Cos4Cloud
Co-designing Citizen Observatories Services for the European Open Science Cloud

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 863463

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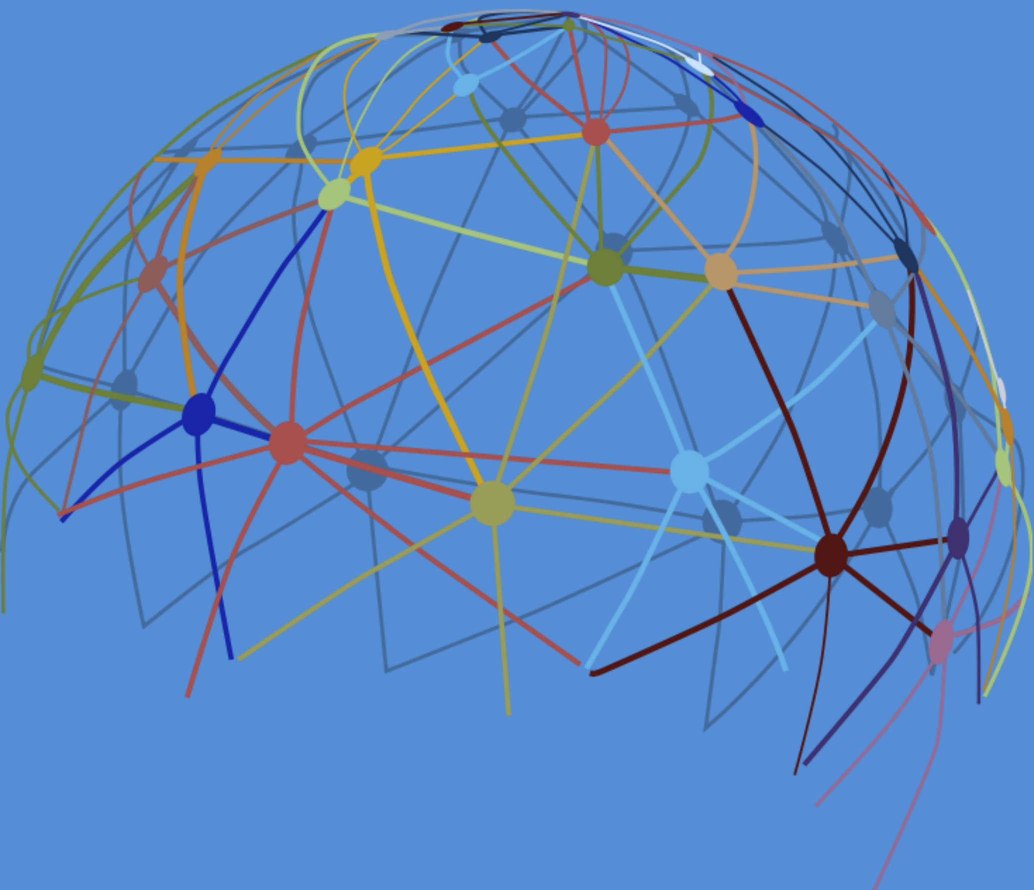

# CITIZEN SCIENCE & ENVIRONMENTAL EDUCATION FOR SUSTAINABILITY

ONLINE
TRAINING
COURSE

ATHENS 2020

**Environmental Education Lab**

**NKUA**

# Module 2

# FROM CITIZEN SCIENCE
# TO CITIZEN OBSERVATORIES.
# SUPPORTING ENVIRONMENTAL PROTECTION
# IN ACTION

**REFERENCE:**

Daskolia, M., & Gkotzos, D. (2020). From Citizen Science to Citizen Observatories. Supporting Environmental Protection in Action. In M. Daskolia (Ed.) *Educational material for the Long Distance Learning Programme "Citizen Science and Environmental Education for Sustainability*", a Cos4Cloud ("Co-designed Citizen Observatories Services for the EOS-Cloud") project. Module 2, pgs. 21-51. Environmental Education Lab, NKUA / EU Project Cos4Cloud ("Co-designed Citizen Observatories Services for the EOS-Cloud") / Centre for Education and Lifelong Learning, UoA.
Available at: https://eclass.cce.uoa.gr/courses/CCEHUMAN121/.

# Contents

## In This Module...

The second module of this learning programme seeks to connect Citizen Science (CS) with Citizen Observatories(CO) in the context of environmental protection, highlighting a central and key field of application of both.

This is initially done by investigating the ways CS can serve as a tool in environmental protection. Later, the definition of COs is provided, and the main aspects and characteristics is analysed. Subsequently, the fields of application of COs and their relation to CS is examined. Finally, the most important COs in Europe are presented. Lastly, the necessity and value of monitoring biodiversity as one of the main fields of application of COs is analysed in the appendix.

All the above are covered in the 2nd module's framework as to answer the following questions:

- ✓ *How can CS contribute to environmental protection?*
- ✓ *What are Citizen Observatories?*
- ✓ *What are the main aspects and characteristics of Citizen Observatories?*
- ✓ *What are the fields of application for Citizen Observatories?*
- ✓ *What is the relation between Citizen Observatories and Citizen Science?*
- ✓ *What are the most important environmental Citizen Observatories in Europe?*
- ✓ *Why does monitoring biodiversity constitute a central focus of Citizen Science?*

## Expected Learning Outcomes - Goals

Upon completing the 2nd module, you are expected to be able to:

- ✓ understand the connection between CS with the promotion of scientific research about the environment and the social contribution towards its protection
- ✓ define what COs are and how they relate to CS
- ✓ list the main characteristics, goals and fields of application of COs
- ✓ cite specific instances of European COs
- ✓ define biodiversity and list factors that constitute a threat to regional and global biodiversity

## Key Words

- Citizen Science
- Active citizen participation
- Citizen Observatory
- Biodiversity Monitoring
- Environmental quality

# 2. From Citizen Science to Citizen Observatories. Supporting environmental protection in action

## 2.1 How can CS contribute to environmental protection?

THe wide scope and complexity of modern environmental issues poses serious **challenges** in the fields of maintaining biodiversity, managing natural resources and environmental quality in general. Most human activities and practices in modern societies bring about important and **rapid** changes to environmental systems. Climate change, urbanization, deforestation, and converting nature into arable land all reduce the ability of ecosystems to sustain life, create a series of dangers for many species of flora and fauna, and degrade the well being and quality of life of human societies (Steffen, Grinevald, Crutzen, & McNeill, 2011).

On the other hand, initiatives to protect the environment are comparably little when compared to the pressures exerted onto ecosystems. Furthermore, in addition to the functions and dynamics of natural ecosystems, social, cultural and political factors that affect them need to be considered in order for these initiatives to be effective. Finally, an essential parameter for any environmental protection initiative is the **active participation of citizens** and their mobilisation/involvement in advocating for and developing sustainable solutions.

CS presents a great opportunity in the effort to combat the various challenges posed to the environment on several levels, and can function as a **"tool" for environmental protection** in several ways (McKinley, Miller-Rushing, Ballard, Bonney, Brown, Cook-Patton, & Ryan, 2017), such as:

(a) the development of scientific and general **knowledge** in the fields of conserving/managing natural resources and environmental protection,

(b) assisting in informed **decision-taking** for environmental policy making at a local, national and international level,

(c) encouraging **public participation** and inspiring citizens to take **interest** and **actively involve** themselves in matters of environmental protection.

**Image 1:** CS in the service of environmental protection

Specifically, a large number of CS programmes involve citizens in essential and applied scientific studies on various ecological and environmental subjects and matters (Dickinson, 2010). Some of these programmes include, for instance, the basic monitoring of basic ecological and environmental indicators, the monitoring of types of endangered flora and fauna, the recording of environmental observations, and providing information on environmental management initiatives. Other programmes focus on environmental issues occurring at a local level, such as identifying the source of pollution in a river. Others yet focus on matters of a global scale, such as climate change and cross-regional movements of population. Through CS, volunteers and amateur scientists involve themselves in **data collection**, as well as the collection of further **scientific observations** in various environments such as forests, grasslands, wetlands, beaches, lakes, rivers, and even neighbourhoods and city gardens.

It's also important to note that many wide-scale researches on environmental issues would not be feasible, if it weren't for the participation of volunteers in actions such as providing scientific information on a long-term basis, taking part in scientific observations over large geographical regions, recording extraordinary events or emergency situations, or reporting the random/sudden appearance or fluctuation in frequency of certain species (Stepenuck & Green, 2015). CS thus facilitates the **conducting of scientific research** and contributes to the **development of scientific knowledge** on environmental matters and affairs. In turn, these can inform the various initiatives and actions regarding **environmental protection, environmental governance,** and **environmental policy.**

**Image 2:** Citizen scientists in action

CS also goes beyond just strengthening scientific research in the aid of developing environmental policy. It also offers opportunities for participation in the development of **new open access environmental knowledge**, which most citizens can approach, understand, and trust (McKinley et al., 2017). Additionally, CS promotes scientific and **environmental literacy in citizens**. This form of literacy is connected equally with scientific, regional, and traditional knowledge. It cultivates and supports **discourse** and **participation in decision making** concerning environmental issues. Through the broader exchange of scientific information, it contributes to the search for further **solutions and synergies** in environmental protection efforts. It **involves and inspires** citizens to actively participate in protecting the environment in two ways: First, directly, when citizens make use of what they learned by participating in a CS programme and can better understand or comment on a government or otherwise administrative decision; Second, indirectly, when they share information in their communities and urge others to get involved in the protection and management of natural resources and the environment, as well as discourse and political decisions.

Finally, CS contributes towards **citizens developing a relationship with the environment**, cultivating their **interest** and **care** towards it (Ballard, Dixon & Harris, 2016). Through citizen's involvement with local environmental protection issues, their **relationship with the land** is strengthened. Citizens are challenged and motivated, furthermore, to set new criteria in relation to their personal choices and habits on matters of environmental care and management. The interest and knowledge that is developed in CS programmes flows down to friends, family, colleagues and other social networks through sharing their experiences in the activity, as well as through discussion of topics highlighted by the experience. This way, more citizens are challenged and inspired to change their stances and habits on matters of environmental protection and management.

**This is an indicative case as to why monitoring environmental quality is a main focus of CS:**

The 1.2 million inhabitants of Brussels do not know much about the air they breathe daily. Let's take, for instance, particulate matter PM2.5. The observation stations that record the levels of this pollutant in Brussels can be quite literally counted with one hand, as they are five in total. However, for a city of over 160 sq.km, these are too few.

Given that public authorities do not seem to intend to inform the citizens of Brussels about air quality - even following submitted complaints made by inhabitants - it appears CS can play an important role. Thanks to the low cost of particulate sensors (a single sensor costs €30), citizens can install one in their homes and thus contribute to creating a dense network of reading points. In Brussels, 400 people have already registered to partake in this programme. Some schools are also registered to participate (see image 3).

The data that will be collected from these devices will provide a precise picture in real time, and also track the spatio-temporal evolution PM2.5. This will help both scientists and city authorities to better understand and deal with pollution by taking relevant actions. Apart from the scientific data collected by the official observation stations, the programme will also function as a way to raise public awareness with regard to air pollution. Through active participation, people become more interested in the issue and understand it better. As a result, it becomes easier for them to take action, such as, for instance, opting for public transport rather than a personal vehicle.

Are these low-cost sensors reliable enough to be used as an air pollution measuring instrument in a city like Brussels? To answer this question, a comparison between their measurements and that of scientific observation stations was conducted. The conclusion was that, although there were slight deviations, general reading tendencies remain the same. This meanings that this particular CS programme can surely contribute greatly towards greater awareness as to where, when and how air pollution in the city increases or decreases, leading to appropriate measures being taken (Dornier, 2019).

**Source: Dornier, P. (2019). How citizen science is helping combat air pollution in Brussels.**

Available at:
https://www.transportenvironment.org/news/how-citizen-science-helping-combat-air-pollution-brussels


**Image 3:** Schools in Brussels participating in the CS programme for particulate PM 2.5

## 2.2 What are Citizen Observatories?

**Citizen observatories** are a new concept and an **emerging reality** that is inextricably linked with CS. In essence, it is an idea that emerged from international organizations and EU environmental policy committees. It seeks to combine participatory observation by members of a community, modern technology, and government structures together for the observation and management of scientific environmental issues by the broader public.

Both the idea and term **"Citizen Observatory"** is recorded, possibly for the first time, in a speech given in 2009 by Jacqueline McGlade, a professor of marine biology and environmental informatics at the University of London, on the role of citizens with regard to monitoring and understanding a changing world. Among other things, McGlade argued that the role of citizens should not be limited to being passively informed by third parties (such as scientists and politicians). Instead, they must **actively participate**, with a mind towards sustainability. in monitoring and recording how their environment is changing. Towards this aim, she invited organizations that support large digital environmental monitoring systems to open their doors to local knowledge, and empower citizens to participate in their activities, themselves monitoring and gathering information and data about their local environment (McGlade, 2009).

As to the meaning of Citizen Observatories, **various definitions** have been suggested, most of which reference their function, means and goals. According to Liu, Kobernus, Broday and Bartonova (2014), the majority of COs are "spaces" of participatory governance, in which citizens collect observations and references with regard to particular environmental issues, making use of digital applications and social media. In another attempt at defining the term, Alan Grainger (2017) includes, under the concept of COs, any use of Earth observation technology, through which citizens collect data and are simultaneously emboldened by the information produced to participate in managing their environment. Additionally, the notion of COs has been approached through the framework of an "ecosystem". Ciravenga, Huwald & Lanfranchi (2013) thus define COs as "*a method, an environment and a technological infrastructure that, all together, create an ecosystem in which citizens, communities, but also specialised institutions converse, monitor and intervene in relation to certain situations, areas and events" (pg.146)*

**Image 4:** Discussion and recording

The European Commission (EC) has played a decisive role in the implementation and development of the concept of COs through the various initiatives promoted over the last decade to strengthen such institutions and services at a political and financing level. According to a definition provided in one of the recent invitations of interest for the support of such initiatives, COs are defined as "community-based systems of information monitoring and management, which utilise new and innovative technological observation applications, connected to or built into mobile or portable devices. Owing to the wide range of information and data that can be collected and made available, COs can provide to relevant authorities the required documentation to inform their environmental policy, supplementing more formal networks and systems of local monitoring and observation, while also aiding all parties involved" (SC5-19-2017).

In the above definitions, certain **common elements** are observed that underly the concept of COs, such as promoting citizen participation in environmental monitoring and management, the bi-directional flow and use of data and information, their complimentary function with more formal systems of environmental observation and recording through citizen-made on-site comments, and the use of modern technology as a basis for achieving this goal.

## 2.3 What are the main aspects and characteristics of Citizen Observatories?

A central aspect in the function of COs is the use of **digital technologies**, both as infrastructure and services provided. More specifically, citizen/user participation in a CO is contextualised and supported by a **digital platform** and the use of **specialised technological equipment** and **tools**, such as fixed or mobile sensors and daily-use mobile devices, as well as specialised software and Web 2.0 applications. These "accessible" digital capabilities permit and support citizen involvement in activities of monitoring, recording and making use of information, such as measuring levels of air pollution or radiation, or calculating environmental danger posed by flooding based on water measurements in a riverbed. These activities are based on **personal, subjective and/or objective observations and recordings,** but also on **information, comments and files exchanged** by CO users for collection, sharing and publication, which are aided by the digital technologies, tools and services used. Through these two basic aspects (a. Open digital infrastructure and services, and b. Personal observations and recordings), COs promote volunteer participation, but additionally, the cooperation and exchange of information in the context of the citizen/user community, which support and strengthen the benefits on a scientific and social level (Morandi, Iacopo, Enrico, Ian & Stewart, 2013 in Montagril & Santos, 2017).

**Active citizen participation** in environmental monitoring is, according to the Finnish Environment Institute (2016), another basic aspect of most active COs. While monitoring is considered a fundamental requirement for environmental protection and management, public education and awareness-raising is also sought after as an aim, providing thus opportunities for meet-ups and cooperation between one community and another, therefore


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creating social capital for sustainability. On this basis, Rubio-Inglesias (2013), highlights the following four **characteristics** as distinguishing features of the operation of COs:

- Citizens are not simply receivers of information, but important transmitters/creators of information produced and shared.
- New opportunities emerge for the role of citizens, such as being given the means to collect, combine and use important information more times, based on the needs and requests posed by them.
- Environmental governance can be supported in more levels, such as through evaluating success of various environmental policies.
- Complementarity with other systems of environmental monitoring is also promoted, greatly strengthening the degree and scope of on-site observations, while also reducing public cost.

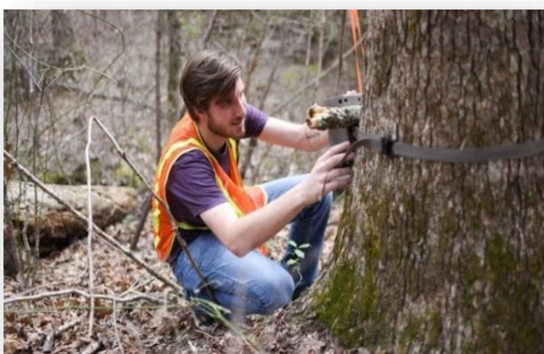

**Image 5:** Citizen scientists in action

Based on the above aspects and characteristics, Liu et al. (2014) propose a **conceptual framework** on the nature and role of COs based on four pillars. Three of them place emphasis on the **bi-directional/collaborative procedures**, supporting functions such as: (a) **Citizen-user participation** through mutual collaboration and with other factors and contributors (scientists, etc.), (b) **bi-directional interactive communication**, and (c) organising programmes and initiatives that adopt models which can move **in both directions** (both hierarchical, top-down models and bottom-up democratic ones). Finally, the fourth aspect (d) pertains to the dual input method of collected information entered into the system. This means data is collected by the citizens themselves (personal observations and recordings, comments, exchanges) but also from sensors and other devices (see Figure 1)

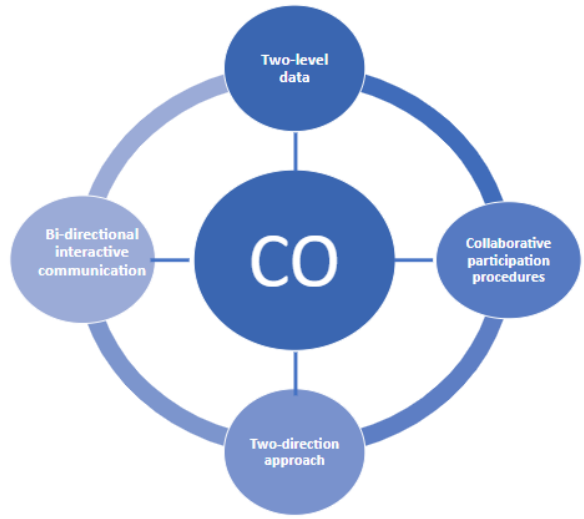


**Figure 1** Conceptual framework of a Citizen Observatory (Liu et al., 2014).

Based on the above, COs constitute initiatives that focus on the broader community and seek to achieve the social change that occurs when citizens become more involved in the collection and exchange of environmental information, through the use of services provided by modern technological developments (such as, for instance, constant connectivity to the Internet, the Internet of Things [IoT], Social Media, cheap and portable sensors etc.). Additionally, COs provide citizens with the opportunity to cooperate, become informed and actively participate in environmental decision taking, to raise awareness with regard to environmental issues, and to contribute to the creation of more resilient societies (Group on Earth Observations).

## 2.4. What are the fields of application for Citizen Observatories?

Thematically, the majority of COs focus almost exclusively on environmental monitoring. However, in more recent years, cases of COs involved in other issues have been recorded. They remain, nevertheless, much fewer. Specifically in Europe, almost 80% of known and recognised COs promote the recording and collection of information on issues such as various species of flora and fauna, biodiversity, air, water, rivers and streams, snow, the sea, precipitation and, naturally, climate change (see Figure 2).

More than 16 European countries actively participate in one of the various types of COs. The United Kingdom is by far the most active country in this domain, hosting 38% of all environmental COs in Europe. Greece is among these 16 countries too, albeit with a small amount of representation (3%). Finally, there is a 15% of environmental COs that are not strictly connected with one country, but with the whole of the EU (Finnish Environment Institute, 2016).

In an attempt to depict the situation regarding various COs, the European project WeObserve suggested the following categorisations based on their field of application (WeObserve, 2018).

## Categorisation of Citizen Observatories based on their field of application

| |
|---|
| **Observatories of city management,** that support decision making on issues regarding city management, such as: transportation, bicycle routes, land usage, energy consumption, surroundings classification, environmental conditions, traffic and parking monitoring, citizen needs and perceptions (Case examples: FixMyStreet, SeeClickFix, VizWiz, Waze, CiclePhilly). |
| **Observatories that collect data about water, rivers, the sea, as well as water quality, precipitation, streams, lakes, snow, ice and sea environments (Case examples:** CURA H20, Järviwiki, Brooklying Atlantis, Lakewatch, CoCoRaHS). |
| **Biodiversity monitoring observatories,** that focus on flora, forests, mountains, biosphere and trees (Case examples: Plant Watch, Leaf Watch, iNature, Mountain Watch). |
| **Air and spectrum monitoring observatories,** meaning observatories that gather data about air quality, noise, sounds, and radiation, especially in cities (Case examples: Common Sense, SafeCast, Noise Tube, CitiSense, Bucket Brigades). |
| **Observatory tools for creating monitoring projects,** involving tools that are useful for the creation or integration of citizen observatories, such as: configurable citizen observatories (plug-and-play tools), image classification components and sensor-monitoring components (Case examples: Glassnost, Ushahidi, CitSci, Public Lab). |
| **Global monitoring observatories,** on issues of astronomy and climate change, that seek to monitor global trends (Case examples: Galaxy Zoo, Spring Watch, GLOBE at Night). |
| **Disaster and crises observatories,** that focus on, for example, earthquake monitoring and their early detection (Case examples: iShake, Did you feel it?). |
| **Land-use observatories,** that deal with issues of land use, land cover, and change in land use or land, in both rural and urban settings. |
| **Commodity-based monitoring observatories,** that focus on economic, social or environmental cover value, such as fisheries and forestry activities. |

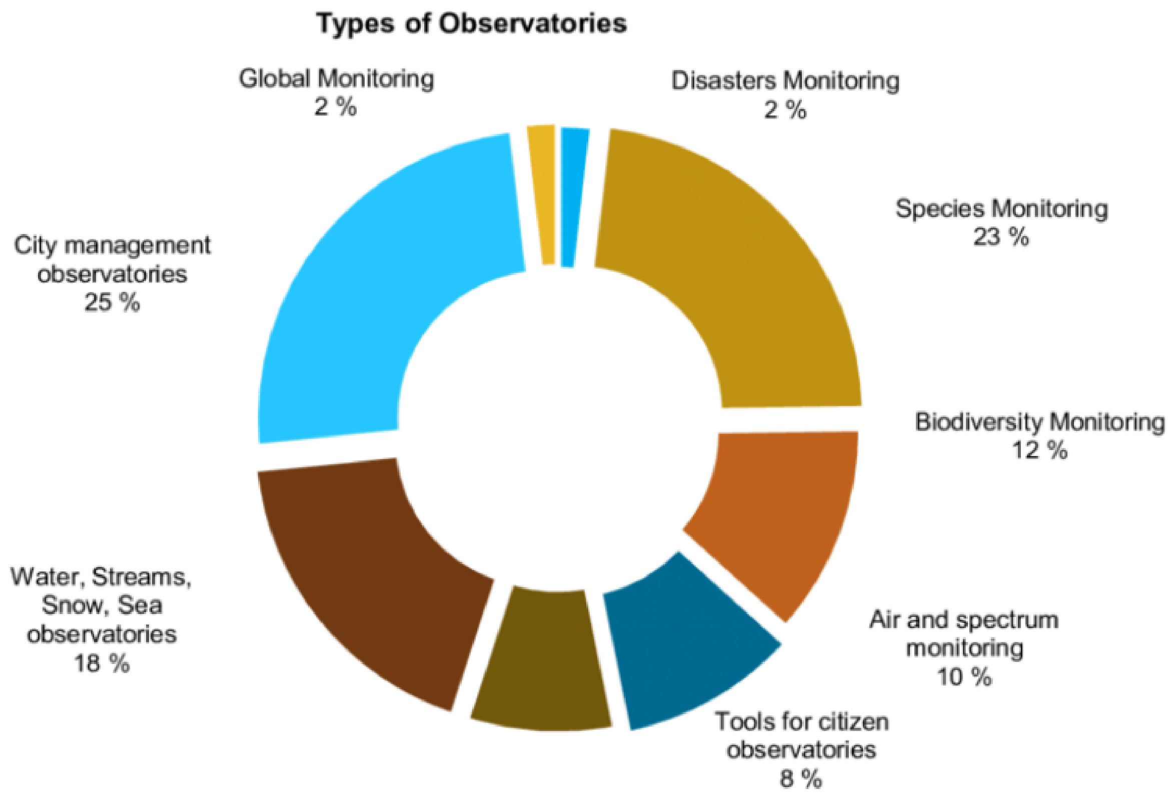


**Figure 2:** Types of Observatories (Palacin-Silva et al., 2016, in WeObserve 2018)

## 2.5. What is the relation between Citizen Observatories and Citizen Science?

CS could be broadly defined as "making science accessible to society" and "promoting citizen participation in scientific research". More specifically, and as noted in Module 1, **the demand to democratise science** has been documented since the 1970s. A well-known representative of this current is science philosopher P.K. Feyerabend, who argues that the monopoly on research by universities, companies and large institutions is contrary to the interest of science, which has a long history of involving ordinary citizens. As he notes in one of his characteristic aphorisms: "Everywhere, science is being enriched with non-scientific methods and non-scientific results" (in Liu et al., 2014). However, several attempts between 1970-1990 to get ordinary, non-scientific citizens involved in research, proved to be fruitless.

With the advent of the new millennium, demand returned in an updated form, as the desire to promote active societal participation in science. In response to this, the European Union, through the project SOCIENTIZE (2012-2014), creates a joint forum of cooperation between IT infrastructure providers and service providers for CS. In this forum, each user interested could participate in the scientific process. The "Green Paper on Citizen Science" emerged from this project, which constituted a roadmap for the development and implementation of CS in Europe. It's publication lead to a series of further initiative, out of which **CS became interlinked with the notion of "democratic participation of society in scientific research".**


**Image 6:** CS Promotional poster

On the other hand, COs realised an idea emerging from EU environmental governance and policy circles; an attempt to practically combine participatory monitoring, use of technology and strengthening government structures in order to record and manage the environment. **Active participation of ordinary citizens** through COs is promoted, essentially, as the key to protecting the environment. A crucial drawback of traditional forms of environmental monitoring (e.g., satellites and on-site observation in official research networks) is the lack of active participation and immediate experience by citizens on issues that concern them, a factor that also obstructs their participation in decision-making processes in their community. **The development of COs as an institution**, therefore, **constitutes an important step in bridging the gap between environmental knowledge and active participation in environmental governance and citizens** (Liu et al., 2014).

In the context of both CS and COs, citizen-volunteers participate in scientific research or monitoring programmes, while being guided towards playing an active role in data collection processes and/or the commenting, sharing and information exchange, towards approaching specialists who will answers their questions, and towards they themselves contributing towards greater understanding and decision-making on issues that are of concern to their community.

Additionally, through the specialised services offered, they seek to invite, host and support voluntary participation and action/observation by citizens. The relation between CS and COs is described through three versions
(see Figures 3a,3b,3c based on the discussion at CoP Launch Workshops - Geneva, 2018):

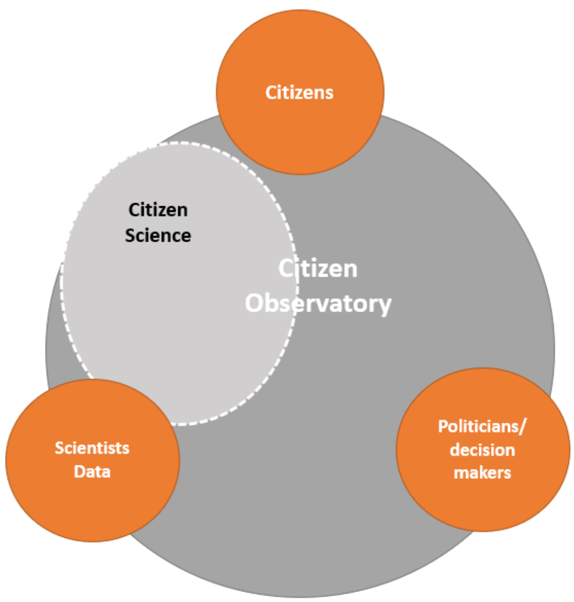


**Figure 3a:** CS as a concept underlying that of COs

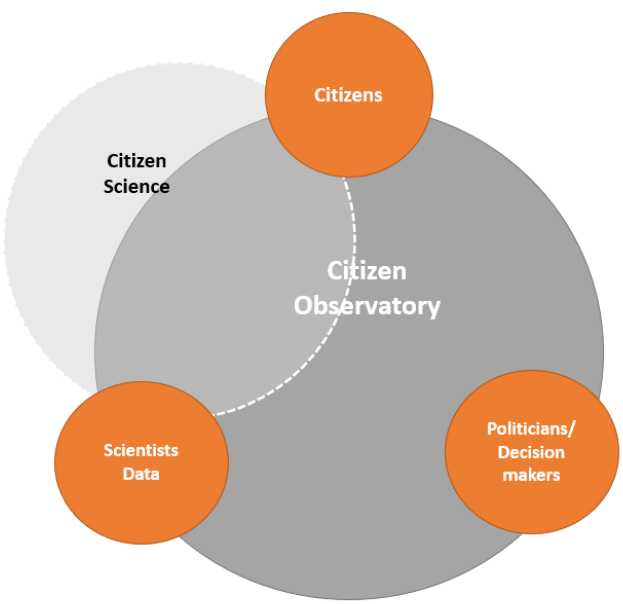


**Figure 3b:** Commonalities between the concepts of CS and COs

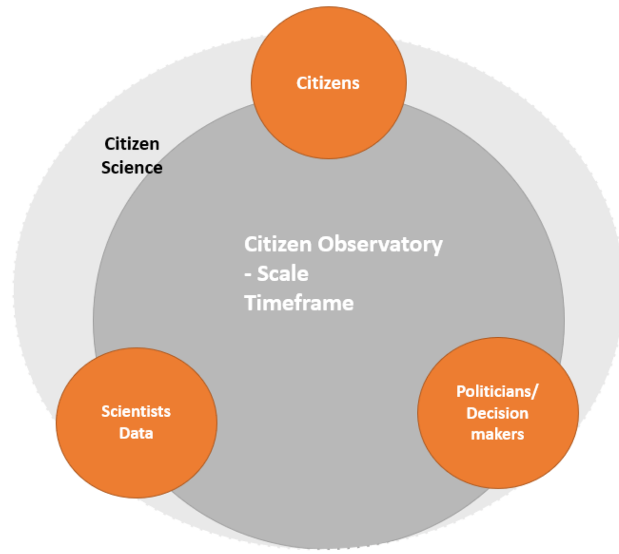


**Figure 3c:** CS as a concept overlapping that of COs

According to the first version, CS is a **concept underlying that of COs**. Although it is included entirely in the scope of COs, it is but one part of it, distinct but limited. Specifically, it is connected with data collection procedures on the citizen's part within a scientific research framework, enacted under the responsibility of certain scientists or scientific groups, but always within the scope of COs.

According to the second version, there are **commonalities between the concept of CS and COs**, that, like in the previous version, are about citizen/scientist participation and common research projects, and also include data collection and analysis. Each of the two, however, have a field of activity that operates separately from the other. In both the first and second version, the concept of COs is naturally broader than that of CS, since it's connected with empowering citizens to participate in decision-making and policy.

Finally, according to the third version, **the concept of CS overlaps that of COs**. COs field of operation is included entirely in that of CS, with COs being a big (perhaps even main) part of the field of CS, and a dominant expression of CS. There are however, other CS actions and initiatives that are not included in the work and operation of COs. We could therefore say that CS infrastructure is delimited as COs on the basis of their focus (mostly monitoring the environment), the scale of their activities (mostly local) and the time frame for their implementation (mostly long-term) (WeObserve, 2018).

In essence, **the idea behind both is common**: Both through various CS programmes and CO framework, citizens are called and empowered to participate, with the goal of them playing an active role in the collection of significant information that will allow better understanding and management of these issues, alongside raising awareness, improving participation and supporting decision-making. Grainger (2017, pg. 5) notes that **COs differ from CS** in the following two aspects:

a) Information gathered and created in COs must, by definition, **directly benefit citizens and society** at large, as opposed to science alone, as happens in many of the more conventional CS programmes.

b) Organizationally, **COs constitute more elaborate structures and procedures compared to CS programmes**. Owing to greater citizen participation from the starting phases, most COs are conducive to co-creation and participation to a greater degree on the citizen's part, and in more ways than merely contributing to data collection.

## 2.6. What are the most important environmental Citizen Observatories in Europe?

The European Union supports the establishment and operation of COs, which are considered supplementary to the long-range satellite technological systems and scientific programs for the observation of the usage and quality of the environment. Apart from the basic data collected through them, great importance is also attached to the further data collected in situ by the observations made by citizens themselves through COs and the crowdsensing services they possess, strengthening global databases and the potential for assessment, prevention and handling of situations. (Montagril & Santos, 2017).

In recent years, a series of COs has been established across Europe, mainly within the framework of **projects funded by the European Commission (EC)**. For instance, in an attempt to strengthen European citizens' ability to participate in the observation of the environment, the EC supports, through the Seventh Framework Programme, the following five projects: Citclops, CITI-SENSE, COBWEB, OMNISCIENTIS and WeSenseIt. Through these, corresponding COs with a clear environmental orientation have been established. However, the serious issue of continued CO operations when funding expires remains. The cost of maintaining and developing the services provided is somewhat high, and often as a result of this, the end of funding results in the suspension of their operations.

Further down, we present more information on these five COs:

The CO established within the framework of the **OMNISCIENTIS** project works to combine citizens' active participation with the application of innovative technologies, having the aim of improving the handling of unpleasant scents. This type of pollution is not easy to monitor or manage, since its perception has to do with a human sense, smell, and presents a significant level of subjectivity. The monitoring programmes was carried out in three locations (Brussells, Virton, and Angiers), in communities close to activities that produce odours (from industry, agriculture, sewage treatment and chemical installations). Participants had access to an online form, in which they reported their perceptions on the type of odour (on a nominal scale with five categories), the intensity of the odour (on a three-point scale), and the degree of unpleasantness they suffered (on a four-point scale). They also reported the location, date, and time of the observation. A mobile phone application developed for this purpose (OdoMap,https://apkpure.com/odomap/com.spacebel.odoMap) (see Image 2) was used in order to enable the participants to report their impressions of odours, using a procedure similar to that on the website (Liu et al., 2017, Montagril & Santos, 2017). The coordinating body for this project and the CO was the Belgian company Spacebell SA, with the participation of Odometric SA (Belgium), KKT-IMA SARL (France), APS Technology SCRL (Belgium), the University of Liège (Belgium), the Graz University of Technology (Austria), BURGO Ardennes SA (industry – final users, Belgium), the Inter-Environment Wallonie (NGO – final users, Belgium) and the Public Research Centre Henri Tudor (Luxembourg) (OMNISCIENTIS, n.d).

**COBWEB** (Citizen Observatory WEB) is a citizen observatory established by a partnership led by EDINA, the UK's National Data Centre, which is owned by the University of Edinburgh (Liu et al., 2017). The other participants of this joint partnership were: from Germany, the Dresden University of Technology and the company Secure Dimensions GmbH; from Holland, the company GeoCat BV; from the United Kingdom, Aberystwyth University, the Ecodyfi organisation and Environment Systems Ltd; from Ireland, the University College Dublin; and from Greece, the University of Patras and OikoM Environmental Studies Ltd (OIKOM). COBWEB allows other institutions or organised groups to undertake CS research using Android mobile devices. With this aim in mind, a series of software applications have been developed, to support the development of a questionnaire, the realisation of research, the storage of data, and the visualisation of data from georeferencing.

Thus, a group of people who wish to carry out a study in a particular field of CS may make use of the software resources available through COBWEB. On a trial basis for its research, the project was supported by cooperation with UNESCO's Network of Biosphere Reserves; however, the software and applications are available to any user who wishes to test their idea and develop their own research. COBWEB has also developed a collection of tools that can be used by other COs and CS programmes for the development and management of their own researches.

The **Citclops** project aims to develop a CO based on CS applications for the bio-optical observation of coasts and seas (http://www.citclops.eu) (see Image 7)

This allows the classification of natural waters (rivers, estuaries, coasts, open sea etc.). Using EyeOnWater, a geographical application for mobile phones (http://www.eyeonwater.org) the user can take photographs, pointing the camera at the surface of the water while following a few simple rules. The user takes a photo, selects the correct colour of the water from a scale, according to their own impression, and then submits the information. The system later automatically calculates, from the image, an FU index value (an indicator of the level of microscopic plant life, sediment and dissolved organic material in the water). Access to the data deriving from the users' measurements can be found at www.eyeonwater.org (Liu et al., 2017: Montagril & Santos, 2017). This project is the result of joint action, with the participation of partners from academic institutions and technology centres (BDIGITAL - Spain, CSIC - Spain, UNIOL - Germany, NIOZ - Holland and VU-VUmc - Holland), industry (Kinetical -Spain, TriOS, MARIS - Germany and NOVELTIS, France) and end-user organisations (TCD-Coastwatch - Ireland and Deltares, Holland) (Citclops, 2020).

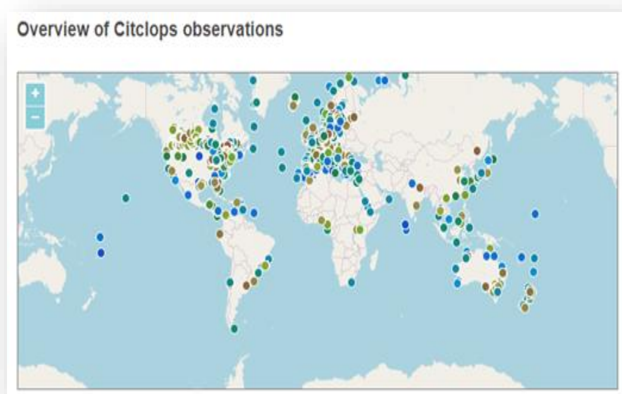


**Image 7:** Map of Citclops observations

The CO created by the **WeSenseIt** project emphasises the ability off citizens actively involving themselves in data collection, evaluation and communication with regard to the marine environment, including flood danger (https://www.wesenseit.com/). It is the product of joint action headed by the University of Sheffield, with the participation of Hydologic Research (Holland), the IHE Delft Institute for Water Education (Holland, affiliated with UNESCO), the Disdro company (Holland), the Starlab company (Spain), and the water supply company Delfland Water Authority (Holland) (WeSenseIt, 2020).

WeSenseIt allows users (i) to share information before and during floods (such as flood warnings or roads closed by flooding), (ii) to access information on these matters shared by other users, and (iii) to access regularly updated information gathered by sensors.

While the aforementioned COs may be considered as oriented towards the observation of natural resources, WeSenseIt focuses on the management of dangers and urgent needs This may well be accompanied by a different evaluation, on the part of users, of the value of the data, depending on the frequency of the untoward events. The project chose to focus on three case studies, one in Doncaster (United Kingdom), the second in Delfland (Holland), and the third in Vicenza (Italy).

Through an android application, users can share information with regard to (i) floods and flood hazards, (ii) community life, and (iii) the sensors. The sharing of the information takes the form of a report, and after users complete a form on which they give the title of their report, they provide a brief description, assign a category to the report (closed road, closed bridge, etc.), note the date, time and location of the event, and may also include a photograph or a URL address. If users choose to share information under the selection "Community life", they will have access to a form for the sharing of a post within the application, with fields for the title, description, date, time and location.

WeSense thus allows the filing of data from two different sources: One, from sensors, and two, from the forms that users can utilize to describe an event. Both may be considered objective measures, as the form does not include questions on the users subjective impressions (such as the perception of danger that might follow a flood warning). Rather, it attempts to evaluate objective variables. WeSense also uses social media (Facebook and Twitter) for the propagation of data and the participation of the community.

**Image 8:** Presenting CITI-SENSE's activities to students in Ljubljana

**CITI-SENSE** aims at empowering citizens to take part in environmental governance by developing various services in support of COs for the measurement of air quality, both in outdoor spaces and indoors in schools, and for the perception of the environment in public places (http://www.citi-sense.eu).

The project included pilot schemes in eight cities (Barcelona, Belgrade, Edinburgh, Haifa, Ljubljana, Oslo, Ostrava and Vienna). However, it also permitted users in other locations to use the available applications and access data. CITI-SENSE provides the possibility of monitoring air quality by means of a personal toolkit, which comprises of (i) a portable sensor unit (measuring temperature, relative humidity, nitric oxide, nitrogen dioxide and ozone, georeferentially), (ii) an Android application that connects to the sensor unit, allowing the reading of data and their transfer to the server, and (iii) a computer application for the control of the sensors.

A user may, for instance, transport the sensor unit attached to a jacket or a belt. The user's Android smartphone can then connect to the sensors through Bluetooth, read the data, and store them on the CITI-SENSE platform. The measurements give an indication of the levels of air pollution and provide information about any changes, even though the measurements are not compatible with those previously carried out by the authorities (Liu et al., 2017, Montagril & Santos, 2017). CITI-SENSE is a joint action by 29 partners (complete list can be found at: https://co.citi-sense.eu/TheProject.aspx). The CITI-SENSE CO gateway at https://co.citi-sense.eu/ is designed not merely to allow citizens to have access to environmental data in real time, as provided by a large number of inputs from applications and sensors (including both portable and static sensors, applications on mobile 'phones, and various studies of perceptions of air pollution), but also to provide a forum for discussion and common use of individual observations.

The above five projects were designed independently from one another. However, they have important similarities as to their structure, function and methodology in relation too their communication with citizens. Additionally, there was cooperation between them in (a) the facilitation of the exchange of data, knowledge and success stories, and (b) the establishment of common methodologies and models for crowdsourcing (Liu et al., 2017, Montagril & Santos, 2017).


**Image 9:** Smartphone application for the measurement of air quality

## To sum up…

In this second module of the learning programme, an attempt was made to link CS with COs, focusing on environmental protection. The ways in which CS can contribute to environmental protection, and particular with regard to monitoring biodiversity, was explored. The concept of COs was defined. Furthermore, a review was provided of their basic aspects and characteristics. Additionally, the relation of COs and the fields of applications with CS was examined. Finally, a selected presentation of certain established COs operating at a European level was provided.

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The term "biodiversity" refers to the variety of lifeforms on Earth. The term covers "all organisms, species and populations, the genetic variation among these, and the complex assemblies of communities and ecosystems" (UNEP, 2010). The **value of biodiversity** is immense and multi-dimensional, and has been much studied. Specifically, the individual components of biodiversity – genes, species and ecosystems of direct, indirect or potential use to humanity, which are referred to as "**biological resources**" – offer a wide range of benefits and facilities to society. Examples of such cases are hybrids used by agriculturalists for the development of new crop varieties, species used in various foods, medications and industrial products, and ecosystems that provide such benefits as water purification and flood control (National Research Council, 1999).

**Image 10:** "Biodiversity" expresses the variety of species on Earth

However, in our times, biodiversity faces some very serious **threats and pressures**, with about one species in four in danger of extinction. Various **human activities** constitute serious threats to a large number of species, endangering biodiversity, as shown in Figure 4.

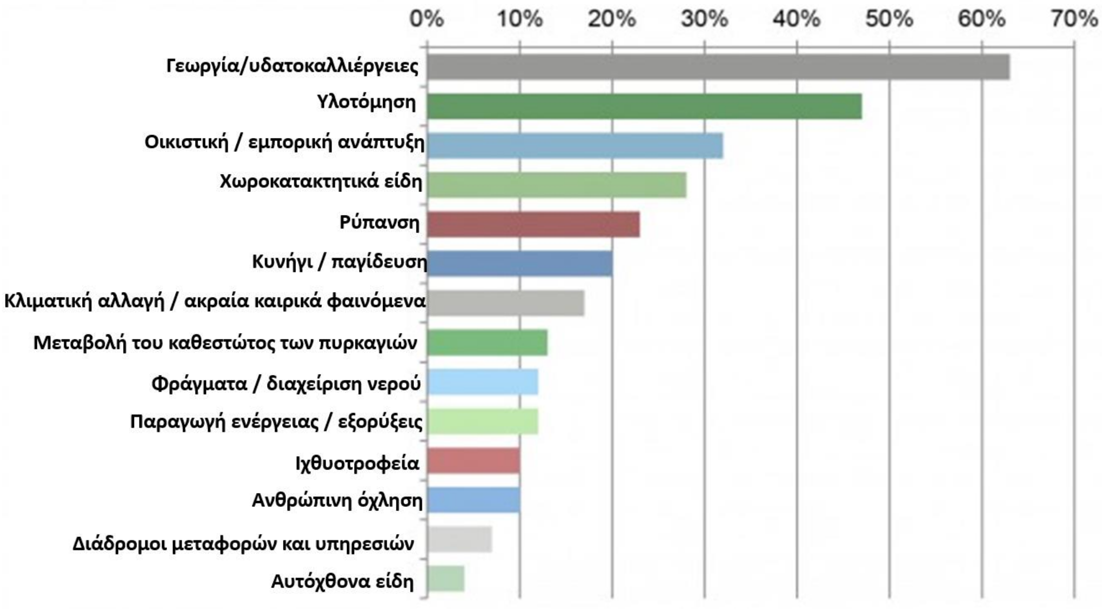


**Figure 4:** Main threats to biodiversity and the percentage of species endangered (UNEP, 2012, pg. 139).

More specifically:

- There are many factors that may threaten **terrestrial biodiversity**, such as changes in the use of land, habitat disturbance, intensive exploitation, invading species, ground compression, erosion, and pollution.
- As for drinkable water, the poor ecological state of many **freshwater ecosystems** is a cause of global concern, since these systems contribute to ensuring the availability of clean water, which may face shortages in the future.
- **Marine biodiversity** is another vital sector, connected with exploitation of fish stocks, food chains, and the integrity of the deep seas.
- **Agrobiodiversity** may be threatened by the increasing intensity of farming practices (increased use of agrochemicals, simplification of crop rotations, increasing the cultivated area, deterioration the natural features of the locality, etc.), as well as by neglect of the land. Specifically worries about the conservation and quality of agrobiodiversity have been among the concerns of the Common Agricultural Policy (CAP) since the early 1990s, that aims to mitigate the consequences of the factors that cause its loss. Moreover, it has set as an aim that the agricultural industry should be advised on the preservation of biodiversity and the important services offered by ecosystems (such as pollination, control of parasites and limitation of erosion), while at the same time reducing certain negative consequences (washing away of nutrients, emissions of greenhouse gases, etc.).
- Reductions in **woodland biodiversity** leads to losses in the productivity and viability of woodland ecosystems. Woodland ecosystems cover almost 40% of Europe's surface. Apart from providing wood, woodlands offer many benefits for climate control, human health, recreation, fresh water resources and biodiversity pools. Woodland ecosystems and the biodiversity of species that develop inside of them are interconnected; biodiversity is, to a great degree, dependent on the integrity, health and vitality of wooded areas. Sustainable woodland management, therefore, aims to support the provision of woodland goods and services and to increase levels of biodiversity.
- **Invasive species** are another cause for concern. Human activities, such as shipping, aquaculture, the construction of canals and trade, have removed some of the natural barriers between bio-communities, allowing species to subsequently enter regions to which they are not indigenous. Europe is greatly afflicted

by such biological invasions, which are considered one of the most significant direct factors in loss of biodiversity, and place great strain on various kinds of ecosystems, with both ecological and economic repercussions.

In Table 1, below, an overall picture is provided as to the pressures and threats to biodiversity in Greece.

<table>
<tr><th rowspan="2">Pressure-threat category[59]</th><th colspan="8">Number of species</th></tr>
<tr><th>Plants[60]</th><th>Birds[61]</th><th>Amphibians[62]</th><th>Serpents[63]</th><th>Land mammals[63]</th><th>Sea mammals[63]</th><th>Sea fish[63]</th><th>Freshwater fish[63]</th></tr>
<tr><td colspan="9">1. Residential expansion. Industrial and tourist development</td></tr>
<tr><td>Residential expansion and industrial development</td><td>6</td><td>60</td><td>6</td><td>6</td><td>14</td><td></td><td></td><td>26</td></tr>
<tr><td>Development of coastal tourist infrastructure</td><td>33</td><td rowspan="2">30</td><td rowspan="2">5</td><td rowspan="2">5</td><td>2</td><td>1</td><td></td><td></td></tr>
<tr><td>Development of non-coastal tourist infrastructure</td><td>11</td><td>13</td><td></td><td></td><td>5</td></tr>
<tr><td colspan="9">2. Agriculture, fishing and aquaculture</td></tr>
<tr><td>Expansion and intensification of agricultural crops</td><td>16</td><td>89</td><td>7</td><td>6</td><td>9</td><td></td><td></td><td></td></tr>
<tr><td>Woodland plantations</td><td></td><td>11</td><td></td><td>3</td><td>6</td><td></td><td></td><td></td></tr>
<tr><td>Livestock (over-grazing)</td><td>50</td><td>39</td><td>1</td><td></td><td>2</td><td></td><td></td><td></td></tr>
<tr><td>Aquaculture (sea)</td><td></td><td>4</td><td></td><td></td><td></td><td>1</td><td></td><td></td></tr>
<tr><td colspan="9">3. Energy production and mining</td></tr>
<tr><td>Mining</td><td>11</td><td>16</td><td>1</td><td>2</td><td>2</td><td></td><td></td><td>3</td></tr>
<tr><td>Energy production from renewable sources (non-hydroelectric)</td><td>17[64]</td><td>23</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="9">6. Transport, energy and telecommunications networks</td></tr>
<tr><td>Roads</td><td>21</td><td>45</td><td>1</td><td>8</td><td>13</td><td></td><td></td><td></td></tr>
<tr><td>Energy and telecommunications networks</td><td></td><td>23</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

**Table 1** Pressures and threats to biodiversity in Greece (YPEKA, 2014, pg. 54)

**Protected natural areas** are an essential condition for the conservation of biodiversity and ecosystems, so their extension is a central aim not only of the European Union but also of the United Nations They are, moreover, of particular importance in developing countries, where the population is highly dependent on natural resources. The international community has committed itself to the protection of at least 17% of land area and inland waters, and 10% of coastal and sea areas by 2020 (Joint Research Centre, 2015).

The range and variety of threats and pressured that biodiversity faces in the present make **monitoring** and **recording** a necessity, to swiftly identify the changes that are occurring as a result, and to plan relevant interventions. Finally, it is worth noting that this monitoring/recording of biodiversity functions as an indicator of environmental quality, and is also useful in the observation and prediction of the evolution of climate change. For these reasons, Citizen Science has positioned biodiversity among its central objectives, while its monitoring and recording is one of the most frequent fields of application for CS (See Image 11) Existing and planned projects in many COs, and the results of their trial runs, demonstrate that they have the potential to complement official networks for the local observation of biodiversity and contribute to European measures and policies, in sectors that range from water management and the protection of air quality, to the preservation of endangered species or the observation of climate change (Liu et al., 2017).

**Image 11:** Citizen Science supports oceanographic research projects that help enrich our understanding of the world's oceans, through technological innovations, smart observation and analysis, and an open exchange of information (World Ocean Observatory, 2019).

In **Greece,** there is the **Hellenic Biodiversity Observatory (EPB)** https://www.biodiversitygr.org. The idea behind it was the ability of voluntary participation of not only of scientists but also of citizens, who can provide data and information near their homes. It is worth noting that the EPB deals with the observation and recording of all species and not only some specific species (ex. endangered species). The following are listed as the objectives of the EPB (Hellenic Biodiversity Observatory):

- ✓ Conservation of wildlife and biodiversity
- ✓ Observation and recording of biodiversity
- ✓ Care for and reintegration of wild animals into the environment, and
- ✓ Promoting ecological awareness towards wild creatures and Greece's environment.

Four of the largest Cos for biodiversity participate **in the European programme Cos4Cloud**: **Natusfera** https://natusfera.gbif.es), **iSpot** (https://www.ispotnature.org), **PlantNet** (https://plantnet.org/en) and **Artportalen** (https://www.artportalen.se) (CREAF, 2020).

Some other biodiversity COs that focus on flora, forests, mountains, the biosphere, and trees are:

- ✓ **PlantWatch** https://www.naturewatch.ca/plantwatch in Canada, which allows citizen scientists to participate by recording flowering times for selected plant species and reporting the dates of the recordings to researchers working to identify ecological changes that may affect the environment (Naturewatch, 2020).
- ✓ **LeafWatch** https://gastateparks.org/LeafWatch is directed at residents of the U.S. State of Georgia, and invites them to visit and photograph the Georgia's state parks. The best photos are displayed on the abovementioned website, but citizens are also encouraged to upload and share their photos and stories to the Georgia State Parks' Facebook and Instagram accounts, as well as on Twitter, under the hashtag #GaLeafWatch (Georgia Department of Natural Resources, 2020).
- ✓ **Mountain Watch** https://scistarter.org/mountain-watch is one part of the ongoing South Carolina project of the same name, which monitors seasonal plant growth (known also as phenology) of a small set of alpine and forest plants in the Eastern Appalachian Mountains and other north-eastern regions of the U.S.A. (SciStarter, 2020). (SciStarter, 2020)

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