

NAVARINO
ENVIRONMENTAL
OBSERVATORY

ANNUAL REPORT

2020



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Foreword

When we entered 2020, the assumption was that it would be yet another year to continue the development of the NEO collaboration, not least with a new long-term collaborative agreement with the three founding partners in place. This included current research activities but also the development of new proposals, monitoring programmes, workshops and seminars as well as many visits by student groups and researchers taking advantage of the beautiful and, from so many dimensions, amazing environments of Messinia. However, that all changed with the arrival of the pandemic in March 2020. The impacts on societies have been sometimes overwhelming, not least evident in Greece with so much of the economy built around tourism.

Not everything came to a standstill, as is evident with this annual report. The NEO collaboration stands strong, and with the small but dedicated group of NEO colleagues, a substantial part of the planned activities for 2020 continued. Ongoing research collaborations adjusted to the new circumstances and could continue more or less as planned. A further positive development in 2020 was that NEO became part of the European Civic University network (CIVIS) in Solid Earth System Dynamics, formed by the alliance of eight leading research higher education institutions. During 2020, researchers with a connection to NEO have been involved in the publication of 24 research articles in international journals. An impressive achievement. Monitoring activities continued as planned, which is essential to ensure the availability of reliable and high-quality data from the region. Some meetings, visits and seminars were organized before the pandemic struck, and additional events were arranged virtually throughout the year.

The pandemic will hopefully soon be over. The NEO collaboration, however, focuses on the many other fundamental challenges facing our societies. Climate change, water scarcity, biodiversity loss and unsustainable natural resources use all represent examples of a growing environmental crisis that must be addressed in the coming decades. Just as with the pandemic, reliable data and science-based decision-making are fundamental components of efficient strategies to meet the environmental crisis, from the local to the global level. Collaboration among key actors, where NEO serves as a good example, is more important than ever.

I would like to take this opportunity to thank all those that have been engaged in NEO activities in 2020 and I welcome you and many new partners to continue working with us in the years ahead.



Johan Kuylenstierna
Chairperson of the NEO Steering Committee

What is NEO?

The **Navarino Environmental Observatory (NEO)**, is a Mediterranean hub for research and education where science, business, society and policy-makers join in a pioneer cooperation to create a more sustainable future under a changing climate. NEO is an international partnership between **Stockholm University**; **Biomedical Research Foundation of the Academy of Athens**; and **TEMES S.A** (Tourism Enterprises in Messina, SA), resulting from a collaboration between the academic community and the private sector. The NEO field station is located at Costa Navarino, Messina, Greece, and is open to researchers and students from collaborating institutions and other universities from Greece and abroad, as well as to other interested societal stakeholders who are willing to share their challenges and contribute to solution developments.

In addition to the research taking place at NEO, emphasis is given to the education and training of students and young researchers. Workshops and events, such as Café-NEO (scientific café), are organized to promote research outcomes, to bridge the gaps between societal actors, and to bring together academics, corporates, policy-makers and society members to discuss important environmental issues of local, regional and global interest. NEO turns research on associated social and environmental challenges and climate change into actions.

NEO Structure

The *NEO Steering Committee* (NEO SC) consists of a chairperson and two delegates from Stockholm University, two delegates from Academy of Athens and two delegates from TEMES SA (Figure 1).

NEO management consists of the NEO director (Dr. Zahra Kalantari, Associate Professor in Land and Water Resources Engineering, and Research Area Leader of Bolin Centre for Climate Research, Department of Physical Geography, Stockholm University), the NEO Manager (Giorgos Maneas, PhD student at Department of Physical Geography, Stockholm University), and NEO assistant (Christos Pantazis, National Observatory of Athens). In 2020, the NEO operations were strengthened with the recruitment of Dr Samaneh Seifollahi and Dr. Carla Ferreira, who are both postdoctoral research fellows at Stockholm University.



Figure 1: Structure of the NEO Steering Committee (2020).

NEO Associated Members and networks

Since its start, NEO has gained several associated members, academic colleagues with whom NEO collaborates (Table 1). The aim is to welcome more associated members namely from the private sectors.

NEO is a member of **ACTRIS**, the European Research Infrastructure for the observation of Aerosol, Clouds and Trace Gases; **GWEN**, a Global Wetland Ecohydrology Network; and **LTER-Greece**, the Greek Long-term Ecosystem Research Network which is a collaborative network of scientists and their stakeholders engaged in long-term, developing site-based ecological, social and economic research in Greece. In 2020, NEO became part of the European Civic University network (**CIVIS**) in Solid Earth System Dynamics, formed by the alliance of eight leading research higher education institutions aiming to bring together a wide community of students, academics and researchers.

Table 1: NEO Associated members	
Affiliation	Location
National Observatory of Athens	Athens, Greece
Environmental Chemical Processes Laboratory (ECPL), Dep. of Chemistry - University of Crete	Iraklion, Greece
Laboratory of Atmospheric Physics (LAPUP), Dep. of Physics - University of Patras	Patras, Greece
Laboratory of Climatology, Climate Dynamics and Climate Change, Dep. of Geography - Justus Liebig University Giessen	Giessen, Germany
Laboratory of Archaeometry, Dep. of History, Archaeology and Cultural Resources Management - University of Peloponnese	Kalamata, Greece
Soil and Water Lab, Dep. of Biological and Environmental Engineering, Cornell University	Ithaca-NY, USA
Laboratory of Tree-Ring Research, University of Arizona	Tucson, USA
Department of Geography, Johannes Gutenberg University	Mainz, Germany
Department of Archaeology and Ancient History, Uppsala University	Uppsala, Sweden

2020 NEO activities at a glance

Compared to previous years, **2020** was a distinct year for NEO as we hosted very few activities due to the COVID-19 pandemic (Table 2). All the events were cancelled from March and onwards, affecting 86% of the field courses (6/7), the Hellenic Association Aerosol Research (HAAR) summer school, 67% of the workshops and meetings (4/6), and 100% of the field work campaigns planned (2/2). With the expectation that the pandemic situation will improve in the future, some of the visits at NEO are already rescheduled for 2021.

In January 2020, two events took place at NEO, the annually *LTER-Greece* meeting and the visit from *Sivitanideios Public School* students. In February 2020, more than 40 scientists (professors and researchers) from India participated in the 3rd *AdapNET* training workshop entitled “Climate Change and Agriculture”, which was held with NEO’s support and contribution. In March 2020, NEO hosted one BSc course from Department of Physical Geography, Stockholm University.

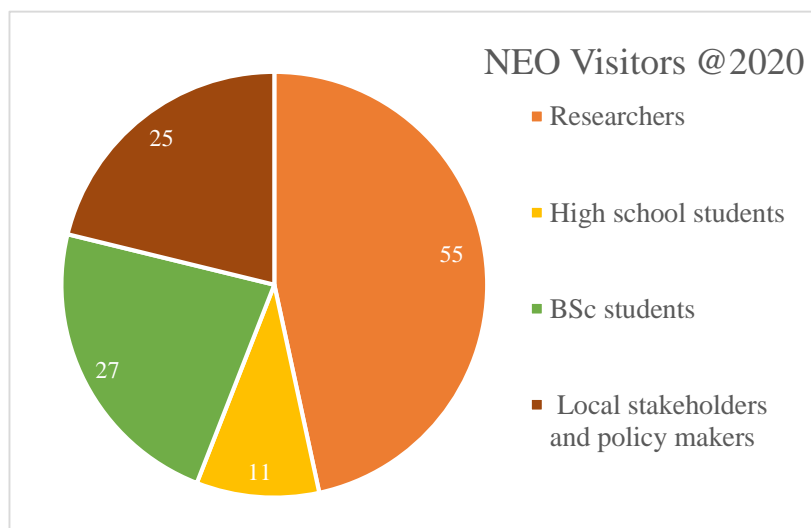


Figure 2: Visitors at NEO during 2020.

During 2020, NEO researchers have been actively involved in the publication of 24 research articles in international journals (17) and (virtual) conferences (7). In terms of research projects, NEO continued the previous work under the EU-COASTAL project with a specific focus on the development of quantitative System Dynamics models to be used as a base for discussions with stakeholders, and development of business recommendations and policy roadmaps.

In addition to the ongoing projects, NEO team has been active in developing and submitting four new project proposals in European and national (Greek) calls. In 2020, NEO became part of the European Civic University network (CIVIS) in Solid Earth System Dynamics. The partners involved in this network are from Greece (National and Kapodistrian University of Athens), Romania (University of Bucharest), Italy (Sapienza Università di Roma), and Sweden (Stockholm University). The participation of NEO in this network is established in the core of CIVIS Hub 1 Activities: Climate, Environment and Energy. At a local level, NEO in collaboration with Greek research institutions (e.g. University of Ioannina and Hellenic Center of Marine Research), local foundations (e.g. Captain Vasilis and Karmen Konstantakopoulos Foundation), management structures (Management Body of Protected Areas of Peloponnese and Kythira island), and the local fishermen, initiated a new project entitled “*Science-Policy-Society interactions for the Water Management of Gialova*”.

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Lagoon wetland” supported by Yialova Fish, the company which has been assigned with the management of the lagoon.

A NEO Communication Platform was developed in close collaboration with Gullers Grupp. This platform comprises a strategy for coherent communication with target stakeholders and general society, aiming to further clarify NEO’s current position, explore its future vision, and identify potential target groups for dissemination purposes. Based on this platform, a communication and dissemination strategy was also developed as a plan for harmonized communication activities with the identified target stakeholders over the next two years.

Table 2: Implications of COVID-19 pandemic on NEO activities in 2020. Each row of the table contains information about the activity (in bold), and the main co-organizer of the activity.

Field courses @ NEO	Status
BSc course in “Physical Geography” Dep. of Physical Geography, Stockholm University	Completed
MSc course in “Cultural Heritage Materials and Technologies” Dep. of History and Archaeology, University of Peloponnese	Cancelled
MSc course in “Plant Biodiversity and evolution - a global perspective” Dep. of Biology Education, Stockholm University	Cancelled
MSc course in “Ecohydrology: a Mediterranean perspective” Dep. of Physical Geography, Stockholm University	Cancelled
BSc course in “Environmental Studies” American College of Greece	Completed one visit
Upper secondary class course in “Natural disasters form a natural- and social science perspective” Värmdö Gymnasium, Stockholm	Postponed to 2021
BSc, MSc course in “Climate, Climate Change Impacts: Greece Dep. of Geography, Justus-Liebig University of Giessen	Postponed to 2021
Summer schools @ NEO	Status
International PhD summer school in “Theory and practice of aerosol chemistry and engineering for climate, air quality, emissions and health effects, by means of In-Situ and Remote Sensing Observations” Hellenic Association of Aerosol Research (HAAR)	Cancelled
Workshops @ NEO	Status
Adapt-NET Workshop: Climate change and Agriculture Agricultural University of Athens, Academy of Athens	Completed
COASTAL workshop: Multi Actor meeting Hellenic Centre of Marine Research	Completed online
PELOPS workshop – Past climate and societies Department of Archaeology and Ancient History Uppsala University	Rescheduled for 2021
NEO Communication platform Gullers Grupp	Cancelled
Gialova project – meeting with stakeholders University of Ioannina Hellenic Centre of Marine Research Captain Vasilis Foundation Management Body of Protected Areas of S. Peloponnese and Kythira island Divari (fishing company) Policy stakeholders	Completed
Climate change and climate refugees. A reality or a denial? University of Athens (UoA) National Technical University of Athens	Rescheduled for 2021
Researchers’ visits	Status
Feasibility evaluation of water use efficiency study Department of Physical Geography, Stockholm University Imam Khomeini International University, Iran UMR G-EAU, SupAgro, France	Cancelled
Maintenance and upgrade at Methoni station Department of Environmental Sciences (ACES), Stockholm University Institute of Environmental Research and Sustainable Development (IERSD), National Observatory of Athens	Cancelled
Other visits @ NEO	Status
WWF	Completed
Visit from a Greek school Avlonari high school (upper grade), Greece	Cancelled
Ambassador and staff of the Swedish Embassy in Athens Swedish embassy in Athens	Completed



Figure 3: Picture selection from 2020 NEO work in the field (top three pictures), and in close collaboration with local stakeholders and policy makers.

Education

Activities @NEO station

Compared to the previous years, in 2020 the regular flow of courses was interrupted due to the pandemic situation, and only a few were performed (Table 3).

Course in	Level	Affiliation of main organizers
<i>Exploring the wildlife of Messinia</i>	Upper secondary school	Sivitanideios Public School, Athens
<i>Physical Geography</i>	Bachelor	Dep. of Physical Geography, Stockholm University
<i>The Gialova experience!</i>		American College of Greece, Athens
<i>Climate Change and Agriculture</i>	Researchers Workshop	AdaptNET

Students from **Sivitanideios Public School** (Athens, Greece) had the opportunity to visit the NEO field station, and engage in discussions with the NEO management about the status of the natural environment in the area, but also about the NEO local and regional research and educational activities. The overall purpose of the fieldtrip was for the students to explore the wildlife of Messinia together with the NGO ANIMA (active in the field of nursing and rehabilitation of wild animals in their natural environment). The field trip included an education stop at NEO, followed by a stop at the Wild Life Protection and Rehabilitation Center (W.L.P.R.C.) which operates at Gargalianoi, where they had the unique opportunity to liberate a common buzzard *Buteo buteo*.

The 9th **Physical Geography course**, organized by the Department of Physical Geography, Stockholm University took place at NEO in March 2020 (Table 2). Sara Cousins and Peter Jansson were the instructors of the field course which was attended by 14 bachelor students. The main goal of this course was to provide students with knowledge in a variety of methodologies for environmental research. The course was developed in two phases. The first phase included excursions to different places all around Messinia and Arcadia, and the second phase was the field work carried out at four study areas (Methoni, Artemisia-Lousios River and Canyon, Gialova-Navarino Bay-Voidokoilia, Taygetos). Topics covered included the geomorphology of the area, the impacts of human pressure on ecosystems and how climate change and land-use processes might shape the landscape in the future.

NEO, in collaboration with the American College of Greece (ACG), continued their educational activities for bachelor students following Environmental studies at ACG. However, compared to previous years, in 2020 the students had the opportunity to visit the station only once.

Adapt-NET Workshop

The AdaptNET (Strengthening education, research and innovation for climate smart crops in India) is an ERASMUS+ CAPACITY BUILDING project, funded by the European Commission. Its 3rd workshop of the AdaptNET training series was held during 3-8 February 2020 at NEO, focusing on the impacts of **Climate change on Agriculture** (Figure 4). The workshop was attended, along with 29 Indian teachers/scientists, by 15 graduate students from Greece.



Figure 4: Lecture of Dr. Elena Xoplaki, during the AdaptNET workshop at NEO.

Hence, the AdaptNET workshop provided a culturally diverse and stimulating learning environment for trainees. The training was organized by researchers John Kapsomenakis and Dimitris Voloudakis from the Academy of Athens in collaboration with NEO.

Outreach

Workshops and day visits

The annual *General Assembly of the Greek Long-term Ecosystem Research Network (LTER-Greece)* was held at NEO in January 2020. The focus of the meeting was to identify new possible members, to discuss and work on research proposals and outreach material for supporting the network's activities.



Figure 5: Participants of the LTER-GR network during the general assembly meeting at NEO (left). The daily visit from the Swedish Ambassador in Greece along with the delegation from the Swedish Embassy (right).

In June 2020, NEO organized *a workshop with local stakeholders and policy makers* to discuss about the environmental status of the Gialova wetland, and the challenges that will need to be addressed for the gradual restoration of wetland's ecosystem services. The workshop was organized as part of the Gialova project (see information below), and the outcome was a joint decision for the re-opening of the sea-lagoon channel, an intervention which was suggested by the scientific team as a first step towards improving the conditions within the wetland. In June, we also had the honor to welcome the Swedish Ambassador in Greece along with the delegation from the Swedish Embassy.

NEO communication platform

To facilitate and better plan NEO's outreach activities, a communication platform was developed in 2020, in a close collaboration with Gullers Grupp¹, for coherent communication with stakeholders and general society. The platform clarifies NEO's current position, articulates its future vision, highlights potential target groups, and aims to facilitate and harmonize NEO's communication activities. Based on this platform, NEO is defined as a Mediterranean hub for research and education where science, business, society and policy-makers join in a pioneer cooperation to create a more sustainable future under a changing climate. NEO's vision for the next five years is to:

- explore the current lack of knowledge on climate change and its drivers, its environmental impacts, and their interconnection with human societies and ecosystems in the Mediterranean region;
- observe atmospheric composition changes and link them with local, regional and global scale factors and policies;
- review and investigate Mediterranean land degradation problems connected with extreme events (e.g. droughts, fires, floods), management practices and related land-use changes, and their implications for business (green) sectors;
- identify water and food security issues in the Mediterranean region (e.g. challenges raised by hydro-climatic changes and implications for human wellbeing and ecosystem sustainability);

¹ <https://gullers.se/>

- investigate the impact of climate change on Mediterranean economic sectors (e.g. agriculture and tourism);
- support the UN Greek Initiative in the topic of climate change impacts on natural and cultural heritage, which has been initiated in collaboration with the World Meteorological Organization (WMO) and UNESCO;
- develop solutions and business roadmaps under ongoing climate and anthropogenic changes and evaluate their feasibility in Mediterranean region;
- bring together scientists, business companies and policy makers to address complex issues of environmental management in coastal areas;
- follow and address missions and priorities defined by the European Commission to tackle global challenges through research and collaboration activities and business partnership.

The purpose of NEO's communication platform is to support its vision for the future, and clarify the role of NEO as a regional hub for climate change and sustainability. As part of the developed communication platform, five target groups were identified for effective and coherent communication, including academia and universities, business and industry sectors, local and regional stakeholders, regional and international organizations, and politicians and decision-makers. For each target group, a key message was developed reflecting their specific needs and priorities that can be addressed and met by NEO, its research and educational activities. The developed communication platform is being used as a basis to support NEO's communication and outreach activities in future, e.g. restructuring and updating the website, planning for various events, and promoting further partnership with the target groups.

As a first step to implement the developed communication platform, the NEO research and management team developed a communication and dissemination strategy in 2020. The overarching aim of the developed strategy is to outline actions and activities to enhance targeted distribution of information on NEO's current position and future vision, as well as scientific findings and activities to the target groups. The developed communication and dissemination strategy is expected to support NEO management during 2021-2022 to further develop NEO's network of internal and external partners and relevant stakeholders, and promote NEO's growth by involving relevant partners that can efficiently support and promote NEO's activities. The strategy plans for creating new dissemination materials (e.g. an introductory short video, interview videos with NEO people, leaflets, and activity booklets) and updating and restructuring the existing ones (e.g. website, social media (Twitter and Facebook profiles), annual reports, and newsletters) as well as organizing events (e.g. thematic Café NEOs, virtual fieldwork, an open day, and a technical seminar).

NEO team has already started conducting these activities to maximize the visibility of NEO at the regional scale, as well as promote potential sectors and stakeholders to get involved in NEO's activities.

NEO Website

NEO website is under continuous overhaul. A new way for the dissemination of NEO research is now available at <https://www.navarinoneo.se/> (under 'Research'). The current clustering of NEO's scientific research has been inspired by the defined themes on Missions and Research and Innovation prioritized in Horizon Europe, which was adapted to fit NEO research topics. That provides new insights on the extent of NEO research and better linkages to current publication themes (Figure 6). The work is now focusing on the development of a new online service, such as the provision of open access data from the NEO's Gialova Lagoon Monitoring Network (GLMN).

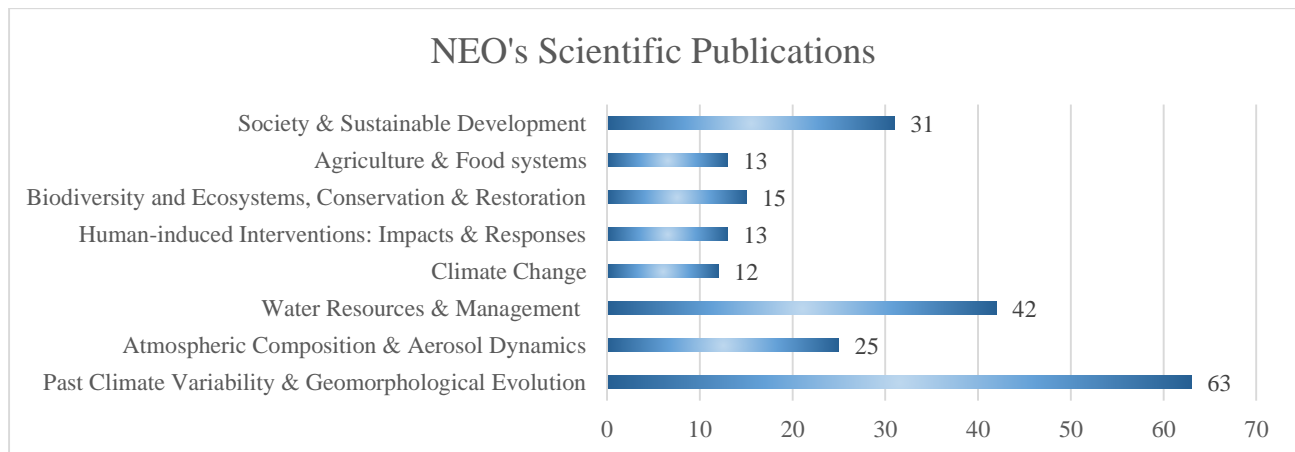


Figure 6: Clustering NEO’s scientific publications according to the specified research topics inspired by Missions and Research and Innovation prioritized in Horizon Europe.

Research activities

European, national and local projects

COASTAL - Collaborative Land-Sea Integration Platform

In 2020, the focus of the NEO research team working under the EU-COASTAL project (No 773782), was to develop quantitative System Dynamics models as a base for discussions with stakeholders, and for the development of business recommendations and policy roadmaps. The Greek team had also the ambition to organize the second Multi-Actor Lab workshop in Messinia, but the workshop was postponed for 2021 due to the pandemic situation.

The Gialova-project: Science-Policy-Society interactions for the Water Management of Gialova Lagoon wetland Land-Sea Integration Platform

In collaboration with Greek research institutions (University of Ioannina and Hellenic Center of Marine Research), local foundations (Captain Vasilis and Karmen Konstantakopoulos Foundation), management structures (Management Body of Protected Areas of Peloponnese and Kythira island) and the local fishermen, NEO has initiated a new project entitled “Science-Policy-Society interactions for the Water Management of Gialova Lagoon wetland”, funded by Yialova Fish, the company which has been assigned with the management of the lagoon. The project will be developed during three years, aiming to suggest scientifically robust solutions for the gradual restoration and co-management of the Gialova wetland for both environmental and economic factors, under different climatic scenarios. The project builds on existing NEO research and involves researchers, practitioners and policy-makers in working together for tackling challenges related to management of multi-functional areas, such as coastal wetlands, and provides an example for other similar areas in Greece and across the Mediterranean region.

Under the Gialova-project, an extended monitoring network [Gialova Lagoon Monitoring Network (GLMN)] will be deployed for evaluating the current status and the effect of future restoration work on the hydrological, ecological and environmental conditions of the wetland. The GLMN will built on the existing network of NEO stations, which will be upgraded with new high-tech field equipment and additional stations (Figure 7).

In June 2020, the research team of the Gialova project, completed and presented the Reference Study² to the relevant policy makers and stakeholders. The outcome from the workshop was a joint decision for the re-opening of the sea-lagoon channel, an intervention which was suggested by the scientific team as a first step towards improving the conditions within the wetland.

² The Reference Study, describes the current conditions in the Gialova wetland, proposes interventions for the gradual restoration of the ecosystem and its services, and discusses the constrains and the trade-offs that should be considered by the wetland managers.

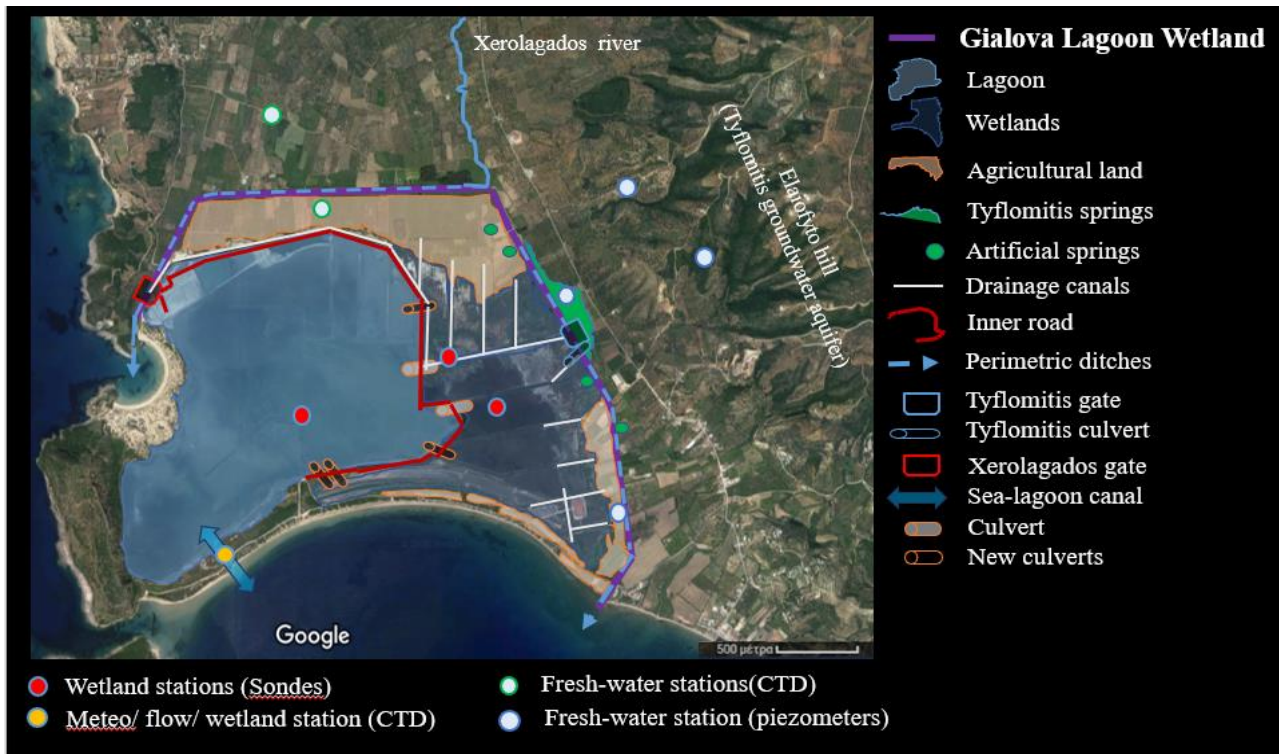


Figure 7: A map of Gialova wetland and surrounding area, showing the set-up of the Gialova Lagoon Monitoring Network (GLMN). The GLMN builds on the existing network of NEO wetland stations (red and yellow dots), which will be upgraded with new high-tech field equipment and six additional stations (white dots) for the monitoring of groundwater resources.

Ongoing research linked to NEO

Atmospheric research

NEO atmospheric research is undertaken by researchers from the Biomedical Research Foundation of the Academy of Athens (BRFAA), the Department of Environmental Science of Stockholm University (ACES) and the Institute for Environmental Research and Sustainable Development of the National Observatory of Athens (IERSD). The long-term monitoring of aerosol physical, chemical and optical properties, atmospheric trace gases, different solar radiation components as well as meteorological parameters, is the main focus of the atmospheric research activities conducted at NEO. The observations aim at shedding light on the factors that control the levels and variability of the species above as well as to discriminate the relevant contribution from long range transport versus local sources. NEO, as part of PANACEA, serves as one of the 3 sites selected in Greece to concentrate national and international efforts in the study of atmospheric composition and its relevance to climate change. PANACEA, standing for “PANhellenic infrastructure for Atmospheric Composition and climatE change (PANACEA)” (<http://panacea-ri.gr/>), was launched in September 2018. PANACEA, as part of the Hellenic Research Infrastructures (RI). The RI is actively linked with relevant European Infrastructures (ACTRIS/ESFRI and ICOS/ERIC) that target aerosol, clouds, trace gases and the carbon observation, and aims at developing a coordinated system for monitoring of atmospheric composition, solar radiation variations, climate change and related natural hazards in Greece, merging all existing facilities and upgrading its infrastructure.

In 2020, researchers from the Biomedical Research Foundation of the Academy of Athens (BRFAA) started a campaign of analyzing atmospheric concentrations of ozone (O₃) and carbon monoxide (CO) in Messinia, Greece, from measurements conducted at NEO’s atmospheric monitoring station in Methoni since 2016.

The role of the NEO site, which is part of the PANACEA Research Infrastructure, is to maintain long-term monitoring of key particulate and gaseous species, in an attempt to shed light on the factors that control their levels and temporal variability, and to discriminate the relevant contribution from long-range transport versus local sources. O₃ and CO concentrations are measured continuously at NEO by two gas analyzers, an Ecotech

Serinus 10 and an Ecotech Serinus 30, respectively. Daily and monthly means are calculated in order to study the seasonal cycle of the two air pollutants. To investigate the regional representativeness of the measurements, especially within the climatologically different parts of the western and eastern part of Greece, the data were compared with corresponding concentrations from the Finokalia station, on Crete Island. The correlation coefficient between the mean daily O_3 in Methoni and Finokalia rural areas is about +0.6. Similar correlation is also found for CO as shown in Figure 8. The scientific results were presented at the 2nd scientific conference of PANACEA which was held online from 29 September to 1 October 2020. Special focus is given on the factors that govern their covariance or periods where the levels differ significantly. Comparisons with corresponding data from the Copernicus Atmosphere Monitoring Service (CAMS) are an important aspect as a means of model evaluation in the region.

In addition, researchers from NOA, in collaboration with the Department of History, Archaeology and Cultural Resources Management of University of the Peloponnese, published a paper on spatial variability of aerosols over Greek archaeological sites using Space-Borne Remote Sensing. This work enhanced the research on cultural heritage and it came out as a result of MSc in Cultural Heritage Materials and Technologies (CultTech).

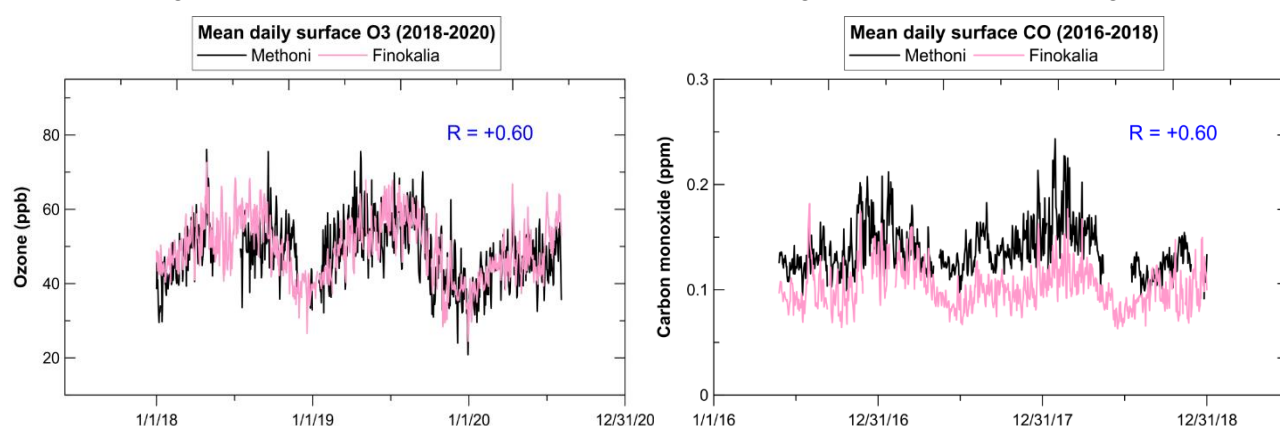


Figure 8: Ozone and CO daily measurements at Methoni, NEO, and at Finokalia, Crete.

Water research

The water research undertaken by the team of Professor Georgia Destouni aims at advancing our understanding of key natural and human-driven environmental and societal processes and changes with impacts on water availability and quality in Greece and the Mediterranean region. Moreover, it aims at developing improved and novel methods and tools for process and change quantification that can support effective strategies for sustainable management of national and regional water resources. In previous NEO work, the team has, for example, investigated and identified tipping points for seawater intrusion into coastal groundwater under rising sea level and other hydro-climatic changes, and cost-efficient management measures for coastal aquifers via recharge with treated wastewater and desalination of brackish groundwater.

In 2020, water research at NEO was focused on wetlands. Wetlands contribute more than 20% of the total value of global ecosystem services, while covering only a small percentage (4%–9%) of global land surface. While they can support regional sustainability through various ecosystem services, they are also one of the most vulnerable ecosystems globally, being continuously affected by climate change and human activities. The scale mismatch between the existing large-scale studies of various landscape changes and the still mostly local wetland impact studies creates an urgent need for comprehensive, science-based assessment of the interactions between large-scale drivers of change and large-scale wetland systems. Assessments at larger scales are needed to enable the formulation of scientific evidence-based guidance and strategies to protect wetlands under global change. The combination of high wetland vulnerability and rapid large-scale changes subject to major knowledge and data gaps highlights the need to synthesize and create datasets available for evaluating change effects and feedbacks at the scales of whole wetlandscapes.

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NEO researchers along with other contributors from different parts of the world, addressed the need for large-scale wetlandscape studies and created and published a novel database, named Wetlandscape Change Information Database (WetCID), for 27 wetlandscapes around the world (Table 4 – including the Gialova lagoon) and their associated geographical, wetland, hydrology, hydroclimate and land-use conditions, to support such efforts ([Ghajarnia et al., 2020](#)).

Table 4. General geographic, climate and wetland type information for the investigated wetlandscapes in WetCID.

Site no.	Site name	Country	Classification	Climate zone	Wetland type	Area of wetlands relative to total catchment/wetlandscape area (%)
1	Tavvavuoma	Sweden	Wetlandscape	Subarctic	Peat plateau/thermokarst lake complex	2.8
2	Forsmark	Sweden	Wetlandscape	Humid continental (cold summer)	Bogs, fens, marshes, (shallow lakes)	0.01
3	Vattholma	Sweden	Wetlandscape	Humid continental (cold summer)	Bogs, fen, riparian	–
4	North Baltic WMD	Sweden	Wetlandscape	Humid continental (cold summer)	Multiple	100
5	Simpevarp	Sweden	Wetlandscape	Humid continental (cold summer)	Bogs, fens	0.01
6	South Baltic WMD	Sweden	Wetlandscape	Humid continental (cold summer)	Multiple	100
7	Upper Lough Erne	Ireland	Individual wetland	Cold (dry winter, cold summer)	Flood plain/shallow lakes	22
8	Selenga	Russia	Wetlandscape	Cold (dry winter, cold summer)	Marshes (riverine, palustrine)	0.13
9	Volga	Russia	Wetlandscape	Cold (dry winter, cold summer)	Marshes (riverine, palustrine)	1.0
10	Le Sueur	USA	Wetlandscape	Temperate	Isolated, fluvial/riparian, lakes/ponds, marshes, forest/shrubs, constructed	100
11	Sacca Di Goro	Italy	Individual wetland	Cold-summer Mediterranean	Shallow saltwater coastal lagoon	4.2
12	Lake Urmia	Iran	Individual wetland	Continental	Lake	8.8
13	Anzali Mordab	Iran	Individual wetland	Caspian or Hyrcanian climate	Inland and marine/coastal wetland	4.0
14	Gialova Lagoon	Greece	Individual wetland	Hot-summer Mediterranean	Coastal wetland	13
15	Lower Mississippi River Delta Plain	USA	Wetlandscape	Humid subtropical	Riverine, marine, estuarine, Lacustrine	3.5
16	Shadegan	Iran	Individual wetland	Warm desert	Palustrine, estuarine, marine	31
17	Zone Humide de Souss	Morocco	Individual wetland	Mediterranean semi-arid	Marine and coastal	0.01
18	Geographically isolated wetlands	USA	Wetlandscape	Humid subtropical	Freshwater marshes and swamps	100
19	Everglades	USA	Individual wetland	Tropical to subtropical	Freshwater wetland, coastal wetland	32
20	CGSM	Colombia	Individual wetland	Tropical	Estuarine	–
21	Mekong Delta	Vietnam	Wetlandscape	Tropical monsoon	Marine	5.0
22	Panama Canal	Panama	Wetlandscape	Tropical/Central America	Chagres River, lake	100
23	León-Atrato	Colombia	Wetlandscape	Tropical rainforest	Marshes and swamps	17
24	Lagunas Plaza and Grande	Colombia	Wetlandscape	Extremely cold and very dry	Glacial lake	4.4
25	Fúquene, Cucunubá y Palacio	Colombia	Individual wetland	Cold and very dry	Natural shallow lake	1.7
26	Sumapaz Páramo	Colombia	Wetlandscape	Tropical	High-altitude wetland	46
27	Pantanal	Brazil	Wetlandscape	Tropical savanna with dry winter	Periodically inundated savanna	27

WetCID consists of a survey-based collection of local information and data, combined with compilation and synthesis of gridded large-scale datasets of 30-year time series of mean monthly precipitation and temperature along with annual average land uses and their changes over this time period for each wetlandscape. WetCID can support site assessments, cross-regional comparisons, and scenario analyses of the roles and impacts of various land-use, hydroclimatic and wetland conditions and their changes on whole-wetlandscape functions

and associated ecosystem services. The information on local data availability–accessibility and observed or perceived change occurrence summarized and structured in WetCID can guide further study directions and support identification of key needs for complementary new local data and/or use of additional regional–global gridded datasets. Additionally, [Stengård et al. \(2020\)](#) developed a simple method based on the use of depression-based digital elevation model to inventory wetlands, and thus support the analyses of their spatial and temporal trends, relevant for establishing effective management and protection strategies.

Land degradation in the Mediterranean region

The land degradation research undertaken by NEO researchers from the Department of Physical Geography at Stockholm University, in collaboration with scientist from several Mediterranean universities, aims at advancing our understanding of the current status of soil degradation in the Mediterranean region and their key natural and human-driven environmental and societal processes. Better knowledge on land degradation processes and their future trends is relevant to support effective strategies for sustainable land management across the region, and to achieve the Land Degradation Neutrality targets.

The Mediterranean is one of the most vulnerable and severely affected European regions by soil degradation, with 34% of its land under high or very high risk of desertification. The main causes of degradation include the high soil erosion rates (>2 Mg/ha), the loss of already low and very low soil organic matter content (<2%) triggered by high mineralization rates, and salinization problems that are aggravated by groundwater abstraction and sea water intrusion. However, additional physical, chemical and biological degradation processes, such as soil sealing and compaction, contamination, and loss of biodiversity, are also of great concern. Nevertheless, the lack of systematic inventories of soil degradation status in the Mediterranean region impairs understanding of the current spatial and temporal dimensions of the degradation processes and their past trends. However, researchers believe that soils' natural capital is already being pushed towards possible critical limits for its ability to provide essential ecosystem services.

Increasing population and its density in urban and coastal areas (and consequent abandonment of rural areas), coupled with the intensification of socio-economic activities (e.g., agriculture and tourism) and unsustainable land management practices have enhanced the vulnerability of the Mediterranean landscape to degradation. Additionally, the climate gradient characterized by contrasting dry and wet seasons and the ongoing climate changes marked by increasing frequency and intensity of extreme events (e.g. droughts and floods) also play an important role on soil degradation in the Mediterranean region. Based on climate change projections, expected land-use changes and increasing water availability constraints, land degradation is projected to continue or accelerate if restoration and effective strategies to improve soil quality are not implemented.

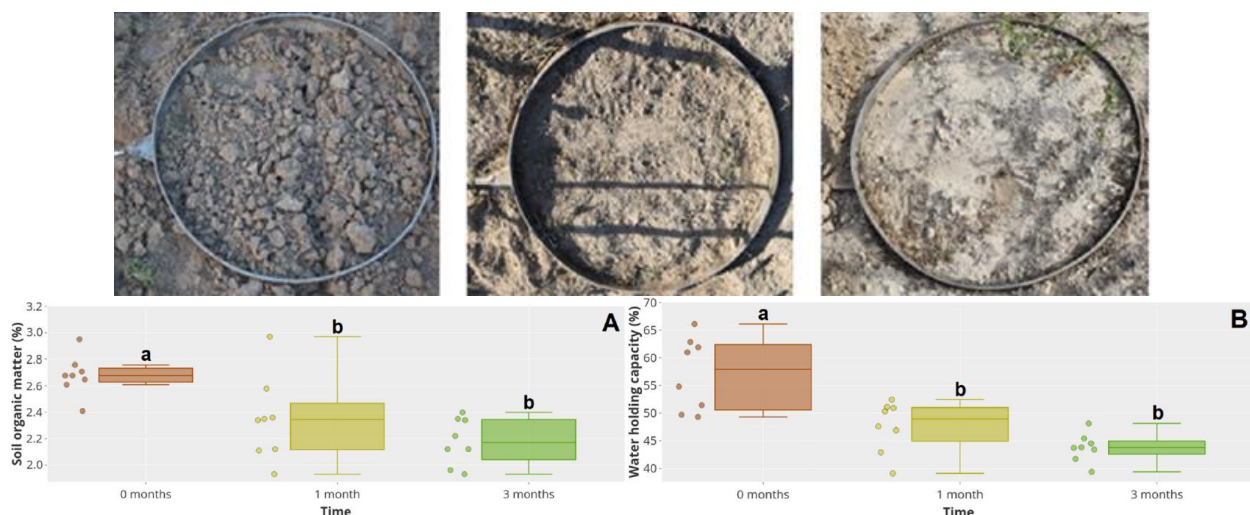


Figure 9: Temporal changes in the soil surface within a fig orchard in Croatia immediately after soil tillage and 1 and 3 months later, and their consequences for soil organic matter (A) and water holding capacity (B). Different lower-case letters represent significant differences between monitoring periods ($p < 0.05$). Dots next to a boxplot represent measured values. Source: Telak et al., 2020.

In 2020, the research team have published articles assessing the short-term impacts of tillage on soil and hydrological responses in fig orchards located in Croatia, demonstrating the significant loss in soil organic carbon and decrease in water holding capacity (Figure 9) caused by this type of agricultural management practice in poorly investigated cropping system (Telak et al., 2020). The manuscript of Ferreira et al. (2020) investigates the impact of urbanization and associated soil sealing on increasing flood hazard and land degradation in a Portuguese peri-urban catchment, and demonstrates the potential of specific nature-based solutions planed at catchment scale in mitigating the problem (Figure 10). Additional research articles have been developed and are currently under review in international scientific journals.

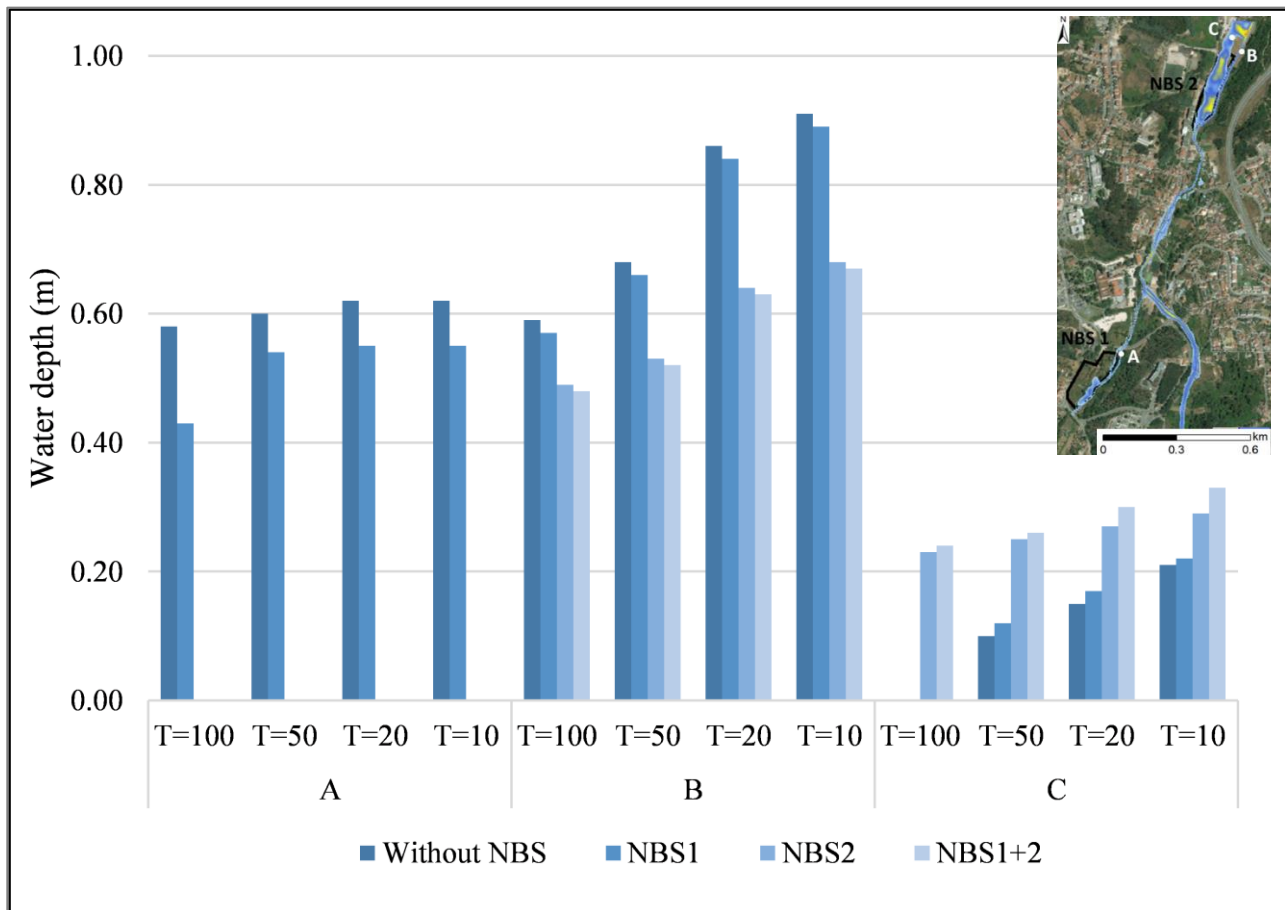


Figure 10: Mean water depth during 10-, 20-, 50- and 100-year floods for three sites within the peri-urban Ribeira dos Covões catchment, located in the centre region of Portugal (A: located upstream; B: located downstream; and C: located downslope), in the four simulation scenarios investigated (without NBS, and with implementation of NBS1: controlled flooding of an abandoned area upslope, NBS2: controlled flooding of an agriculture area downslope, and NBS1+NBS2). Source: Ferreira et al., 2020.

Co-management of Ecosystem Services in Gialova Lagoon wetland and surrounding areas

Research done in close cooperation with different stakeholders aim to develop a co-adaptive management approach of multifunctional landscapes such as wetlands, that can help to enhance and diversify the local economy, while still sustaining critical ecosystems and associated ecosystem services. Monitoring and analyses of socio-ecological parameters were initiated in 2016 in the nearby coastal lagoon (Gialova lagoon) and adjacent streams, rivers and cultivated land, aiming to provide viable alternatives for long-term sustainable tourism and agriculture. The research considers resilience to future climate changes and minimization of the impact of tourism and agriculture on the Natura 2000 sites, exploiting the expertise and experience of local stakeholders. The work is based on the PhD work of Giorgos Maneas, his supervisor Dr. Håkan Berg, his co-supervisor Dr. Stefano Manzoni both Ass. Professors at the Department of Physical Geography, Stockholm University and a number of master students who have contributed significantly to this direction during the last 4 years. Since 2018, the area is also considered as one of the six case studies of the EU-COASTAL project, adding to our understanding and to the capacity to reach the local community.

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A major achievement for 2020, was the initiation of the Gialova project (see more above under relevant chapters). In addition, the research team has published two articles in 2020, one focusing on the status and the distribution of the waterbirds in the Gialova lagoon, and another unravelling the diverse values of wetland ecosystem services based on the Q methodology.

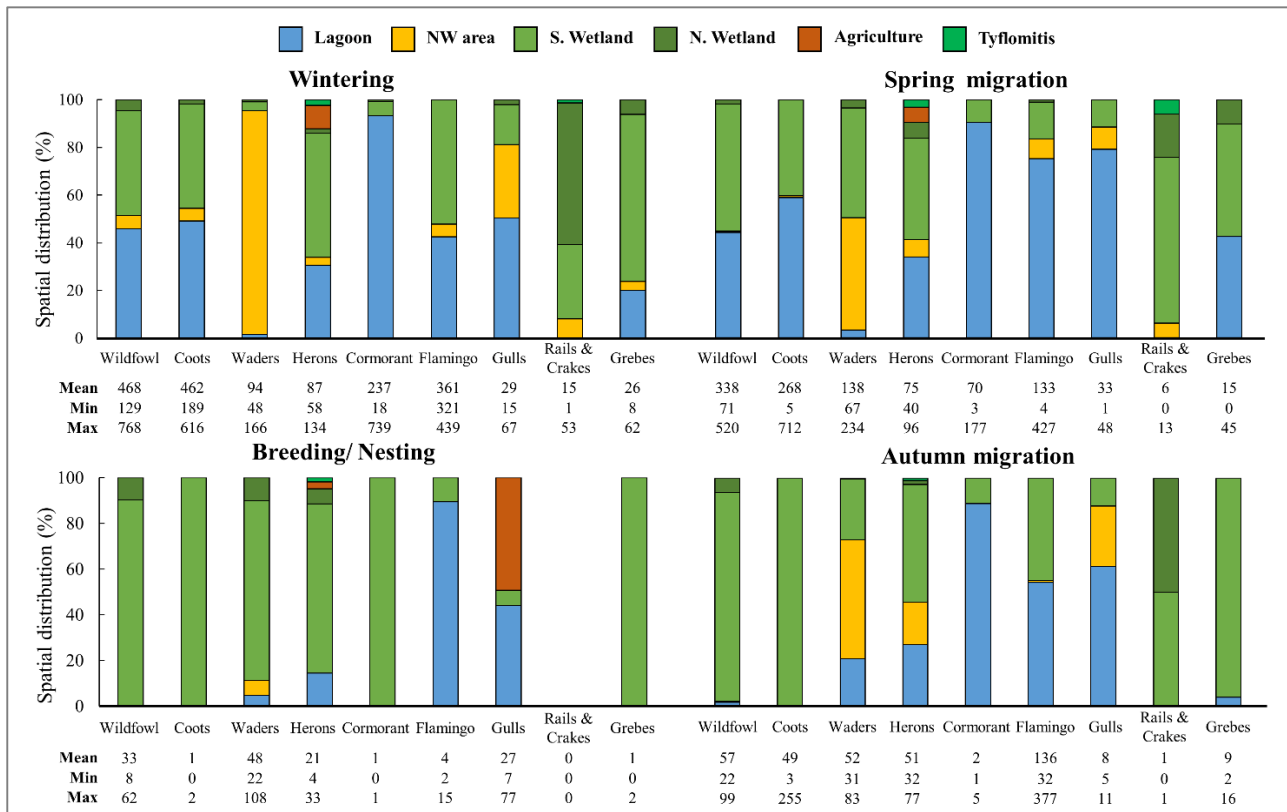


Figure 11: Stacked column graph showing the spatial distribution (percentage) of waterbirds' categories in the different sub-areas of the GLw-Natura2000 area, based on their average population distribution during the different periods. The abundance (mean, minimum and maximum values) of each waterbirds category during the same period is presented in the table at the bottom of each graph.

Based on results from [Maneas et al. \(2020\)](#), waterbirds richness and abundance were higher during the Wet season and corresponding periods (Wintering and Spring migration). All parts of the wetland supported waterbirds and threatened species, with the South. Wetland sub-area being the most diverse during the Breeding/Nesting, and both migration periods (Figure 11). However, compared to previous counts the abundance of most waterbirds and IBA (Important Bird Areas) species have declined over the last 20 years. During the two years study, we have recorded and identified 149 bird species representing 43 families and 15 orders, including 36 threatened species at an International, European or/and national level, and 40 species listed in the Annex I of the EUs Birds Directive (21 species were listed as both threatened and under Annex I). As such, the area meets Ramsar criterion 2 (*to support vulnerable, endangered or critically endangered species*) criterion 4 (*to support animal species at a critical stage in their life cycle, or provide refuge during adverse conditions*), and thus it should be further investigated and evaluated to potentially become the eleventh Greek Ramsar site. Regardless the Ramsar status, the restoration of fresh water inflows which could improve habitats and water conditions for IUCN and IBA species, should be implemented with high priority. The above results have already been incorporated in the development of the Gialova project (see also above in the report).

Additional publication by [Maniatakou et al. \(2020\)](#), provided new insights about the different perceptions of local stakeholders on 25 pre-identified Wetland Ecosystem Services (WES). Alongside diverse perceptions of the relative importance of different WES (figure 12), it was observed a range of explanations of why certain WES are important and analyzed these through the lens of “value pluralism”. Such analyses move beyond ecosystem service identification towards an understanding of value justifications and conflicts, and can support the deliberation of conflicted views, and policy design in alignment with people’s values.

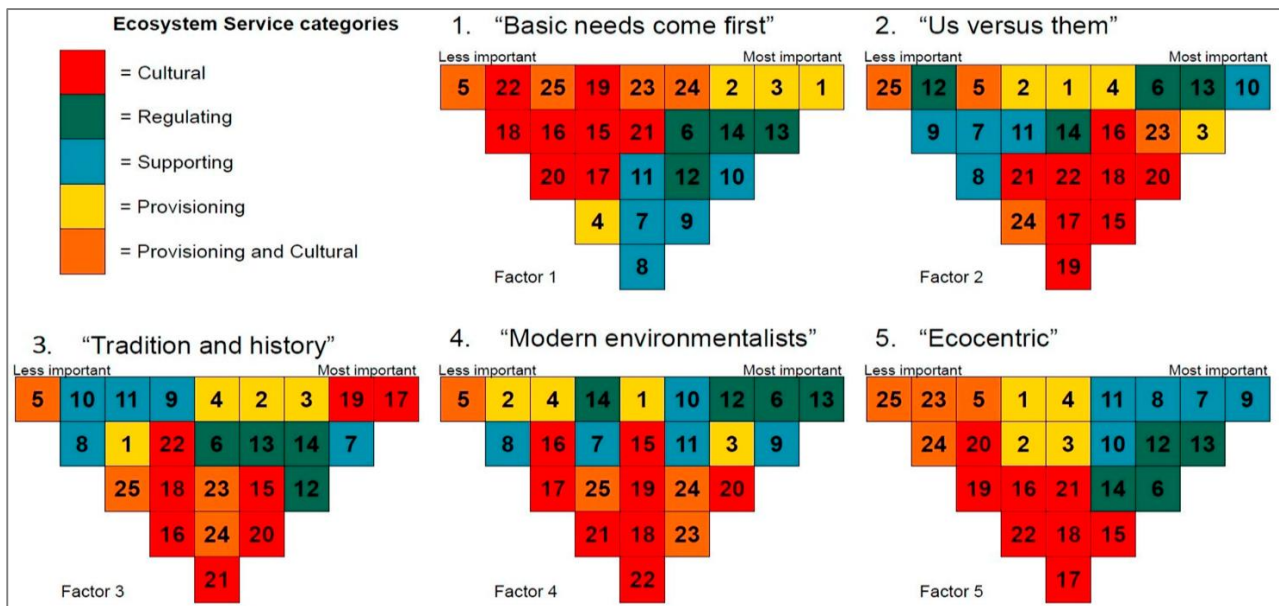


Figure 12. The five major perspectives of participants as identified by the factor analysis and represented by archetypal Q-sorts for each perspective generated from the quantitative results. The numbers in the boxes correspond to the 25 WES references in Maniatakou et al., 2020. The colors refer to the WES category.

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NEO in Scientific Peer-review Publications

Scientific Journals

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