BEST INTERREG V-A GREECE-ITALY 2014/2020 PROJECT

Monitoring of Areas

- M01-02 -

University of L'Aquila – Department of Civil, Construction-Architectural and Environmental Engineering (DICEAA), Environmental and Maritime Hydraulics Laboratory (LIam)
Polytechnic University of Bari – Department of Civil, Environmental, Land, Building Engineering and Chemistry (DICATECh)

Macro-activity	Report	Revision	Date
M01	02	R03	20th March 2022

Interreg Greece-Italy
BEST
European Regional Development Fund
EUROPEAN UNION

WORKING GROUP

Project leader

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1. Introduction

The Civil, Construction-Architectural and Environmental Engineering Department (DICEAA) of the University of L'Aquila, through its Environmental and Maritime Hydraulics Laboratory (LIam) and the Department of Civil, Environmental, Land, Building Engineering and Chemistry (DICATECh) of the Polytechnic University of Bari, constituting a RTI (hereinafter referred to as UNIVAQ-POLIBA), have been selected by the Department of Mobility, Urban Quality, Public Works, Ecology and Landscape of the Puglia Region (hereinafter referred to as the "Customers") as custodians of the service "*Analysis of the evolutive dynamics of the coast in the coastal stretches of the pilot action area 1 and implementation of smart monitoring systems within the project BEST Interreg V-A Greece-Italy 2014/2020*".

The activities began on 31/03/2021 with the start of the contract under urgency procedure.

The service is part of the wider implementation of the BEST project "*Addressing joint Agro and Aqua-Biodiversity pressure Enhancing SuSTainable Rural Development*" funded by the INTERREG V-A Greece-Italy 2014/2020 Program. On the whole, the project aims to protect the natural and cultural heritage, restore biodiversity and coastal and rural natural habitats, involve local actors in cross-border projects and common pilot actions through the use of new technologies with a low environmental impact, with the final goal to improve the quality of life of the citizens in the concerned regions.

Starting from the analysis of the state of knowledge, the service therefore aims to assess the evolutive dynamics of the involved coasts and to monitor the areas subject to intervention (Regional Natural Park of the Coastal Dunes, Regional Park of the Mar Piccolo of Taranto and areas of the regional territory affected by the effects of Xylella).

Activities entrusted to UNIVAQ-POLIBA are related to two fundamental aspects, mutually correlated:

- monitoring of the areas (macro-activity M-01);
  analysis of the evolutive dynamics of the coasts (macro-activity M-02).

This report refers to the macro-activity concerning the monitoring of areas and the design of the monitoring network, starting from the composition of a cognitive framework based on pre-existing knowledge of environmental parameters, the definition of sampling stations, sensing areas and points depending on the characteristics of the territory, the presence of any sensitive areas (Natura 2000 sites, wetlands, nature reserves, etc.) and in agreement with the management authorities of the nature reserves concerned with activities planned and/or with local authorities having jurisdiction. The ultimate goal of the implementation of the monitoring network is the preservation of the biodiversity in the areas under the investigation. On the other hand, results of the analysis of the evolutive dynamics of the coast aim to give additional information about the areas that will be monitored, guiding the observation strategy.

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2. SUMMARY OF THE CHARACTERISTICS OF THE MONITORING NETWORK

2.1. GENERAL ASPECTS

The monitoring network, whose goal is the observation, measurement, archiviation and restitution of appropriately validated and identified environmental and biological parameters based on the analysis of the state of affairs, will need to represent a useful tool for the management of processes and decision-making in planning and re-planning phases not just on a regional level, as these are complex territories denoted by a huge environmental diversity and thus of species, rich in values that need to be protected and promoted. The monitoring network itself will need to ensure the possibility for potential problems related to current activities to emerge, such as those deriving from deviations from predictions, thus allowing the possibility to reschedule activities and/or possible new project opportunities for surveying.

A simplifying scheme of the structure defined for the monitoring network of biodiversity is shown in figure 2-1. The basic components are:

1. a group of distributed sensors for monitoring biotic and abiotic parameters (for a total of 27 measuring points and 75 monitoring stations);
2. a network for trasmitting data to a server (based on the network usage);
3. a point/server for collecting data (images, video and data related to environmental parameters);
4. a collection of computational resources with medium-high performances on the data collection server's end aimed at archiving data, verifying data consistency, managing station malfunctions, data correlation analyses, data elaboration, biodiversity monitoring, etc.

The support system for decision-making and results management is part of the monitoring network. It will be made up of a series of procedures aimed at regulating and allowing access and sharing of heterogeneous information through a set of services. In short, it will be developed as a system synthesizing the information acquired by the monitoring network, also through the use of geographic databases, on the basis of which protocols and rules, aimed at identifying the onset of anomalous or critical unexpected conditions, compared with reference values, will be defined through the construction of "rule matrices". Such protocols and rules will be defined alongside institutions managing regional natural parks, so that they can be coherent with pre-existing policies and strategies. The aforementioned reference values will be defined on the basis of the results of data analyses performed through the same monitoring network and on the basis of the analysis of the evolutionary trend of coastlines (M02 activity of the project in the inscription).

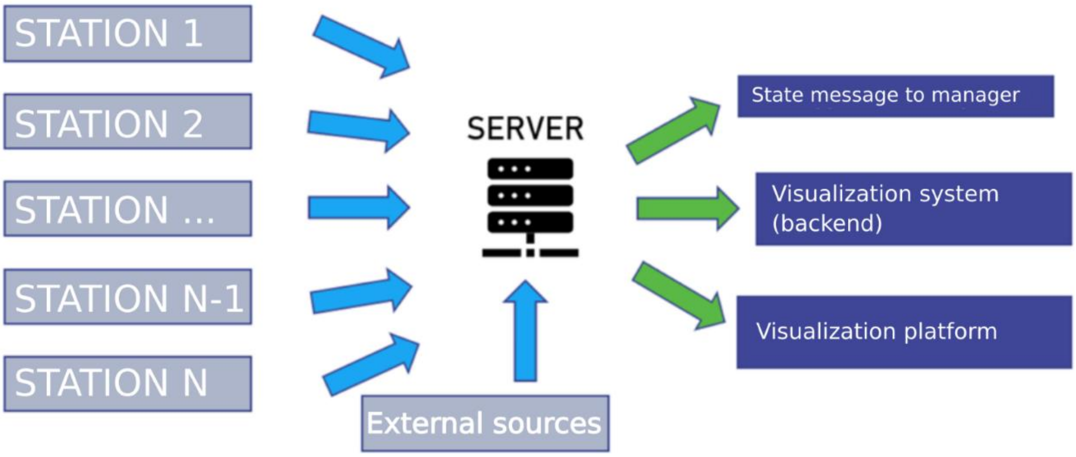

Figure 2-1: Architecture of the monitoring network.

The aforementioned system will be assembled, from a practical point of view, through an IT system directly installed on a server which will handle data collection and analysis. The requested service requires the implementation of an integrated unitary information system, developed in an *open source* framework, which will enable the interaction between available data collected by measuring stations and those available (as an example, spatial images from the Sentinel Network).

2.2. Goals of the system

The goals of the system for supporting decision-making and the management of monitoring results are:

- the creation of documentary standards and resulting increase in speed of the analysis of the observed data, aimed at the synthesis of the monitoring results (also through the monitoring forms described in the following):
- the interaction between the Region and stakeholders (for example, institutions managing regional natural parks) for an effective exchange of information necessary for various requests (for example the assessment of environmental impacts, etc.);
- the possibility to integrate results from unsupervised analyses (obtained automatically from the developed system, which can be seen as a "virtual operator") with results from details analyses carried out in a specific and focused way by specialized users (in the sense of "human operators");
- the use of tools for the computation of structured statistical parameters, able to detect possible anomalous situations;
- make all the information available to the general public through the visualization of cartography, on which results from the analyses of data acquired through the monitoring system are overlapped.

While implementing the system for supporting decision-making and the management of monitoring results, the use of *Open Source* technologies will be preferred, in order to decrease both subsequent costs related to the management and maintenance for the Administration and the risk of technological *lock-in.*

3. ARCHITECTURE OF THE SYSTEM

3.1. GENERAL ASPECTS

The system for managing monitoring results and decision-making will be structured, in short, as follows:

- data collected from instruments prescribed for the different types of measuring stations will be transferred, with different sampling frequencies depending on the data (as specified in the "M01-01" report), to the server;
- all "raw" data will be processed with appropriate algorithms or statistical analyses (specifically developed in the scope of the project's activities), depending on the data type, so that it can synthetize information on the sensing of relevant environmental and biotic parameters;
- information collected will be compared with qualitative and quantitative indicators which can be found in literature, so that the eventual onset of anomalous situations can be defined;
- appropriate actions will be planned depending on the processing that data undergo and on the comparison with indicators, which will be prescribed for critical situations;
- results of synthesis analyses will be made available through a geospatial visualization system which will allow the actual functioning of the system for decision-making support.

3.2. SYSTEM ADMINISTRATION

The administration subsystem will be completely accessible via web without the need for the installation of any plug-in, so that every aspect of the configuration and data service can be managed in a simple way. It will allow the following minimal functions:

- integration of data flux management for *data ingestion*, addition and configuration of new data source and related services;
- functionality and integrity control for the geospatial server through the resource and usage log;
- management of users and their access rights to services and resources, taking into account the fact that users proliferation will require management separated from the one in charge of the Region;
- monitoring the proper functioning of the monitoring network and management of maintenance interventions (both ordinary and extra-ordinary).

It will also be useful as a tool for solving problems and providing support in terms of planning and monitoring activities concerning the management of monitoring results. As an example, and not as a comprehensive list, some other functionalities will be:

- scheduling and monitoring activities;
- managing communications with possible stakeholders;
- managing the authorizations workflow.

3.3. Data ingestion

The *data ingestion* subsystem is a set of procedures, both for automated and one-time database population (for example, in relation to the possibility of entering information inferred from the forms filled in by specialized operators) dedicated to the integration, in the support system for decision-making and results management, of all the databases taken into account by the project and those necessary for controlling monitoring processes.

The input data flux can be divided into two large categories:

- input fluxes made up of files;

- input fluxes via web services.

In order to organize relevant data coming from measuring stations, functional subcategories will need to be defined (data hierarchy); afterwards, information that can be represented via data tables (i.e. MS-Excel, or files with extensions .dbf, .csv and other databases) will require the definition of the structure of the tables themselves (field names, field types, data domain, etc.).

Each input data flux will need to be accompanied by the related metadata. To simplify, metadata is a set of information which characterizes the data it refers to. It is possible to directly refer to the definition gave by legislation (DPCM, 03/12/2013) which, despite specifically referring to "IT document", constitutes a unique definition: "set of data related to an IT document, or to an IT file, or to a computerized document aggregation, in order to identify it and describe its content and structure, allowing the time management of the conservation system". Minimum metadata consistency consists of an ID code, the chronological date to which data is referring, the type of data and the subject producing the data.

Metadata will have to be validated following current standards – with room for customization – and memorized in an appropriate database structure. A software for filling out the metadata will be made available to subjects providing the data (users specialized in filling the monitoring forms). Given that "data historicization" means the presence, in the database, of the information needed to use the temporal component of the data itself, especially acquisition and expiration date of the content of the database, the *data ingesting* fluxes will manage data historicization.

The possibility for a workflow to manage variability (of the structure or of the data domain) of input data will be taken into account. As an example, one can consider the possibility of using, in the later phase of historical analysis of the monitoring data, space images from the Sentinel network, the nuclei of the European network Copernicus for environmental monitoring, in order to make comparison with measurements made by measurement stations from the monitoring network in this project.

Moreover, a specific flux related to the reporting of errors will be prescribed, implementing an automated log generation

The suggested applications and configurations will be flexible and will not necessitate any modifications to the software in order to update or edit workflows; it will moreover be possible to easily add new fluxes without relevant impacts on the system and especially on operators.

A management/control panel will be set up and it will enable the following of automated acquisition processes and possible found anomalous stations through the sending and visualization of alert signals.

The configuration of different measurement stations (for example the sampling interval) will be able to be modified remotely itself via server.

3.4. Data analysis

The monitoring network database will have the following functional requirements:

- it will need to be scalable;
- it will always be possible to select all available data related to that territory during analysis or report construction, depending on the considered territory;
- the spatial component of the dataset will be equipped with spatial indexing;
- its data structure will be specially designed and implemented for metadata management;
- it will allow automatic update of data;
- it will support the acquisition of data structures that can change in time with low impact on the system, meaning they will be supported without the need of modifying the server (from an acquisition, memorization, analysis or reporting point of view);
- il will provide a memorization logic for the acquired data through historicization, thus attributing a version for each data/table/flux;
- it will be the subject of complete and incremental backups which will also take advantage of cloud-hosting.

Data collected via the various measuring stations and transferred to the central server will be processed, so that it can yield useful information for biodiversity analysis. It will, of course, depend on the type of collected data and type of station:

- for the sampling of animal species (birds, mammals, reptiles, insects), algorithms will be implemented in order to identify, among all recorded video and audio on the server, samples that actually document the presence of animal species; in the following data analysis phase, other algorithms will be used in order to define the type of animals so that they can be categorized. During the experimental phase for the system, results of unsupervised analysis of acquired data (obtained through algorithms) will be compared to those obtained in a standard way (through specialized users) with the goal of validating/improving/train the implemented algorithms. In this respect, it is important to stress that standard sampling generally requires specific times of the day in which animal species are more active and thus in which it is more convenient to carry out sampling; the possibility to have almost continuative video footage (with very small sampling times, of the order of seconds), like those for the monitoring network in the present project, will allow the confirmation of such standard of sampling;
- for the sampling of vegetal species, long-term analysis of video footage is more effective to assess the variation of the specific composition (qualitative analysis) and variations in the extension of formations (quantitative analysis). An adequate compromise, in terms of amount of useful data and sampling frequency, will be reached through statistical analyses; in this case, too, results obtained automatically will be validated through the use of standardized monitoring forms filled out by specialized users;
- for the sampling of environmental, land and water parameters, temporal analysis will be useful for highlighting evolutionary trends and possibly relate criticality conditions for other analyzed biotic parameters; in this respect, identifying values over certain thresholds that can be found in literature and that are related to biodiversity conservation will be useful.

All data will be compared to qualitative and quantitative indicators from literature, which will allow to determine the presence of possible critical issues related to biodiversity conservation. This process will be automated, so to activate alert commands, which will be catalogued and later used to define indexes of risk, which will be then published online through *webgis*.

Data collected from monitoring stations and transferred to the central repository will be sorted in different folders (through the definition of a dedicated file system) depending on the type of monitoring station (birds, mammals, insects, reptiles, flora, weather, water, soil). Access to both raw data (collected with unique sampling times) and data processed with (i) algorithms specific to animal species and (ii) through statistical analysis for environmental parameters, will be made possible. See Appendix A.

3.5. Reporting

The core functions of the examined subsystem will have to allow, depending on each of the possible profiles having access to the system and their specific permissions (from senior management to executives), access to appropriate reports thorugh a screen showing different objects, in order to have an easier and immediate visualization of a set of indicators, tailored to certain themes of interest, data, graphs and/or geographical representations, in one page/dashboard that users will be able to browse.

The system will thus include all the functions aimed at supporting users decision-making processes. The user will be able to check pre-configured dashboards, set up in the implementation phase in agreement with the Contracting Authority.

The home screen for the initial login to the system will be a portal. Once the user has logged in the portal, a list of available dashboard elements grouped by theme will be shown, together with other useful information such as links to documents and relevant websites. Dashboards will have to allow, through dedicated links, browsing metadata of the visualized information.

Some of the objects that will allow customization in the dashboard are:

- variables;
- selection parameters;
- representation type;
- representation characteristics;
- graphical aspects.

The required tools will have to allow the production, publishing, management and browsing of dashboards. The following requirements will have to be met:

- dashboards will be able to include tables, graphs, text boxes, pictures, audio, videos, graphical objects and maps;

- dashboard production will have to be carried out in a desktop and web client environment having tools (query management, reporting, graphical, editing) which allow the production of content, and enable users to employ all available data from the monitoring network database;

- specifically, map production will be able to be carried out both via uploading already available maps, as those published by the National Geoportal or other geoportals through *web-service standard OGCs* (WMS, WFS, etc.);

- dashboards will always have to clearly show the date to which shown data refers to, as well as consulting date, and both will have to be printed out when files are printed or exported;

- dashboard will always have to clearly display the level of confidentiality of shown data, which will be either inferred from the characteristics of represented data or explicitly indicated by the source;

- when accessing monitoring dashboards, data visualization will be updated to the latest generated data;

-the possibility to export dashboards (in their entirety as they are displayed or by selecting single components) in pdf format must be provided;

- for every type of dashboard, interactive consulting of metadata must be provided.

The system, together with the possibility of browsing available reports on demand, will generate reports on a daily basis related to the functioning of the network (in order to aid network maintenance) and to analyses results (for historical data analysis availability).

3.6. Monitoring forms

For the analysis of biodiversity over time, which can be carried out as the final result of the monitoring through the network subject of this project, the algorithms must be reliable. Therefore, an experimental period will be required during which the results obtained by the virtual operator (the algorithms) will be compared with those obtained by specialized operators.

In order to achieve this goal, monitoring forms must be set up. It must be noted that pre-existing literature and legislation regarding biodiversity monitoring generally refers to *in situ* measurement techniques. The monitoring network that this project intends to implement will be smart, meaning it will allow automated acquisition and cataloguing of data which will then be further elaborated for providing useful information, comparable to what current legislation requires. In short, automated elaboration can be interpreted as the filling out of monitoring forms by a virtual operator, which is the algorithm itself, For this reason, in order to "define a system for supporting decision-making and management of results of monitoring", Activity 6 (A,06) of the technical offer states that the aforementioned monitoring forms must be prepared starting now, with the following minimum requirements for the biotic component;

- ✓ Definition of the sampling unit:
  - the sampling unit for cameras/microphones/hydrophones consists of continuative watching/listening/recording;
  - sampling geographic coordinates have to refer to positioning geographic coordinates of the considered camera/microphone/hydrophone;
  - direction and amplitude of framing with fixed parameters (to be determined depending on the instrument characteristics, soil altitude/depth).
- ✓ Definition of sampling effort:
  - sampling will be carried out in 6 time slots over the course of a day of monitoring. The time slots are:
    - the hour before sunrise*;
    - the hour after sunrise*;
    - the hour from 11.30 to 12.30;
    - the hour before sunset*;
    - the hour after sunset;
    - the hour from 23.30 to 00.30.

**Note: sunset and sunrise hours are those listed daily in the Effemeridi section in the Italian Air Force website (https://clima.meteoam.it/Effemeridi.php).*

Sampling through cameras/microphones/hydrophones will be carried out on a weekly basis, defining a working day of the week with the aim of decreasing interference due to anthropic impact.

- ✓ Parameters to be collected for animal species:

- sampling geographic coordinates, date and time;
- name of the user carrying out the sampling;
- species name;
- number of individuals per species;
- parameters sampled by the weather station;
- parameters sampled by the chemical-physical parameters monitoring station;
- additional notes (hurt or sick animal, reproductive or non-reproductive livery, unusual livery).

✓ Parameters to be collected for vegetal species*
  - sampling geographic coordinates, date and time;
  - name of the user carrying out the sampling;
  - species name;
  - number of plants (if possible);
  - phenological phase of the plant per species (flowering, fruiting, senescence;
  - flowering presence per species (yes/no, number of flowers if possible);
  - fruit presence per species (yes/no, number of fruits if possible);
  - parameters sampled by the weather station;
  - parameters sampled by water chemical-physical parameters monitoring station;
  - green Leaf Index**;
  - additional notes (damaged plant, presence of pollinators, presence of bird nests, etc.).

**Note: sampling of vegetal species will only take place in the sampling unit related to the time slot "The hour from 11.30 to 12.30".*

***Note: in order to compute the GLI save one frame in the sampling unit related to the time slot "The hour from 11.30 to 12.30" and elaborate it according to the prescribed standards.*

All animal and vegetal species will be sampled through cameras (as will be sampled all animal species recognized through the use of microphones/hydrophones), taking special care of animal and vegetal species listed in the attachments to the Habitat Directive (Directive n.92/43/CEE) and the Birds Directive (Directive 79/409/CEE), especially noting non indigenous/alien invasive animal and vegetal species recognized by EASIN (*European Alien Species Information Network;* https://easin.jrc.ec.europa.eu/spexplorer/" https://easin.jrc.ec.europa.eu/spexplorer/). Species listed in conclusive reports for the monitoring carried out in the scope of "activity 1 (A.01)" will also be referred to.

For the environmental abiotic parameters, which are:

- Atmospheric conditions:
  - Rainfall (L/m^2 or mm)
  - Atmospheric pressure (atm)
  - Humidity (%)
  - Temperature (°C)
  - Direct irradiance (W/m^2)
  - Wind velocity and direction (Knots: Kn NSWE)
  - Leaf wetting (hours)

- Water parameters:
    - pH
    - Temperature(°C)
    - Dissolved oxygen (mg/L)
    - Turbidity(Nephelometric Turbidity Unit, NTU)
- Soil parameters:
    - Humidity (%)
    - Temperature (°C)
    - Electrical conductivity (μS)

there are no monitoring forms. These will be replaced by reports documenting the temporal evolution of the monitored parameters, which will be combined with the results of the statistical analysis synthesis (i.e. means, monthly maximum and minimum values). Such information will be crucial for the analysis of correlation with results of the direct monitoring of biodiversity.

APPENDIX A

BIRD MONITORING STATION (SMU)

Instruments	Video camera (with infrared illuminator)	Microphone
Analog date acquisition	Sampling time 5s File «Pointx_date_hour_SMU_V.extension»	Continuously File «Pointx_date_hour_SMU_M.extention»
Digital date transfer	Every hour (with subsequent local cancellation), on Server, folder «Pointx_date_SMU_V»	Every hour (with subsequent local cancellation), on Server, folder «Pointx_date_SMU_M»
	*	*
Raw digital date processing	Use of algorithms for species crossing detection File «Pointx_date_hour_SMU_V_oss.extension», folder «Pointx_date_SMU_V_algo1»	Use of algorithms for species crossing detection File «Pointx_date_hour_SMU_M_oss.extention», folder «Pointx_date_SMU_V_algo1»
date processing processed with passage recognition algorithm	Use of algorithms for species type detection File «Pointx_date_hour_SMU_V_speciess.extention», folder «Pointx_date_SMU_V_algo2»	Use of algorithms for species type detection File «Pointx_date_hour_SMU_M_species.extention», folder «Pointx_date_SMU_M_algo2»
**** Network management (instrument malfunction, current, etc.)***	If no date is received for more than 6 hours, "probable station malfunction" is signaled and maintenance is activated	If no date is received for more than 6 hours, "probable station malfunction" is signaled and maintenance is activated

INSECT MONITORING STATION (SMI)

Instruments	Video camera (with night view and fixed focus and motion sensor with induction of zoom on the subject) equipped with light plate
Analog date acquisition	Sampling time 1 s File «Point x_date_hour_SMI_V.extention»
Digital date transfer	Every hour (with subsequent local cancellation), on Server, folder «Point x_date_SMI_V»
	*
Raw digital date processing	Use of algorithms for species crossing detection. File «Point x_date_hour_SMI_V_oss.extention», folder «Point x_date_SMI_V_algo1»
date processing processed with passage recognition algorithm	Use of algorithms for species type detection. File «Point x_date_hour_SMI_V_species.extention», folder «Point x_date_SMI_V_algo2»
**** Network management (instrument malfunction, current, etc.)***	If no date is received for more than 6 hours, "probable station malfunction" is signaled and maintenance is activated

REPTILE MONITORING STATION (SMR)

Instruments	Video camera (with night view and fixed focus and motion sensor with induction of zoom on the subject) equipped with light plate
Analog date acquisition	Sampling time 1 s File «Point x_date_hour_SMR_V.extention»
Digital date transfer	Every hour (with subsequent local cancellation), on Server, folder «Point x_date_SMR_V»
Raw digital date processing	* Use of algorithms for species crossing detection. File «Point x_date_hour_SMR_V_oss.extention», folder «Point x_date_SMR_V_algo1»
date processing processed with passage recognition algorithm	Use of algorithms for species type detection. File «Point x_date_hour_SMR_V_species.extention», folder «Point x_date_SMR_V_algo2»
**** Network management (instrument malfunction, current, etc.)***	If no date is received for more than 6 hours, "probable station malfunction" is signaled and maintenance is activated

FLORA MONITORING STATION (SMF)

Instruments	Video camera (with infrared illuminator)
Analog date acquisition	Sampling time 6 h File «Point x_date_hour_SMF_V.extention»
Digital date transfer	Every 6 hours (with subsequent local cancellation), on Server, folder «Point x_date_SMF_V»
Raw digital date processing	* Statistical analysis (to evaluate variation, composition and extension). File «Point x_date_hour_SMF_V.extention», folder «Point x_date_SMF_V_algo1»
**** Network management (instrument malfunction, current, etc.)***	If no date is received for more than 24 hours, "probable station malfunction" is signaled and maintenance is activated

WEATHER STATION (SMe)

Instruments	Pluviograph / Temperature sensor / Humidity sensor / Direct irradiance sensor / Anemometer / Barometer
Analog date acquisition	Continuously Files: «Point x_date_hour_SMe_P.extention»/ «Point x_date_hour_SMe_T.extention»/ «Point x_date_hour_SMe_U.extention»/ «Point x_date_hour_SMe_I.extention»/ «Point x_date_hour_SMe_A.extention»/ «Point x_date_hour_SMe_B.extention»
Digital date transfer	Every hour (with subsequent local cancellation), on Server, folder «Point x_date_SMe»
Raw digital date processing	Statistical analysis (minimum, average, and maximum values, for each parameter and for each month). folder «Point x_date_SMe_statistics»
** Network management (instrument malfunction, current, etc.)*	If no date is received for more than 6 hours, "probable station malfunction" is signaled and maintenance is activated

UNDERWATER MONITORING STATION, TYPE 1 (SMQ1)

Instruments	Underwater video camera
Analog date acquisition	Sampling time 1s File «Point x_date_hour_SMQ_V.extention»
Digital date transfer	Every hour (with subsequent local cancellation), on Server, folder «Point x_date_SMQ_V»
Raw digital date processing	Use of algorithms for species crossing detection File «Point x_date_hour_SMQ_V_oss extention», folder «Point x_date_SMQ_V_algo1»
date processing processed with passage recognition algorithm	Use of algorithms for species type detection File «Point x_date_hour_SMQ_V_species.extention», folder «Point x_date_SMQ_V_algo2»
**** Network management (instrument malfunction, current, etc.)***	If no date is received for more than 6 hours, "probable station malfunction" is signaled and maintenance is activated

UNDERWATER MONITORING STATION, TYPE 2 (SMQ2)

Instruments	Underwater video camera	Hydrophone
Analog date acquisition	↓ Sampling time 1 s File «Point x_date_hour_SMQ_V.extention»	↓ Continuously File «Point x_date_hour_SMQ_I.extention»
Digital date transfer	↓ Every hour (with subsequent local cancellation), on Server, folder «Point x_date_SMQ_V»	↓ Every hour (with subsequent local cancellation), on Server, folder «Point x_date_SMQ_I»
Raw digital date processing	↓ * Use of algorithms for species crossing detection. File «Point x_date_hour_SMQ_V_oss.extention», folder «Point x_date_SMQ_V_algo1»	↓ * Use of algorithms for species crossing detection. File «Point x_date_hour_SMQ_I_oss.extention», folder «Point x_date_SMQ_I_algo1»
date processing processed with passage recognition algorithm	↓ Use of algorithms for species type detection. File «Point x_date_hour_SMQ_V_species.extention», folder «Point x_date_SMQ_V_algo2»	↓ Use of algorithms for species type detection. File «Point x_date_hour_SMQ_I_species.extention», folder «Point x_date_SMQ_I_algo2»
**** Network management (instrument malfunction, current, etc.)***	↓ If no date is received for more than 6 hours, "probable station malfunction" is signaled and maintenance is activated	↓ If no date is received for more than 6 hours, "probable station malfunction" is signaled and maintenance is activated

UNDERWATER MONITORING STATION, TYPE 3 (SMQ3)

Instruments	Underwater video camera	Ph sensor/ turbidity sensor/ temperature sensor/ dissolved oxygen meter
Analog date acquisition	↓ Sampling time 1s File «Point x_date_hour_SMQ_V.extention»	↓ Continuously Files «Point x_date_hour_SMA_Ph.extention»/ «Point x_date_hour_SMA_Tb.extention»/ «Point x_date_hour_SMA_T.extention»/ «Point x_date_hour_SMA_O.extention
Digital date transfer	↓ Every hour (with subsequent local cancellation), on Server, folder «Point x_date_SMQ_V»	↓ Every hour (with subsequent local cancellation), on Server, folder «Point x_date_SMA»
Raw digital date processing	↓ * Use of algorithms for species crossing detection File «Point x_date_hour_SMQ_V_oss extention», folder «Point x_date_SMQ_V_algo1»	↓ * Statistical analysis (minimum, average, and maximum value for each parameter and for each month). folder «Point x_date_SMA_statistics»
date processing processed with passage recognition algorithm	↓ Use of algorithms for species type detection File «Point x_date_hour_SMQ_V_species.extention», folder «Point x_date_SMQ_V_algo2»	
**** Network management (instrument malfunction, current, etc.)***	↓ If no date is received for more than 6 hours, "probable station malfunction" is signaled and maintenance is activated	↓ If no date is received for more than 6 hours, "probable station malfunction" is signaled and maintenance is activate

APPENDIX B

MONITORING FORM FOR ANIMAL SPECIES (MONITORING STATION FOR BIRDS, MAMMALS, INSECTS, REPTILES)

Point	Latitude °N	Longitude °E	Sensor	Output data (format)	Date	Hour	Species	N° individuals	Weather	Water parameters	Additional note
									°C: Atm: %: L/m^2: Kn(NSWE): W/m^2: ore:	°C: pH: mg/L O_2: NTU:	

MONITORING FORM FOR PLANT SPECIES (FLORA MONITORING STATION)

Point	Latitude °N	Longitude °E	Sensor	Date	Hour	Species	N° Plants	Phenological moment	Flours	Fruits	Weather	Water parameters	Soil parameters	Additional note
											°C: Atm: %: L/m^2: Kn(NSWE): W/m^2: ore:	°C: pH: mg/L O_2: NTU:	°C: %: µS:	

…														

TABLE GREEN LEAF INDEX – GLI

Point	Latitude °N	Longitude °E	Sensor	Date	Hour	GLI calculation
1						
2						
3						
…						