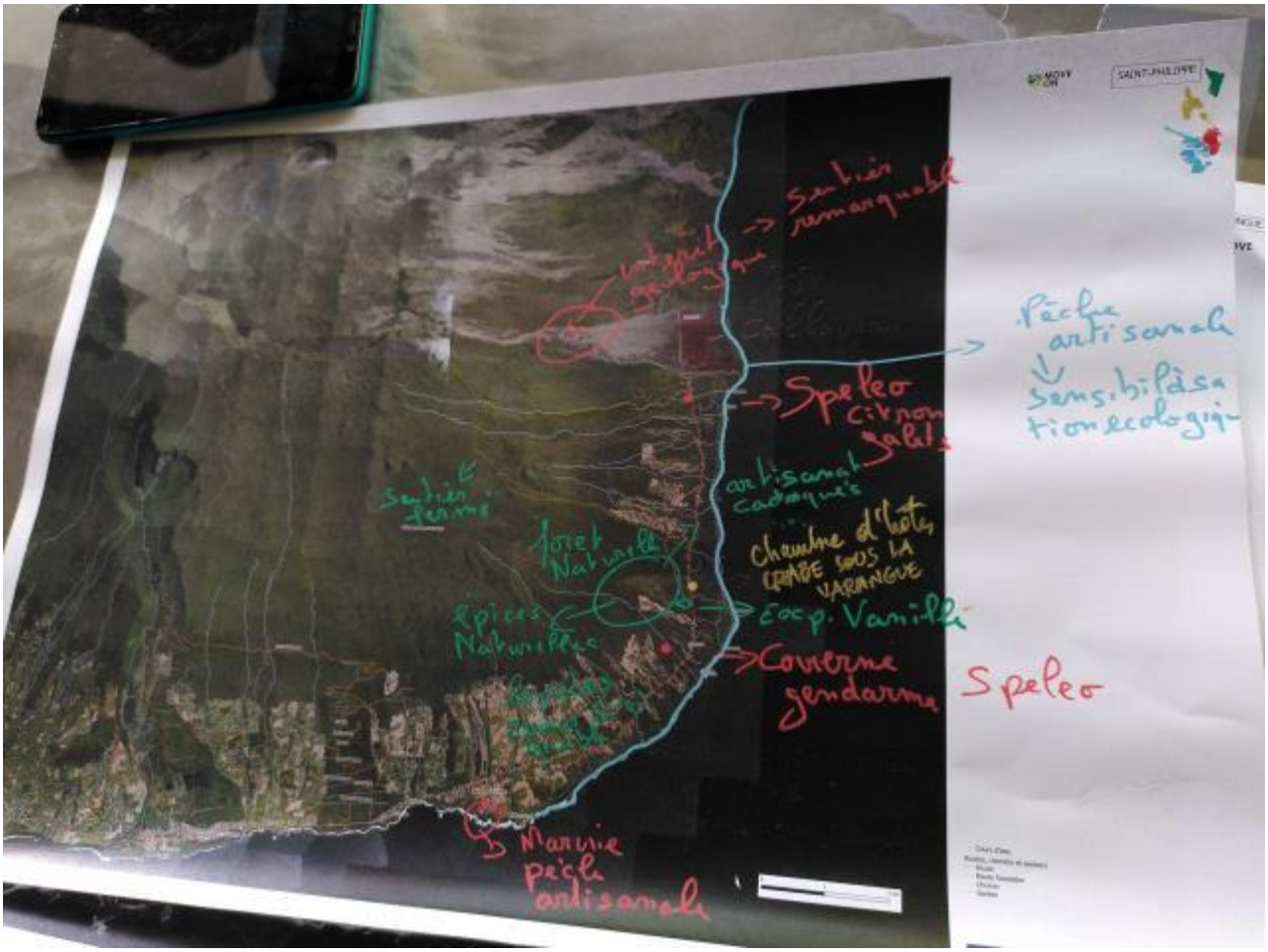


Figure 30: Printed format of A0 map used for participatory GIS mapping at the scale of the municipality of Saint-Philippe, Reunion Island

The GIS participatory mapping were undertaken in the form of focus group meetings. The groups were composed of 2 to 6 people. Two printed maps of A0 size were used in the mapping process. One map at the scale of the municipality of Saint-Philippe (Figure 27) and another map was utilized, focusing on Mare-Longue Nature Reserve (Figure 28).

Figure 31: Participatory GIS-Mapping at the scale of Mare Longue Nature Reserve, Reunion Island

In total 22 participants contributed to the focus group meetings (Figure 29) organised in three main thematics: Agriculture, Forestry, Tourism. The participants were first asked to fill individually an A3 version of the maps, with different color code to help in differentiating the socio-economic activities. In addition, historical sites of importance according to the knowledge of the Stakeholders were added in the map (Figure 30-34). After a 15mins of exchange on each participants content with a consensus by all, the A0 map version were then completed by the participants. The focus group activity, in average, was held for 2-3 hours.

Figure 32: The total number of participants for the focus group meetings

Figure 33: The stakeholders working tourism at large including in vocational rental commonly called "Gîte", mountain guide, speleology guide

Figure 34: The various farmers, including vanilla production and the economic club of Saint-Philippe in the Participatory GIS-mapping

Figure 35: The experts in Forestry working in collaboration for the Participatory GIS mapping

Figure 36: The Horse-riding club of Saint-Philippe undertaking the Participatory GIS-mapping

Figure 37: A focus group dedicated to knowledge on medicinal plants

Following the numerous maps filled by the stakeholders, the maps were transcript using QGIS (Figure 30-34), to showcase the final results of the participatory GIS mapping but also to be used using the InVEST software through the recreation model for analysis.

6.5 Bio-Corridor Forum 1

The wholistic purpose of the first Bio-Corridor Forum was to present the results of the Participatory mapping exercise of the cultural services, and undertake a discussion session with the members of the Steering Committee Meeting, members of the "Ecosystem Sentinel" Community and general public to share vision and priority actions.

Figure 38: The Bio-Corridor Forum 1 in Saint-Philippe, Reunion Island

6.5.1 Production and diffusion of a video

Figure 39: A documentary video created by the University of La Réunion, describing the Mare Longue Nature Reserve forests along with key stakeholders involve in the forest; local community, socio-economic stakeholders and researchers

From the observation that images and patrimonial documents on flora and fauna were quite abundant, University of La Réunion running research in Mare Longue for decades proposed to register sound and images dedicated to people living in and around Mare Longue nature reserve to share their insights and perception about the rain forest of Mare Longue. University of La Réunion implication in Saint-Philippe and Mare Longue bio-corridor is facilitated by the availability of the field research station built into the village of Saint Philippe, the "Station Forestière", part of the "Universe Science Observatories Network". The field station provides research facilities, accommodation and connections with local stakeholders working in Mare Longue especially. In 2021 and 2022, the University of La Réunion has produced a video on people living permanently or working frequently in Mare Longue or its vicinity. People with a range of ages and activities were volunteers to share their experience of Mare Longue forest. This video considered the gender balance, to have a representation of various ages and socio-economical activities of people giving their insight and interest about Mare Longue local stakeholders working in tourism, in forestry, in farming, forest service's workers and former tree nursery manager, students, researchers.

Link to the video: https://www.youtube.com/watch?v=4VqqCe1Tgww

6.5.2 The forum to validate the results

The aim of the Bio-corridor forum 1, co-organised with the Municipality of Saint-Philippe, was to gather the members of the steering committee and the ecosystems sentinel community for a 2-days event designed to motivate the participant on board to participate in the MOVE-ON project (Figure 35). A first day event was undertaken with the municipality of Saint-Philippe, as main administrator to collect their ambition and priority actions throughout the project. The main day event, was held on the 28th October, during available members of the steering committee and the ecosystems sentinel community, general public including secondary-school students, gathered to share insights and thoughts on ES. Findings of the focus group meetings were presented to the audience.

6.5.3 The forum to discuss and share ambition

During the Bio-corridor forum, a session of discussion was held, where 6 guests were invited on the floor, namely 2 guests from the University of La Réunion, the Forestry Services, an organic farmer, the economic club of Saint-Philippe and the Municipality of Saint-Philippe. The discussion session was divided into two main questions, in which the audience had also take the floor and ask questions or also contribute to the discussion.

The two main questions raised were:
What are the priorities to be taken into account in the development of the Mare Longue Nature reserve and its community in Saint-Philippe?
In the near future, and post MOVE-ON project, what are the main themes/ideas to take into account in the co-creation of a project for the Mare Longue Nature Reserve?

6.6 Bio-Corridor Forum 2

As part of the second Bio-Corridor Forum, NEXA has dedicated a full week on ES, taking place from 27.01.2023 till the 08.02.2023. This week entailed activities, seminars and workshops in various locations of the island to reach a maximum of interested stakeholders. This included a workshop at the townhall of Saint-Philippe, next to the Mare Longue Nature Reserve, a Seminar at the AgroCampus of Saint-

Pierre in the West of the island and regional workshops in Saint-Denis, the island's capital.

6.6.1 Profile of participants of the Bio-Corridor Forum 2

This event has been an optimum opportunity to gather a wide range of stakeholders. In terms of targeted audience participation, remote sensing specialists, project managers and planners, geomatics, water managers, researchers, students were present. In addition, project managers, managers, regional authorities (Regional council, Departmental council, Municipalities, public establishments for cooperation between municipalities commonly called in France "EPCI"), consular chambers, project managers from agencies or local public companies "SPL", engineers from research centers and NGO members have fully participated with positive feedback for the Bio-Corridor Forum 2.

Figure 40: The total number of participants for the Bio-Corridor Forum 2, undertaken at regional scale in favour of Saint-Philippe

Figure 41: Nexa's website on to the Bio-Corridor Forum 2

6.6.2 Seminar

On 30.01.2023, a seminar on the topic of MAES methods and case studies took place at the facilities of CIRAD AgroCampus in Saint-Pierre from 10:00 to 12:00 in the morning. 19 participants from diverse institutions and working fields attended. Cathleen Cybèle presented the MOVE-ON project and the work conducted in the Anchor Project. Francesco Sica from University of Trento explained the rationale of EU MAES, tools and methods for ES assessments and showed on the example of the city of Trento, how this information can flow into land use planning using Nature-based Solutions and Ecosystem-based Adaptation measures.

Several questions were raised following the presentations with notably : "*Is there a model to evaluate pest and disease 'invasive species", "We have data on carbon storage, diversity of natural habitats and are there similar examples of studies on island biology including water regulation and if not, how can we implement such study?", "There is a need to undertake a nutrient cycle in La Réunion, even for Mare Longue", "In the case study to the city of Trento with the change in urban planning, how did the economic stakeholders responded or how did you tackle this issue?", "When you evaluated the hotspots for ES, how did you calibrate the ES or how do you select the ecosystem services for such case?".*

Figure 42: Pictures showcasing the Seminar lead by the University of Trento

6.6.3 Anchor Project Regional Workshops

The objective of the Anchor Project regional workshops was to make an inventory of ES (or "services provided by nature") within 18 selected habitats of the territory, where the scoring carried out at regional scale mainly to complete and verify the mapping of the Anchor Project site and to further think about the establishment of a Territorial Capacity Matrix in the long term.

Figure 43: Pictures showing the regional workshops with participants actively filling the matrix of capacity

6.6.3.1 The feedback from local stakeholders for a need in an assessment of ecosystem services in Reunion Island per sector

The format selected for Bio-Corridor forum 2 succeeded to collect general information on behalf of participants to gather their insights on the results of the workshop. A questionnaire was given to each participant to assess how the results of the evaluation of ES in Reunion Island could be useful for the participants and in which sector/action.

The participants were able to determine their work expertise and related habitats to the assessment of ES, specifically in the local economic sectors. Mainly emerged (out of 65 quotes): 26% for agricultural policy – agriculture, beekeeping, medicinal uses of plants, forestry, 22% for tourism along with agro tourism and ecotourism, 12% for urban / land planning, 12% regarding the environment, conservation including management of natural environments, 9% for the energy sector, 6% towards blue economy. In addition, 5% for water management, 3.5% is linked to the economy while 3.5% is related to all economic sectors along with regional and local authorities and also only 1% for Agrifood.

6.6.3.2 Satisfaction rating of Bio-Corridor 2

The participants has expressed their level of satisfaction of the workshop on a level of 1to 5, 1 here corresponds to a useless workshop to 5, an excellent workshop of high value expressing the highest positive level of satisfaction. The participants voted with a mean value of 4.2, showing a useful workshop for the key stakeholders in ES (Figure 41).

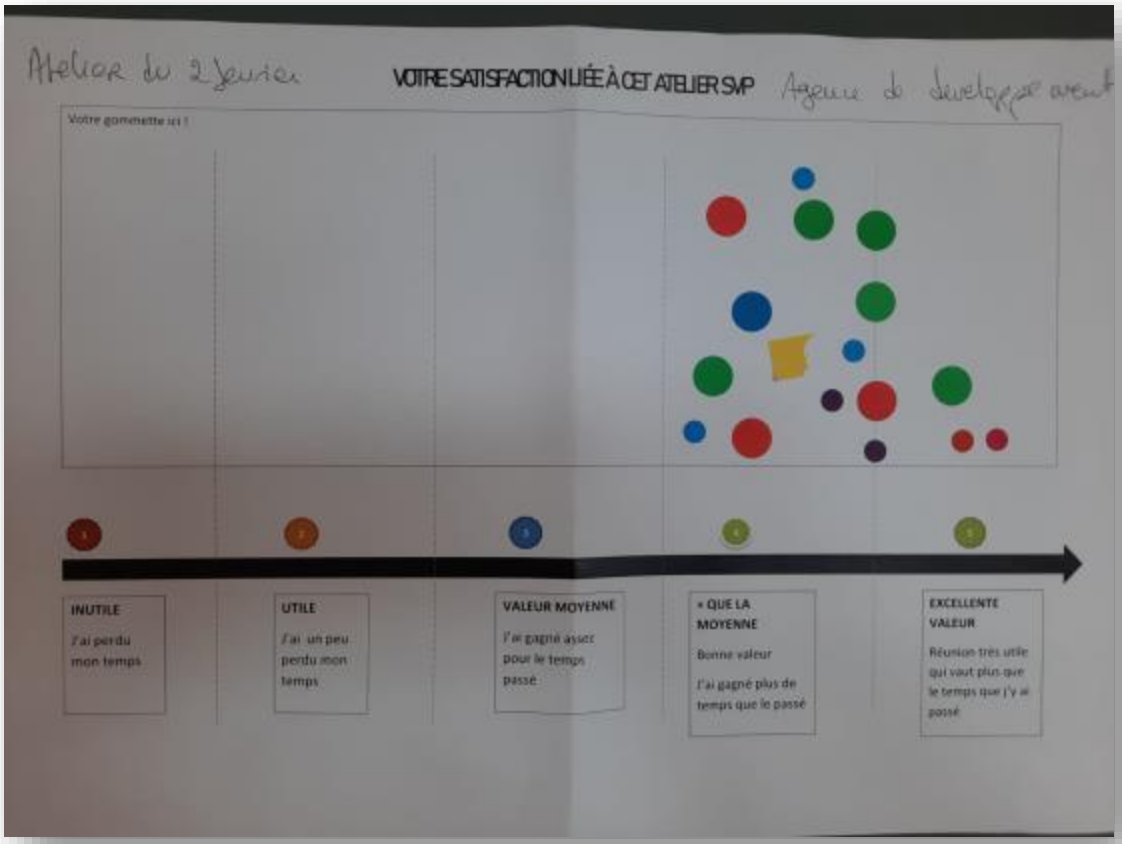


Figure 44: Satisfaction level of the Anchor Project workshops

7 DISCUSSION

7.1 The importance of Governance in the project implementation

Since the MOVE-ON Anchor Project of Reunion Island has been able to be part of setting-up of a CAP for the management of the Mare Longue Nature reserve, this appeased any potential controversies around the governance of the project. Incorporating the MOVE-ON project as an activity within the CAP, also enhanced the involvement of stakeholders within the scope of the Anchor Project site in the creation of the "Ecosystem Sentinel" Community. Undertaking focus group meetings in small group due to sanitary measures, facilitated knowledge sharing among the group, on top of raising awareness of the concept of ES. The trust built between the members of the "Ecosystem Sentinel" Community and the MOVE-ON

project has enabled their participation in the Bio-Corridor Forum. Moreover, participants of the Anchor Project as a whole are looking forward to a synthesized report in French.

7.2 Multi-tiered approach to understand spatial supply and demand for cultural ecosystem services

This is the first evaluation of ES at municipal and regional scale for Reunion Island. The results will provide guidance to land-use planners, site managers, regional authorities, policy and decision makers on the state of ES, which will allow them to devise future project in particular field in the sustainable economic development or for biodiversity conservation and restoration.

The Participatory GIS-mapping and InVEST model demonstrates the high level of visit during the Months (November, March and August) March and August correspond to the holiday time in Reunion Island. November isn't specifically a holiday period, but we could suggest that foreign tourists visit the Anchor Project site during that season or researchers are also actively collecting data.
The preferred habitats types are cultivated forest of colored woods, *Acacia heterophylla* and *Erica reunionensis* forest.

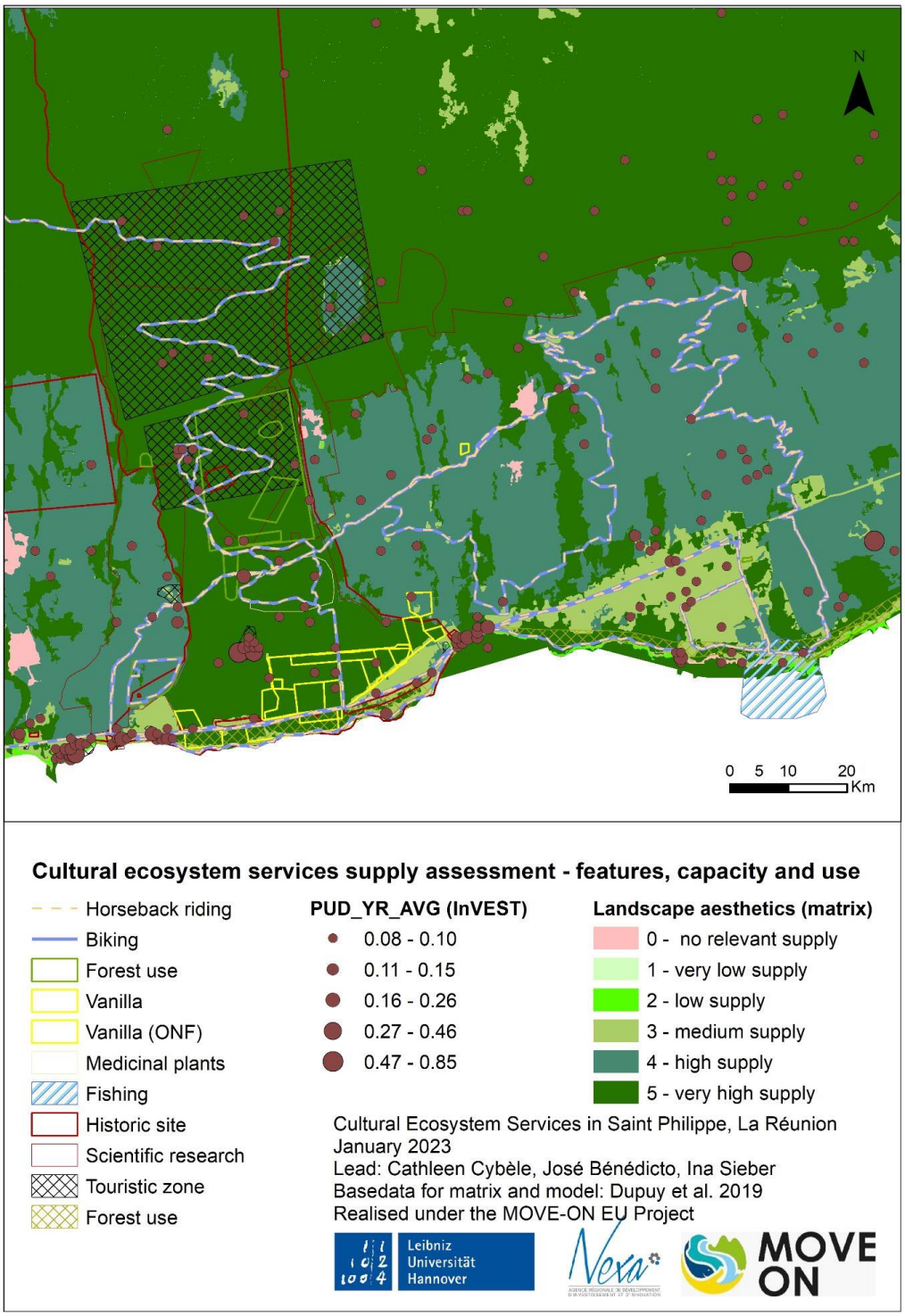


Figure 45: The result of participatory mapping of cultural ES combined with the InVEST result on the average number of, Photo User Day (PUD), thus pictures taken on an annual basis (PUD-YR-AVG) and the capacity of ES to provide with Landscape aesthetics

The map depicts the landscape aesthetics supplied by the area around the city of Saint-Philippe. The Mare Longue Nature Reserve as a component of the municipality of Saint-Philippe, with its historic and scientific research site are shown as well as the vanilla production zones and hiking, horseback riding and mountain biking trails. The dots represent the Photo User Days (PUD) averaged per year for the timeframe from 2005 to 2017, the size of the dots corresponds to the number of PUDs. To a large extent, the visits PUDs coincide with infrastructure - roads and trails guide recreationists. The attractivity at the coastline is especially visible in the high agglomeration of PUDs in the shore west of the Mare Longue, with historic sites and spectacular coast views. Yet, in the forested area, hikers, birdwatchers and botanists seem to leave the official tracks.

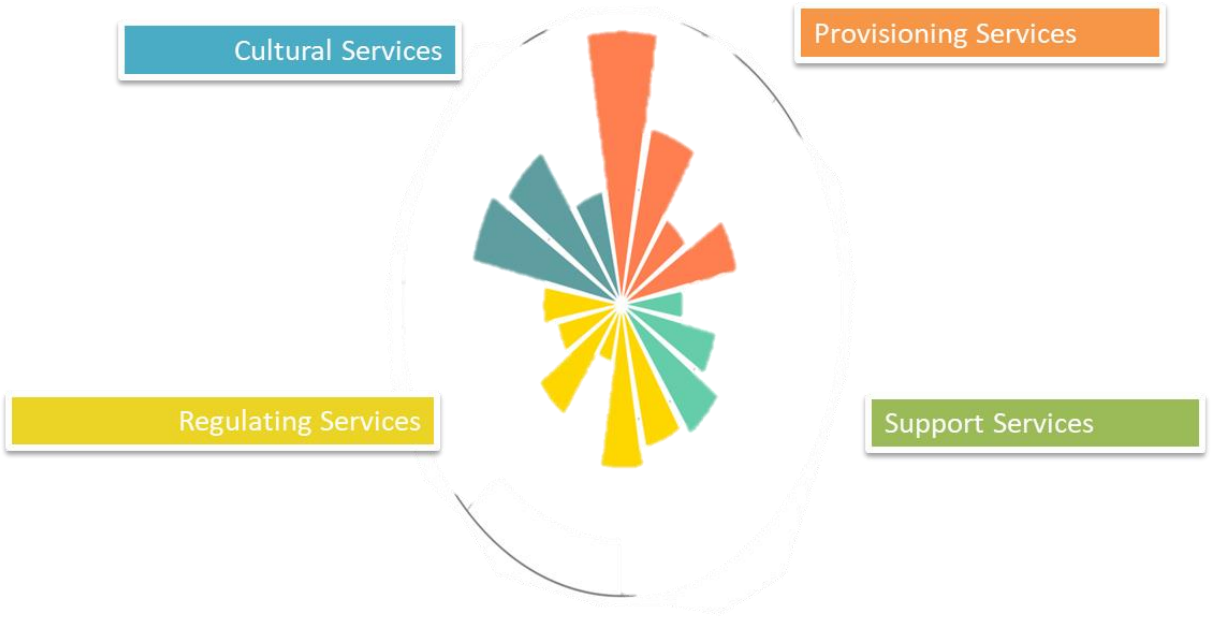


Figure 49: Groups of Ecosystem Services delivered by agricultural habitats at regional scale of Reunion Island

Complementary workshops were organised at island scale and obtained an overall of 30 matrices. Experts represented a diverse group from different fields of work. The capacity of ecosystem to deliver food provisioning is represented in bundles for the four main groups of ecosystem services (Figure 49). In addition, Figure 50 illustrated at island scale a map with the capacity of habitats to supply with ecosystem services for food provisioning services, notably vegetables from a level of capacity of 0 to 5. Moreover, Figure 51 shows at island scale a map with the capacity of habitats to supply with ecosystem services for carbon sequestration.

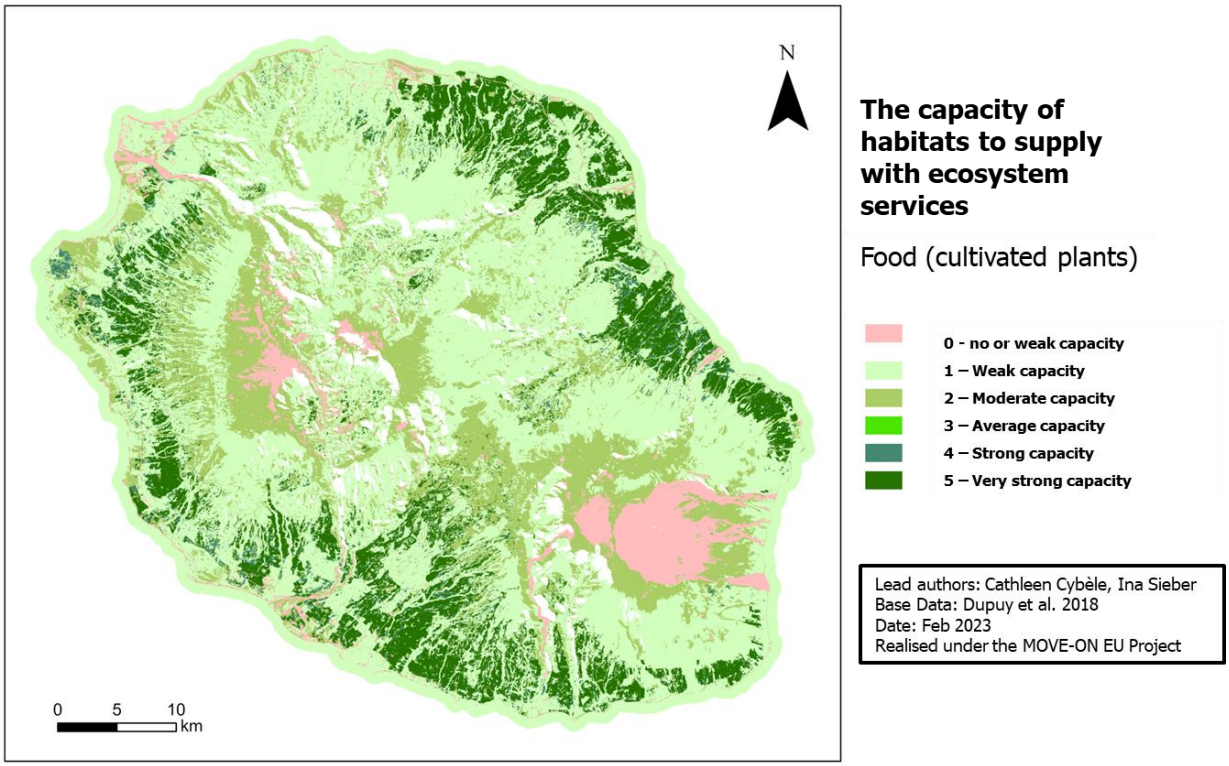


Figure 50: The capacity of habitats at the scale of Reunion Island to generate food provisioning services

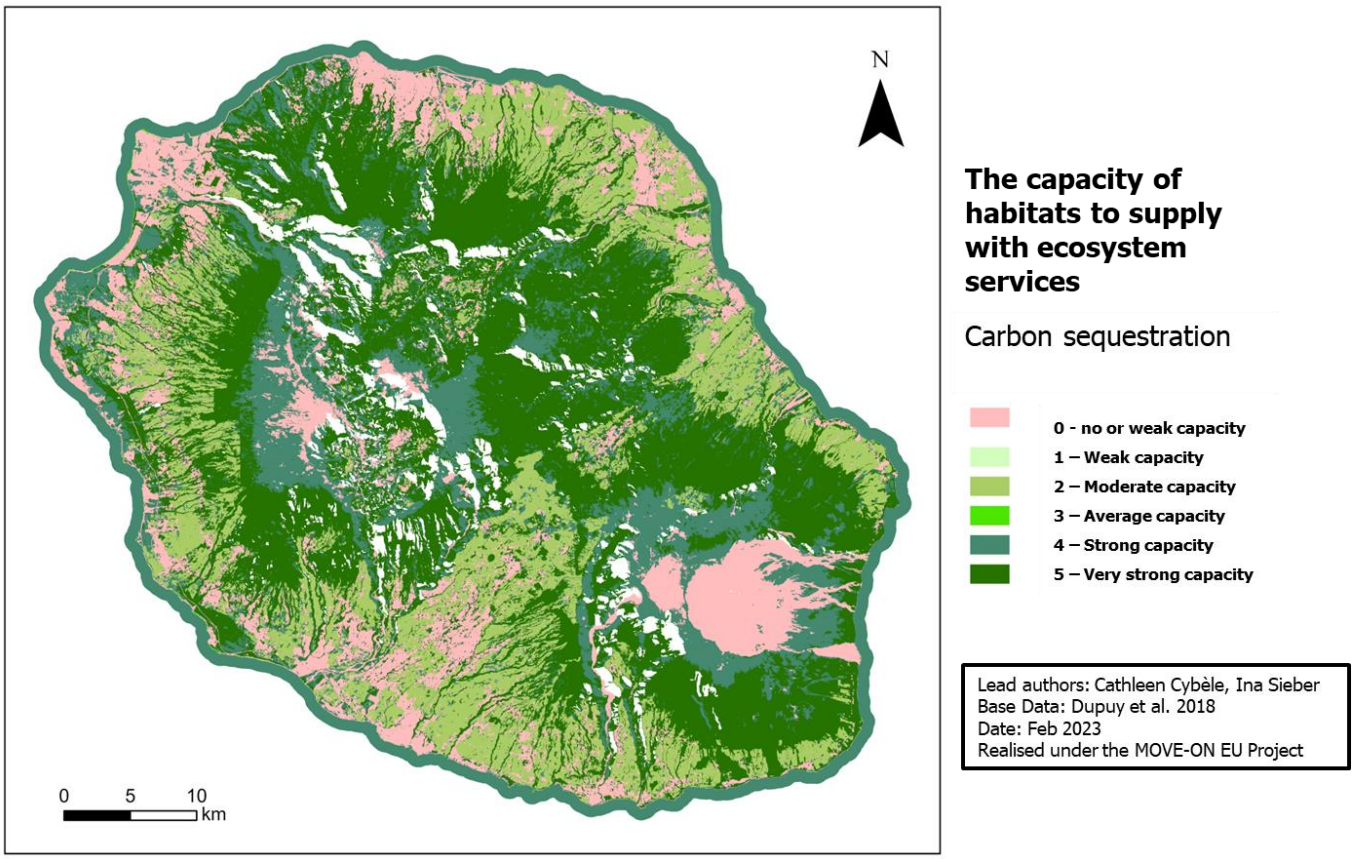


Figure 51: The capacity of habitats at the scale of Reunion island to generate Carbon Sequestration

7.3 Main themes for an action plan in the co-creation a project post-MOVE-ON Anchor Project in Reunion Island

The format used within Bio-Corridor Forum 1, through a discussion session allowed to collect fundamental ideas for the Anchor Project site mainly "*to protect Mare Longue, since there are more tourists*", but also to provide amenities for tourists. Bringing together the result of the Anchor Project site allowed to show policy and decision-makers, where tourists agglomerate, which ecosystems are most valued in terms of cultural aspects, but also, to identify areas for potential future economic activities. Agro-forestry has been mentioned as a sustainable socio-economic activity in the area.

In terms of amenities to improve, it is imperative to enhance trail infrastructure and toilet facilities. Indeed, it is required to invest in better road infrastructure since there is a demand in economic development for visits in the forest, while limiting the impact on the forest edge. This request was a point raised as well during the Steering Committee meeting at the inception of the CAP of Mare Longue.

On the other hand, a general awareness campaign is needed. In terms of key insights to build a communication strategy, a regional awareness campaign should be organized to showcase the nature reserve, its valuable landscape from ocean to mountain and the rich diversity of endemic flora. There is a willingness to showcase the high degree of scientific research undertaken Mare Longue along with the presence of a research station whereby scientists worldwide (with 57 nationalities so far), choose Reunion Island for their research work.

The format used for Bio-Corridor forum 2 through the questionnaire to assess how the results of the evaluation of ES in Reunion Island could be useful for the participants and in which sector/action, demonstrated a willingness to undertake the matrix of capacity at finer scale. The chamber of agriculture and the water office expressed the willingness of using the MAES method in evaluating ES for the agricultural realm of around water to answer contemporary problematics mainly due to climate change and economic crisis.

7.4 The constraints accounted during the project implementation

The World COVID-19 pandemic with strict sanitary measures was the main obstacle in the implementation of the anchor site project. Meetings were postponed, and being able to motivate members for online meeting was a challenge. In addition, the fact that the MOVE-ON consortium met in-person in the middle of the project's calendar, has delayed a comprehensive exchange between members of the consortium.
Moreover, the CAP of Mare Longue is composed of various actions plans and communication plan of the nature reserve. The Anchor Project site main aim was to supply with ES assessment results and provide with key recommendations (for priority actions including for communication strategy) that would be useful not only for the CAP of Mare Longue but also to local authorities, structural partners, and stakeholders at large. Therefore, the Anchor Project report avoided conflict with the CAP of Mare Longue and did not produce action plan *per se* but in the form of recommendations including a synthetic report in French that could be used in existing strategies, plans or schemes.

8 CONCLUSION

The Anchor Project in Reunion Island was a pragmatic step in sharing the MAES process with stakeholders at large through a bottom-up to top-down approach. The Anchor Project initiated a state of the art of the evaluation of ES in Reunion Island, and contributed to existing data of MAES in the OR. The workshops enabled the members of the "Ecosystem Sentinel" Community members and other external participants with diverging profile to understand the definition of ES, the MAES methods and particularly putting in practice the MAES methods in land-use planning. The multi-tiered approach provided a multi-entry results to ES with a special focus on cultural services with socio-economic activities. The MOVE-ON Anchor Project in Reunion Island paved ways to the establishment of MAES methods on the island, with potential projects ahead.

9 REFERENCES

Figure 1 https://ab.pensoft.net/articles.php?id=12837

Brown C, Burns A, Arnell A (2018) A Conceptual Framework for Integrated Ecosystem Assessment. One Ecosystem 3: e25482. https://doi.org/10.3897/oneeco.3.e25482

Burkhard, Benjamin; Kroll, Franziska; Müller, Felix; Windhorst, Wilhelm (2009): Landscapes' capacities to provide ecosystem services - A concept for land-cover based assessments. In LO 15, pp. 1–22. DOI: 10.3097/LO.200915.

Burkhard, Benjamin; Santos-Martin, Fernando; Nedkov, Stoyan; Maes, Joachim (2018): An operational framework for integrated Mapping and Assessment of Ecosystems and their Services (MAES). In 2367-8194 3, e22831. DOI: 10.3897/oneeco.3.e22831.

Campagne, C. Sylvie; Roche, Philip (2018): May the matrix be with you! Guidelines for the application of expert-based matrix approach for ecosystem services assessment and mapping. In One Ecosystem 2367-8194 3, e24134. DOI: 10.3897/oneeco.3.e24134.

Costanza, R.; d'Arge, R.; Groot, R. de; Farber, S.; Grasso, M.; Hannon, B.et al. (1997): The value of the world's ecosystem services and natural capital. In Nature 387 (6630), pp. 253–260. DOI: 10.1038/387253a0.

Dupuy, Stéphane; Gaetano, Raffaele (2019): Reunion island - 2017, Land cover map (Pleiades). With assistance of Stéphane Dupuy, CIRAD.

European Commission (2011): Our life insurance, our natural capital: an EU biodiversity strategy to 2020. Communication from the Commission to the European Parliament, the Council, the Economic and Social Committee and the Committee of Regions, Brussels, Belgium, 17pp.

Grêt-Regamey, Adrienne; Weibel, Bettina; Kienast, Felix; Rabe, Sven-Erik; Zulian, Grazia (2015): A tiered approach for mapping ecosystem services. In Ecosystem Services 13, pp. 16–27. DOI: 10.1016/j.ecoser.2014.10.008.

Grêt-Regamey, A.; Weibel, B.; Rabe S, Burkhard, B. (2017): A tiered approach for ecosystem services mapping. In Benjamin Burkhard, Joachim Maes (Eds.): Mapping Ecosystem Services: Pensoft Publishers.

Jacobs, Sander; Burkhard, Benjamin; van Daele, Toon; Staes, Jan; Schneiders, Anik (2015): 'The Matrix Reloaded': A review of expert knowledge use for mapping ecosystem services. In Ecological Modelling 295, pp. 21–30. DOI: 10.1016/j.ecolmodel.2014.08.024.

Le Mézo, Lionel; Dupuy, Stéphane; Gaetano, Raffaele (2022): La Réunion - occupation du sol - carte 2021 (Spot6/7) - 1.5m. With assistance of Le Mézo Lionel, Dataverse AIDA, CIRAD.

Palomo-Campesino, S., Palomo, I., Moreno, J., & González, J. (2018). Characterising the rural-urban gradient through the participatory mapping of ecosystem services: insights for landscape planning. One Ecosystem, 3, e24487.

Petit, J.; Prudent, G. (2008): Climate change and biodiversity in the European Union overseas entities. Gland, Switzerland and Brussels: IUCN.

Reed, M. S. (2008). Stakeholder participation for environmental management: a literature review. Biological conservation, 141(10), 2417-2431.

Sharp, R.; Tallis, H. T.; Ricketts, T.; Guerry, A. D.; Wood, S. A.; Chaplin-Kramer, R.; Vogl, A. L. (2014): InVEST user's guide. The Natural Capital Project. Sharp, R., Tallis, H. T., Ricketts, T., Guerry, A. D., Wood, S. A., Chaplin-Kramer, R., … & Vogl, A. L. Stanford, CA, USA. Available online at https://invest-userguide.readthedocs.io/_/downloads/en/3.8.5/pdf/.

Sieber, I.M.; Borges, P.; Burkhard, B. (2018): Hotspots of biodiversity and ecosystem services: the Outermost Regions and Overseas Countries and Territories of the European Union. In OE 3, e24719. DOI: 10.3897/oneeco.3.e24719.

Sieber, I.M.; Campagne, C. S.; Villien, C.; Burkhard, B. (2021): Mapping and assessing ecosystems and their services: a comparative approach to ecosystem service supply in Suriname and French Guiana. In Ecosystems and People 17 (1), pp. 148–164. DOI: 10.1080/26395916.2021.1896580.

Strasberg, D.; Rouget, M.; Richardson, D. M.; Baret, S.; Dupont, J.; Cowling, R. M. (2005): An Assessment of Habitat Diversity and Transformation on La Réunion Island (Mascarene Islands, Indian Ocean) as a Basis for Identifying Broad-scale Conservation Priorities. In Biodivers Conserv 14 (12), pp. 3015–3032. DOI: 10.1007/s10531-004-0258-2.

.

10 ANNEX

10.1 Annex 1: Assessment of the Ecosystem Services through semi-structured interviews

Ecosystem Services in MARE LONGUE	1	2	3	4	5	6	7	8	9	10	11	12
	Socio-economic	Administrator	Administrator	Administrator	Administrator	Administrator	Socio-economic	Facilitator/NGO	Facilitator	Socio-economic	Researcher	Researcher
	Latitude fruitière	Municipality	Forestry Services	Departmental Council	Departmental Council	National Park	Jardin des Parfums	Rural Developement	Tourism authority - south	Economic club of Saint-Philippe	University of La Réunion	Mascarin National Botanical Conservancy
SUPPORTING ECOSYSTEM SERVICES												
Nutrient cycle	10		10	8		8						7
Water purification	10		3,5	5		10					10	8
Land/soil formation and composition	10		10	6		8						7
Biodiversity conservation	10		10	10		10					10	7
REGULATING ECOSYSTEM SERVICES												
Atmospheric composition and climate regulation	8	8	9	6	8	10	10	5	6	10	10	10
Air quality	8	8	9	8	8	8	8	5	6	8		10
Flood protection	8	8	6	8	7	10	10	8	6	5	9	10
Erosion control	8	8	5,5	9	7	8	10	10	7	5	9	9
Disease control	7	7	9	8		8	8	10	6	2		
Pest control	7	7	9	8		6	8	10	6	8		
Pollination and seed dispersal	8	8	9	9	7	10	8	10	5	1		8
Risk reduction	8	7	6	8	7	8	10	10	7	8	8	10
PROVISIONING ECOSYSTEM SERVICES												
Food	3	6	2	1	8	4	0	5	5	3	2	-
Fresh water supply	3	5	0	0	8	8	10	5	2	8	9	0
Plant based fibres and materials	5	8	7	2	2	6	5	5	2	1	2	3
Biomass-based energy sources	2	5	1	1	1	5	5	5	2	1	1	0
Genetic material	8	10	10	7	8	10	10	8	8	5		
Aromatic and pharmaceutical resources	8	9	7	7	1	7	10	8	7	5	8	10
CULTURAL ECOSYSTEM SERVICES												
Spiritual and religious values	10	9	0	8	1	8	10	5	2	5	3	1
Aesthetic values	10	10	10	9	9	10	10	10	6	8	10	10
Recreation and ecotourisme	10	8	8	6	9	6	5	8	7	8	9	10
Well-being	10	10	7	9	9	8	10	8	8	6	9	10
Educational and scientific value	10	10	6	10	8	10	10	10	8	10	10	8

10.2 Annex 2: Participatory Scenario Planning decision

Compte rendu Atelier 1
Anchor Project Mare Longue

Contenu

Introduction

L'atelier du 22 décembre 2021 a été l'opportunité de partager avec les participants la liste des Services Ecosystémique retenue pour définir la liste définitive des Services Ecosystémiques à cartographier, identifier les Scenario préféré par les participants et l'enrichir et valider les cartes à utiliser lors de l'exercice de cartographie participative.
Quatre acteurs ont été représentés dans l'atelier.

Scenarii de futur

Le scenario préféré a été le Scenario 3, néanmoins il a été demandé de faire des modifications pour l'intégrer plus explicitement dans les initiatives déjà mises en place. Le scenario modifié est présentes ci-dessous :
Scenario 3 : modèle de développement adapté au territoire et centré sur les besoins
Ce scenario se base sur trois axes de développement : conservation, agroforesterie et agro-écotourisme. Il s'inscrit dans la ligne de ce qui se fait déjà dans la Commune dans le cadre du Plan d'Action Concerté de Mare Longue et, en général, d'autres initiatives de la Collectivité.
Pour diversifier l'agriculture, l'agroforesterie raisonnée est développée en priorité dans les friches à la lisière des zones naturelles (palmiste, café, conflore, fruitiers,

plantes à parfum, aromatiques et médicinales – PAPAM…) ces cultures servent de barrière pour protéger les zones naturelles. La pharmacopée traditionnelle est favorisée, ceci permet de valoriser les espèces endémiques et renforce la valeur culturelle de la forêt. Les institutions aident les initiatives locales de transformation alimentaire.
L'agro-écotourisme est dynamisé. Ceci permet d'augmenter les revenus des agriculteurs et des acteurs du secteur touristique. Ce tourisme est développé d'une façon durable et un soin est pris pour limiter son impact négatif dans les zones naturelles et la communauté. L'offre d'activités touristiques se diversifie, par exemple l'observation du ciel nocturne, facilitée par la faible pollution lumineuse de la commune.
La conservation des espaces naturels se fait par la lutte contre les espèces exotiques envahissantes, la restauration des parcelles dégradées qui permet l'agrandissement des périphéries de la forêt, des initiatives pour compenser la faible régénération naturelle, la sensibilisation de la population et des acteurs locaux, et la lutte effective contre le braconnage. Dans la mesure du possible les zones naturelles sont agrandies pour augmenter la résilience de la forêt. Ces initiatives permettent aussi de diminuer l'impact du changement climatique.
Différentes stratégies sont mises en place pour valoriser les services et les biens produits dans la commune. Il y a une réappropriation du patrimoine naturel par la population. Ce scénario nécessite des moyens, d'une implication et une coordination des acteurs en présence ; les résultats ne se verront pas dans le court terme.

Services écosystémiques

Les services écosystémiques retenus pour la cartographie participative par les Focus Groups sont les suivants :
Services d'approvisionnement :
Ressources génétiques et pharmacopée : Focus Group forestiers et Focus Group agriculture
En lien avec ce service écosystémique un exercice avec les forestiers va être proposé pour cartographier des espèces patrimoniales et les espèces intéressantes pour les tisaneurs. La liste initiale de 5 espèces (Bois blanc, Poivrier des hauts, Bois bleu, Bois de poupart et Bois de fer blanc) va être soumise à validation par le PNR, ONF et CBNM.

Services culturels :
Valeur esthétique: Focus Group tourisme et/ou population générale
Récréation et tourisme: Focus Group tourisme

Le service de régulation (Qualité de l'air/(Micro)Climat) n'a pas été retenu car il requiert des mesures précises qui ne s'appliquent pas à un processus participative qui serait trop subjectif.

Cartes pour exercice de cartographie participative

Les cartes proposées sont considérées pertinentes mais il faut compléter la toponymie et retravailler la forme pour qu'elles soient plus claires.

Les cartes définitives seront proposées aux participants aux entretiens pour validation.