4.4.4 Water monitoring implementation manual - environmental and socio-economic segment

Work package 4. Transferring

4.4 Body of Knowledge

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Executive summary

This report describes the key environmental and socio-economic conditions that can ensure the successful implementation of water monitoring solutions in natural parks, based on the experience gained by EcoSUSTAIN partners, after testing two types of water monitoring systems, namely a Short-Term Monitoring Solution (STMS) and a Long-Term Monitoring Solution (LTMS). As one of four documents forming the EcoSUSTAIN Body of Knowledge, this report is complementary to the *4.4.1. Lessons learnt during water quality monitoring pilot implementation, 4.4.2. Impact analysis of EcoSUSTAIN pilots* and *4.4.3 European Operational Concept on transnational water monitoring.*

It provides guidance on:

- the selection of which parameters to monitor;
- the selection of the proper locations for STMS buoy installations;
- the data collection, analysis and publications;
- management and institutional aspects to consider in similar projects;
- the integration of water monitoring with other environmental and socio-economics priorities of Natural Parks.

It finally includes conclusions and recommendations on the viability of the piloted systems in MED natural areas, based on environmental and socio-economic benefits achieved by the project.

Introduction

This report aims to be a short manual, based on EcoSUSTAIN experience, on the key environmental and socio-economic conditions which ensure the successful implementation of two water monitoring solutions piloted within the project: the Short-Term Monitoring Solutions (STMS) and Long-Term Monitoring Solutions (LTMS). It completes the EcoSUSTAIN Body of Knowledge, a series of four reports that summarises key results and recommendations from the project, aiming to transfer the knowledge gained and experience outside the consortium.

The description of STMS and LTMS solutions, the overview of Natural Parks that implemented the systems, aim and objectives of the pilots, operational aspects and benefits achieved can be found in the other three documents of the Body of Knowledge, to which the reader should refer for a comprehensive overview of the project results.

1. Implementation of water monitoring through STMS and LTMS

1.1 Selection of monitored parameters

For both STMS and LTMS the selection of water parameters to be monitored included a range of physical (temperature, conductivity, turbidity), chemical (Dissolved Oxygen, pH) and biotic (blue-green algae and Chl-a pigments) variables. Despite some special parameters selected for each site, all lists include both basic parameters used in surveillance monitoring and more specific ones, such as variables related to specific pressures.

Besides strategic conservation objectives, water parameters selection should be based also on other considerations. In the case of STMS, for example, factors like the cost of the probes, duration and robustness in specific conditions, maintenance requirements should be considered. The choice of including only few key parameters for which sensors are robust and not too expensive may be a good choice, also leaving budget for more than one buoy, as it was the case for some EcoSUSTAIN partners.

These aspects should be carefully discussed with technical partners or the providers before specifying the solutions to purchase, in order to make the best choice, which should be based on a mix of monitoring, cost effectiveness and management considerations.

1.2 STMS: Location for buoy installation

Location for installing STMS buoys should be selected carefully based on several considerations. First of all, the attention should be placed on the specific objectives of monitoring, based on the particular needs and interest of the protected area.

For example, in EcoSUSTAIN, Mincio Park selected four strategic locations, along the River Mincio, in order to monitor changes in water quality parameters across the Natura 2000 sites “Valli del Mincio” and the lakes around the City of Mantova. The first station is located upstream from the Natura2000 site, before the river widens and forms a wetland and the lakes. The other three stations are located near the closing sections of the three lakes of Mantua, to understand how quality changes after receiving several inputs from the city and the surroundings.

In UNA Park, one buoy has been located downstream from three settlements causing pollution impacts, upstream to the most valuable natural phenomena on Una river, travertine barriers and waterfalls, whose conservation deeply depends on water quality. Moreover part of this river section forms the administrative and natural border between Bosnia and Herzegovina and Croatia, thus the data gained are important for both countries. In La Albufera, the selection of the location was functional to the monitoring of the output from a green filter and its effects on the Albufera Lake, where for Krka NP, the selected spot was again a strategic location for the river system.

However other factors should be considered when selecting the buoy location, which are more related to operational and practical aspects:

- the sensors must be immersed in the river flow and therefore not in excessively stagnant areas, in order to collect representative values of the investigated ecosystem and ensure a better performance of sensors, decreasing the frequency of cleaning; the water speed should be limited in order to prevent disanchoring;

- the buoys should be out of navigation corridors for safety reasons;

- if it is equipped with Photovoltaics panels, it should have a good exposure to the sun light;

- it should be in a visible/monitored position to reduce the probability of theft or damage;

- space to perform maintenance in safe conditions should be guaranteed;

- the position should be favourable for installation and maintenance operations (good accessibility to vehicles/ boat if necessary).

In the case of EcoSUSTAIN, site selection for all pilot cases was supported by technical partner University of Democritus (DUTH) through a unique procedure, even if the buoys had to monitor different things for different reasons in each case study. At the beginning, a detailed preliminary work on all available literature on the study sites was performed to gather information on ranges of nutrients, substance properties and other abiotic parameters, hydrological modifications, pressure and impact assessment. The water uses and pressures were documented and some sites receiving outflows or pollution pressures or designated as sites of special interest due to tourism, bathing, fishing, wildlife preservation etc. were pinpointed. This information along with the request for documentation by the Protected Areas Management Bodies on the possible site selection were coupled. Then, technical information on buoys i.e. on maximum number of probes for different monitored parameters, sensors length, maintenance, etc., were juxtaposed with site traits like depth, trophic state, ease of access etc. The optimum solution was thus suggested, thanks also to local support by technical project partners or local stakeholders, such as GNF in Spain or the University performing research in the park in Italy.

We would suggest to follow a similar procedure to Parks wishing to install similar solutions. The aim for each site can vary. The buoys may provide just a surveillance monitoring but can be a useful tool for operational monitoring too. High frequency real time monitoring can provide useful data for the assessment of pressures caused by human activities and morphological alterations, the inflows-effluent discharge in the water bodies, the safeguard of visitors' wellbeing (Swimming waters, watersports), along with preserving fish life and guaranteeing the sustainability of water for agricultural uses. From a scientific point of view it can also give an insight to primary production and examine daily variations except from seasonal ones as well as the human induced acceleration of eutrophication processes. The monitoring findings could assist in the formation of an early warning system for certain management options as the real-time flow regulation.

Figure 1: Location of STMS buoys in Mincio Park, Italy

1.3 STMS: Data collection and analysis, data processing and publication guidelines

Data detection frequency and data transmission to the server vary across EcoSUSTAIN pilots, depending on the buoy provider and solution offered. In case of La Albufera and Una Parks, data are detected and transmitted every hour, while in Krka every 15 minutes. The frequency of data detection and transmission can be usually adjusted depending on needs and requirements. In Mincio Park, data were collected every 10 minutes and transmitted from the data logger to the server every 30 minute during the first 6 months of activity, but after observing limited variability of values and identifying the need to save energy and increase the life of batteries, the Park decided to reduce the frequency of data detection to 15 minutes. The frequency of data transmission to the server for one of Mincio's four buoys has also been reduced to once/hour, to prevent the batteries from discharging excessively, since the station is slightly in the shade.

General sampling frequency could be set according to the Water Framework Directive minimum prerequisites, or much more often when chasing an occasional event without pattern or when wanting to describe a daily or seasonal pattern. The monitoring programmes will need to take account of variability in time and space (including depth) within a water body. Sufficient samples should be taken and analyzed to adequately characterize such variability and to generate meaningful results with proper confidence. High organic matter pulses usually go along with flood events and classical low frequency sampling fails in capturing such dynamics. In EcoSUSTAIN case, all NPs wanted to test frequent measurements in order to have a real-time picture of the chemical status or to capture special events like the outflow of an artificial wetland. After the testing step, it is however recommended to make the proper adjustment to the frequency depending on monitoring needs (investigative, operational, surveillance).

In relation to data transmission, data are collected on site using the data loggers (purchased by the parks). From there, the data is sent both to the providers' server, thus visualized on Parks' computers and also to the server of EcoSUSTAIN partner RGO, where they are stored inside the EcoSUSTAIN database. While the visualisation and reporting through EcoSUSTAIN platform is common across STMS pilots, the format and functions of each local server and data interface is different based on the buoy provider. The picture below shows a screenshot of the software installed on Mincio Park's server. In this case, by selecting one of the four STMS stations, the user can select the parameter to visualize in a selected time interval. It is also possible to overlay the other parameters of the same or of other stations in the graph. Other providers, such as Krka NP's, offer only raw data in Excel tables.

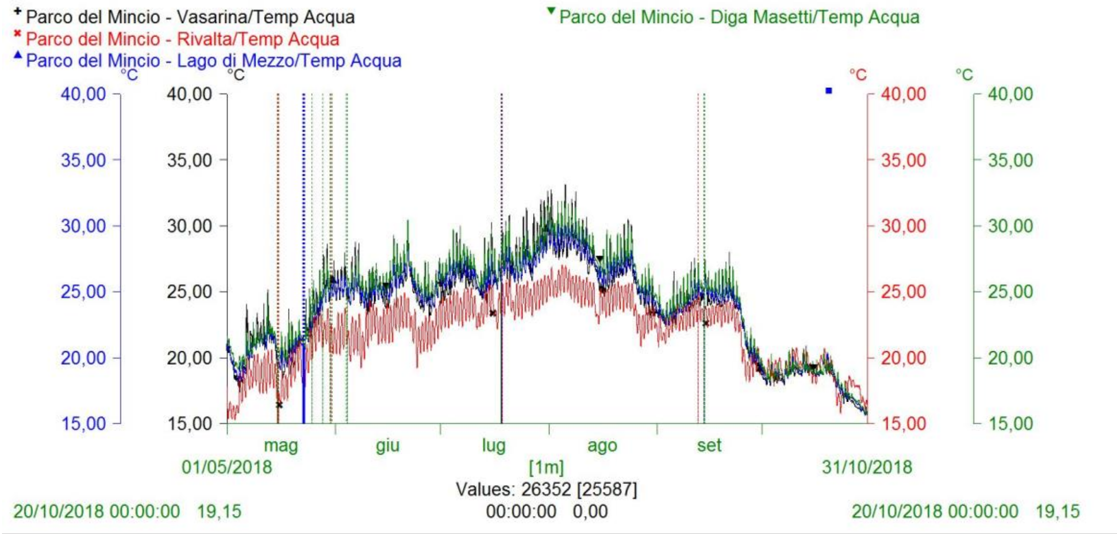

Figure 2: Example of data graphic visualisation from STMS installed in Mincio Park

In relation to the EcoSUSTAIN platform, when the user opens it, the database is queried and the data are displayed on the screen in form of graphs, tables and some statistical values are derived from the raw data (e.g. minimum, maximum and average values from the period). The data are only processed while viewed within the application as live data or through the created reports, but the data itself is valuable and can be further processed outside of the STMS solution using any desired tools. The data simply needs to be exported to a file format, which is easily imported in Microsoft Excel or similar spreadsheet software and analysed further.

Data gained from STMS in the four EcoUSUSTAIN pilot areas are currently available to the public through the EcoSUSTAIN platform. Authorised users (Parks) can create and publish reports on it for any arbitrary period. This report contains a graph as well as a table with minimum, maximum, average and last value from the defined time period. The reports also contain free text provided by the authorized user that may further enrich the report by providing relevant information.

Time	Water temp.	Dissolved oxygen	Turbidity	Nitrogen	Chlorophyll	Bluegreen algae	Conductivity	CDOM-fDOM	pH
06.11.2018 14:00	13.64	4.09	17.51	13.8	19.16	8.45	1446	39.14	7.84
06.11.2018 13:00	13.5	3.88	21.27	14	15.77	8.78	1419	37.93	7.82
06.11.2018 12:00	13.23	3.4	20.07	14	17.21	10.36	1421	38.06	7.81
06.11.2018 11:00	12.95	2.96	21.5	14	20.89	10.73	1421	38.31	7.8
06.11.2018 10:00	12.92	2.67	21.58	14.2	27.16	9.67	1416	37.73	7.78
06.11.2018 09:00	12.79	2.51	20.96	13.6	22.9	10.21	1419	38.51	7.78
06.11.2018 08:00	12.89	2.21	21.14	13.6	26.41	9.36	1420	38.41	7.77
06.11.2018 07:00	13.04	2.5	21.4	13.6	22.91	9.12	1418	37.03	7.78
06.11.2018 06:00	12.91	2.84	26.25	12.9	27.17	9.43	1463	38.59	7.79
06.11.2018 05:00	13.01	2.59	18.11	13.1	21.97	9.65	1433	38.08	7.78

	Min	Max	Average	Last value
Water temp. [C]	12.40	14.92	13.60	13.64
Dissolved oxygen [mg/l]	2.06	8.10	5.09	4.09
Turbidity [NTU]	12.09	54.45	20.31	17.51
Nitrogen [mg/l]	6.60	14.20	10.44	13.8
Chlorophyll [ug/l]	15.77	70.58	31.62	19.16
Bluegreen algae [cell/ml]	7.13	40.73	13.88	8.45
Conductivity [uS/cm]	1368.00	1847.00	1601.74	1446
CDOM-fDOM [ug/l]	36.89	47.71	40.80	39.14
pH	7.75	8.22	7.97	7.84

Figure 3: Examples of data displayed on EcoSUSTAIN platform for L'Albufera (tables)

Figure 4: Examples of data displayed on EcoSUSTAIN platform for L'Albufera (graph)

Even if all data are currently available for publication by the EcoSUSTAIN webpage, EcoSUSTAIN partners recognize that in most cases all monitored data are not of public interest, either due to the large amount, or to the need to translate it into information that can be easily understood.

For all the pilot sites, perhaps a daily median and/or a weakly variation graph of the monitored parameters would be enough for public data presentation along with a small paragraph explaining what is monitored and what it means in a simple understandable way.

The recommendation from EcoSUSTAIN partners is first to select the target audience and then identify the proper data visualisation (which parameters based on interest and relevance, which frequency, which format – tables or graph, trend or punctual, etc.) and thus the level of explanations needed. The aim is to ensure transparency but also avoid unnecessary alarms due to lack of knowledge or understanding.

1.4 LTMS: Data collection and analysis, data processing and publication guidelines

In relation to the LTMS, sampling frequency is limited by satellite coverage of the pilot location. In case of EcoSUSTAIN pilot, Lake Karla in Greece, the selected satellite passes over the area twice per month and this is the maximum frequency of detection, given that there are no weather constraints. The images are selected and processed using a preset algorithm delivered by the project partner Aratos SA. The final result is stored in their server and the Lake Karla Management Body receives the final image.

In EcoSUSTAIN LTMS pilot, the end user gets a processed images of Lake Karla which shows the physicochemical status of surface water according to a coloured palette covering the range of observed water quality parameter values. It is basically a “snapshot” of one selected parameter each time. No more processing is available by the end user using the application developed within the project.

The LTMS tested in EcoSUSTAIN cannot replace at this stage the regular field monitoring but it is able to capture a monthly and annual trend, providing the Management Body with a visual item that could be of supplementary use for communication/dissemination purposes. Bearing in mind the possible error, it can still assist the early alert and the threat prevention, assuming the processed image is provided to the Protected Area Management Body soon after the satellite scanning/sampling. Moreover, it is a great method to monitor the entire lake in a 30x30 pixel and visualize it across its whole extent. In this way, inflows of degraded water quality can be mapped and the most sensitive areas within the lake pinpointed.

The publication of data, assuming the application works properly and accurately, should follow the requirements of the 2000/60/EC Water Directive Guidelines, highlighting parameters which depict special features of pressures in the study area, such as pollution, climate change, hydro morphological alterations, etc. The data should be published as soon as collected and processed.

2. Management and institutional aspects

The institutional framework linked to water monitoring and protection has proven to be an important factor in all EcoSUSTAIN countries. Water monitoring is usually a legal responsibility of other public bodies rather than Natural Parks, such as Environmental Agencies, National or Regional Water authorities. Moreover other entities are in charge of water flow regulation, such as interregional agencies or regional water bodies.

Thus Natural Parks either did not perform water monitoring at all before this project or implemented it with a specific scope, i.e. water and biodiversity protection within the Park's boundaries. Their interest towards water is interlinked within the overall protection of ecosystems and biodiversity of the Park and is often in conflict with the interests and needs that guide the other competent authorities.

The relationship between Parks and these entities varies. In some cases, there is no communication at all, in others relationships are good. Some disagreements on issues of jurisdiction and mechanisms of water quality preservation may exist, while in some cases conflictual interest do not allow to obtain a synergic and coordinated action for water protection.

Across all pilot sites, the implementation of EcoSUSTAIN water monitoring solutions allowed to enhance these relationships: in particular, through the STMS solution, which provides a continuous and huge amount of data available real time, Parks experienced an improvement of contacts and collaboration, thanks to their ability to share meaningful data with other entities. Improved capacity to share, collaborate and set up synergies and joint vision was also ensured by communication, dissemination and transferring activities organised within the project, which created the place and opportunity for setting up and continue dialogue and cooperation.

Thus the conclusion from EcoSUSTAIN is that improved and innovative monitoring carried out by Natural Parks is a driver of networking and collaboration with key stakeholders and that this improved relationship across regions is a crucial factor for enhanced water and biodiversity protection. Proper and effective communication and transfer of results through events, staff exchanges, study visits and other relevant strategies and initiatives, like those organised within EcoSUSTAIN WP4 Transferring, is also crucial in order to set up and continue collaborative and joint work.

Participation of Parks in regional, national and EU networks for exchange of good practices regarding water resources management in Protected Areas is also recommended.

3. Integration of water monitoring with other environmental and socio-economic priorities

According to EcoSUSTAIN Parks, the monitoring solutions piloted in the project are improving their management capacities in relation to biodiversity protection, climate change and also the valorisation of economic vocations of the territory, such as tourism.

Water quality is strongly linked to flora, fauna and ecosystem health, thus improved monitoring and knowledge allow to enhance ecosystem and biodiversity protection. Moreover continuous monitoring and real time alert provided by the STMS, allows to intervene promptly, preventing ecosystems from turning into an unfavourable status to autochthonous species.

In relation to climate change, benefits of a better water monitoring are several, such as:

- Control on water quality and thus on ecosystems health is crucial in order to enhance their resilience to climate change;

- Air-water equilibrium of Oxygen and CO_2 are influenced by water vegetation and plants, thus water quality also have an effect in mitigating climate change;

- Data series and better monitoring can be compared with previous data in order to assist in the prospective development of a model that could track climate change in the pilot sites.

Better ecosystem monitoring has also an impact on the economic potential of natural areas, especially in relation to their touristic vocation with consequent benefits on the local economy. In some cases, such as Krka NP, natural areas are visited by a huge amount of tourists during the summer, thus monitoring is of great importance in order to avoid critical impacts on ecosystems.

In all cases, the fruition of Parks by visitors is highly dependent on good water quality and conditions in relation to several recreational value (for ex. swimming in Krka River, fishing in Una River, visiting tufa waterfalls in Una and Krka, water sport activities, birdwatching and fishing in Mincio, L'Albufera and Karla). These activities often constitute a revenue for the Parks and always represent a source of income for local communities. Improved water quality monitoring is thus the basis for the sustainable development and green tourism in MED protected areas.

Figure 5: EcoSUSTAIN partners visiting Una Park waterfalls by boat, near Bihac, Bosnia

Of course, water quality of rivers and lakes in natural areas have a number of effects and impacts also on the surrounding territories and economic activities, such as agriculture, especially where the water of river and lakes are used and redirected for irrigation or other uses.

For this reason, water monitoring should be strongly integrated with the other strategic priorities of Parks and integrated in their overall Strategies and Management Plans, and this is what is happening within EcoSUSTAIN natural areas. The analysis of the water monitoring results in EcoSUSTAIN natural areas will lead to the optimization of water resource management practices, which will conserve and protect biodiversity and will enhance ecosystem services. This will enforce the principles of sustainable development in the local socio economic life and will benefit sectors such as fisheries, agriculture, tourism and education across regions.

From EcoSUSTAIN experience and lessons learnt, it is clear that the engagement of local communities is crucial in order to succeed in this kind of projects or initiatives, avoiding opposition and gaining support in the short and long term. This highly affects the sustainability of projects and also creates an environment where local populations understand the benefits and opportunities coming from a better water and nature conservation. EcoSUSTAIN Natural Areas are all deeply engaged and connected to local communities through several initiatives, including:

- Environmental awareness and education;
- Ecotourism activities for children, families and adults;
- Vocational trainings on sustainable farming, sustainable accommodation and restoration;
- Summer schools and courses related to water resource management and agriculture, ecotourism and environmental education;
- Involvement of local populations in the Park's projects and activities (maintenance of fences, pathway creation, coast cleaning, etc);
- Participatory processes leading to joint agreements for sustainable development, such as the Mincio River Agreement, signed by over 60 public authorities and associations, with the aim to develop a shared vision for the sustainable development of the territory along the River, including the Mincio Park, joining the need for cultural identity, safety and environmental quality.

Specifically within the EcoSUSTAIN project, partners used many strategies and tools to engage citizens and the general public; starting from general dissemination and communication activities, such as press releases, TV and radio broadcasting, articles on magazines, websites and social media, up to engaging schools and adults in water monitoring and related activities and delivering thematic talks to the city councils on the project and the piloted solutions.

GNF and L'Albufera are also planning specific activities to show the data monitored through the STMS systems to the public, explaining the parameters variations during the day and the night and how parameters change with episodes of rain or dry seasons. In UNA Park, the private landowner facing the buoy location has been engaged since early stages and is supporting the Park to watch over the installed equipment, while local people support the Park's employees for the maintenance. In this park, some local representatives from the settlements located a few kilometres upstream from the buoy also attended to the buoy installation and to the training organised by the supplier, understanding how the system works as well as the potential benefits for their local community.

The recommendation from EcoSUSTAIN is thus to pay great attention to properly inform the local community about these initiatives, their aim and importance to preserve waters, habitats, fauna and flora species, with a strong focus on the potential benefits for the local populations. Engaging them directly in educational, practical and field activities is also very important to create a sense of ownership and understanding, strengthening citizens' participation and support to the Parks. In EcoSUSTAIN pilot areas, the implementation of the monitoring systems has been very well accepted by the local population, thanks also to the engagement strategy delivered by Parks. It is the demonstration that involving the local community creates a common platform for cooperation, shaping future plans and creating a joint responsibility towards the protected area.

Figure 6: EcoSUSTAIN partners visiting Rivalta Ethnographic museum, Mincio Park, Italy

4. Final recommendations and conclusions on the viability of the monitoring systems based on socio-economic and environmental factors

In conclusion, the water monitoring systems piloted by EcoSUSTAIN (STMS and LTMS) have proven to be effective to enhance monitoring, management and protection capacities of parks in many different ways:

- Increasing number and frequency of data gained, knowledge of water quality and dynamics for better protection, planning and quick intervention;
- Data ownership with consequent enhanced capacity to liaise with key stakeholders, setting up new collaborations and cooperation with relevant subjects across the public, research and private sectors;
- Increased ability and power to communicate to the public and the media;
- Strengthening relationship with the local communities and visitors, showcasing the benefits of enhanced knowledge and protection, not only in environmental terms, but also for the local economy.

The key elements of success of this project, can be summarized as follows:

- Careful planning and evaluation of the monitoring solutions to be tested, whereby parks have been supported by technical partners, including private organizations and universities (both EcoSUSTAIN partners and local stakeholders) throughout the whole process, from understanding needs, alternative options, planning and procurement of the systems, up to implementation, maintenance, operations and finally evaluation of results;
- An effective communication, dissemination, awareness raising and engagement strategy towards a range of targets within each pilot region, including: local and regional stakeholders that could support the project or create synergies (universities, relevant agencies and public authorities, providers, associations, education sector, environmental NGOs and private organisations), thanks to each Park dissemination and communication activities and WP4 technical joint events supported by ALOT;
- The transfer of knowledge and experience across EcoSUSTAIN Parks through WP4 study visits and staff exchanges organised by parks supported by ALOT;

- An effective engagement of the local communities, essential for supporting the project implementation and ensuring its long term sustainability.

Even if a full Cost benefits analysis of these systems has not been possible (see D4.4.2. Impact analysis of EcoSUSTAIN pilots) EcoSUSTAIN partners believe that the piloted solutions would be of great benefits to any protected areas across MED willing to improve their water monitoring, management and protection capacities, producing several benefits to the area both in environmental and socio economic terms. Some more precise economic considerations have been included for reference in report D4.4.2, providing an idea of the systems costs and possible financial feasibility. In order to develop more detailed considerations on the systems cost-effectiveness, Parks or entities interested in installing solutions similar to the STMS and LTMS tested in EcoSUSTAIN, should consider carefully the aim and objectives of water monitoring in their area and all recommendations and information provided in the four documents forming EcoSUSTAIN Body of knowledge, to which this report belongs.

EcoSUSTAIN partners involved in the five pilots will continue to monitor the effects produced by the monitoring systems installed, included environmental, social and economic impacts and will be available for any information and further exchange of knowledge with other protected areas implementing similar solutions.