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Gap Analysis Targeting WFD Monitoring and Pressure Mapping: Lessons Learned from "EcoSUSTAIN", Interreg-MED Project †

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Abstract: According to WFD, European countries shall establish monitoring programmes for water quality overview. In EcoSUSTAIN, an Interreg–MED project, Gap analysis, an approach that reveals the difference between current and desired level, was carried out, targeting five Mediterranean hydro-ecosystems covering "Monitoring Practices" and "Water Quality and Pressures". Our goal is to investigate practicing deficiencies, as long as information lack and distance from desirable status, supporting water uses and WFD goals. Data was collected by literature research supported by questionnaires. The findings on both fields, revealed problematic areas dealing with the compliance with the WFD and several deficiencies in tackling pressures.

Keywords: Gap analysis; monitoring; water quality; WFD; pressures; EcoSUSTAIN

1. Introduction

Water is a priceless resource for human health, food security, sustainable development and the environment, and is an economic sector of growing importance for Europe. However, water resources are constantly under pressure from climate change, urbanization, pollution, over-exploitation of freshwater resources and increasing competition between various user groups. Improvement of the state of water resources, both in terms of quantity and quality, will trigger substantial economic benefits. At European level, freshwater policy derives mainly from the Water Framework Directive—WFD (2000/60/EC) while concerning their biodiversity it is also influenced by the Habitats (92/43/EEC) and Birds Directives (79/409/EEC). The designation of Protected Areas (PAs) is the main strategic tool for the conservation of nature against the continuing biodiversity loss. This conservation strategy has received increased attention concerning freshwater PAs as they should meet the goals of the WFD—achieving good ecological status, and Habitat-Bird Directives - achieving favorable conservation status. So, it is of primer importance this legislation to be incorporated successfully into wider management policies, and that prerequisites working beyond natural boundaries and establishing deep collaboration between PA managers [1,2].

Specifically, in the Mediterranean region, the acknowledgement of (a) the additional stress because of the water scarcity along with the increased water demand and (b) the diversity of protected freshwater ecosystems, has been recently reflected in various research [3]. This may have profound practical consequences for water bodies management and policy strategies, but at the same time the gaps between science and policy highlight the very scarce development of efficient tools and models to be transferred towards policy implementation.

EcoSUSTAIN is an Interreg MED Programme; its main objective is to improve monitoring, management and networking of five freshwater ecosystems which are also enlisted in the catalogue of the European PAs under the network of Natura 2000, thus the need for effective management and conservation is highly demanded. Among the key policy recommendations on PAs and water security is to strengthen the knowledge management base. In the context of the main objective, we present the monitoring strategy and the mapping of pressures towards the improvement of the management efficiency and the harmonization with the WFD. The first step in addressing this issue is to estimate the existing information the management bodies of each PA obtain on monitoring and water quality status, in comparison to ecosystem's needs, undertaking a Gap analysis, that clearly addresses the question "where we are and where we want to be". It is used as a simple tool to assist the quantification between present and desired level in knowledge on fundamental aspects of WFD and PA related Directives and further to periodically review and monitor the level of compliance [4–6].

2. Materials and Methods

2.1. Gap Analysis Approach

Here, a Gap analysis was carried out on the sum of five Mediterranean PAs in two fields covering (a) "monitoring practices"; and (b) "water quality and pressures" to investigate sectoral or practicing deficiencies as long as information lack and distance from desirable status. The data of Gap Analysis come from an extended literature review and two sets of questionnaires, created for this exact purpose, and addressed to the Management Bodies of these PAs and collaborating research centers (institutes and local universities). More specifically, analyses on the two fields took place inside the two following conceptual frames.

Monitoring practices: Parameters indicative of biological, hydromorphological and physical-chemical quality elements are required to be monitored within certain frequencies. Similar to the WFD, other EU directives comprising Europe's Water Policy legislation (Bathing, Nitrates, Habitats), coupled with national one, set the frame of requirements for monitoring on which National Parks/Countries are supposed to base their monitoring programmes. In this field, particular quality elements, their monitoring frequencies and special assessments were included.

Water quality and pressures: The water quality criterion is addressed mostly as the knowledge availability, for the ability of comparing biological, physicochemical and other abiotic parameters with these limits of Guidances and Directives, and synthesizing the information required by broadly accepted indexes. Along with the aforementioned parameters, descriptive assessment of probable amelioration/deterioration on certain ecosystem values and services. Acknowledging the major importance and complexity of WFD application, Gap analysis does not compare water quality or trophic status of studied sites.

2.2. Description of the Study Areas

Five freshwater ecosystems enlisted under the network of Natura 2000 found in European PAs of Mediterranean region are set as studied sites:

- Lake Albufera in L' Albufera Natural Park—Valencia, Spain
- Lake Visovac in Krka National Park—Šibenik, Croatia
- Mantua Lakes in Mincio Regional Park—Mantova, Italy
- River Una in Una National Park—Bihać, Bosnia ed Erzegovina
- Lake Karla in Protected Area of Karla—Magnesia, Greece

L' Albufera PA: L' Albufera wetland, declared as Natural Park in 1986, RAMSAR wetland in 1990, Important Bird and Biodiversity Area and site of Natura 2000 Network, occupies 211.2 km^2 while is defined by a freshwater lagoon (23.2 km^2), separated from the Mediterranean Sea by a sand barrier (33.2 km^2). A warm climate with an average annual precipitation of 540 mm, high annual evapotranspiration (885 mm) and temperature of 17.6 °C reveals a semiarid character. It is characterized as a very shallow polymictic lake, hypertrophic since 1970 with existence of potentially toxic

cyanobacteria, with high pH, co-occurrence of both freshwater and oligohaline waters [7,8], intense temperature variation due to its low depth, reaching a bad ecological status. Moreover, it is highly regulated, as the 70% of its inflows pass through a historic irrigation system.

Krka PA: Krka National Park lies within Šibenik-Knin County and covers a total area of 109 km² of the Krka River routine, and the lower course of the Čikola River. It was declared a Natural Park in 1985 and a Natura Network 2000 site. Visovac Lake is located in the karstic region SouthWest of the Dinarid Mountains, formed by Krka river, at about 20 km from the Adriatic coast (Croatia). It is a travertine barrage lake of 7.9 km² with a maximum depth of 30 m, the climate is continental influenced by the mid Mediterranean climate. The average annual precipitation is 1360 mm and temperature of 13 °C [9]. Visovac lake is monomictic system characterized by relatively high freshwater intake. Although it is located in sparsely populated and almost intact environment, upstream some significant anthropogenic sources of pressure can be found (towns Drniš and Knin), making it a sensitive ecosystem [10].

Mincio PA: The Mincio Park is a 19.47 km² PA established by the Lombardy Region in 1984. It is situated in the province of Mantua in a territory belonging to 13 municipalities. It was declared a Ramsar wetland and a natural reserve. Part of it is a Natura Network 2000 site. The climate is warm and temperate with an average annual precipitation of 797 mm and temperature of 13 °C. This National Park hosts a heterogenous natural environment formed by several water bodies with different hydrological characters. Mantua lakes is a group of three eutrophic urban lakes situated in a valley-lacustrine system, with reduced hydrodynamism and many hydromorphological alterations. Based on previous monitoring results for the PA management body the lakes, created by dammed meanders, are usually CO_2 supersaturated, with anoxia impacting on biological communities.

Una PA: The Una National Park, founded at 2008 (Public Company), lies in the northwestern part of Bosnia and Herzegovina, belongs to the Una-Korana plateau and has an area of 198 km². The Park encompasses the Una river valley, the canyon and orographic slopes of neighboring mountains. Una river is 212 km long and emerges as a karst spring, at the foot of the Pljesevica and Straz-benica mountains. A moderately continental climate characterizes the area with average annual temperature of 9.8 °C and high precipitation (1170 mm) [11]. Not visible effects of pollution or morphological alteration can be found in the area. The terrain assists to the self-purification ability of the system through a sequence of small falls, turns, springs, gauges and sinks that cause aeriation to the water, preserving its low temperature and oxygen supersaturation.

Karla PA: The Protected Area of Karla-Mavrovouni-Kefalovriso-Velestino, situated in the Eastern Thessaly has an area of 1280 km² and is characterized by great land uses heterogeneity, as it contains rural plains, mountains of high ecological and aesthetic value, internal and coastal waters. Parts of it have been characterized as Important Bird and Biodiversity Areas and Natura Network 2000 sites. The newly recreated artificial Lake Karla, located at the lowest altitude, covers an area of 38 km². It is a very shallow, heavily modified water body. A continental climate governs the mean annual precipitation of 560 mm, unevenly distributed in space and time, the potential evapotranspiration of 775 mm and the temperature of 14.3 °C [12]. Lake Karla is exposed to point and diffuse pollution sources, which come from the intensive agricultural and livestock activities, leading already to a progressive eutrophication. It is characterized as eutrophic to hypereutrophic with frequent occurrence of algal blooms [12].

2.3. Applied Methodology

The Gap Analysis applied methodology can be described by four steps, presented below:

1. First the identification of the objectives is set, meaning the desirable level (the 100% of the target value) which is different for each field. For "Monitoring practices", the preferable status is assumed that can be abstracted by a set of fifteen queries, covering several types of monitored items and frequencies. Any non-monitored elements or deviation from desired frequencies forms the Gap. Similarly, for "Water Quality and Pressures", equal number of questions with the Monitoring Practices field is selected for the comparability of the results deriving from these two magnitudes. In this field, the knowledge on parameters forming more complex quality

related indexes, as on pressures and their effects is assessed.

2. Second comes the analysis of the current situation. The current situation is quantified based on: (a) Management Authorities and stakeholders' responses on the two questionnaires along with (b) a database formed by raw data, gathered during the literature review; and (c) a matrix of recently (2016, 2017) monitored elements for the waterbodies provided by each PA Management Authority.
3. Third comes the Gap assessment. The Gap stems from the difference between current and desired level; namely the percentage of indices measured along with their values and the ideal situation in which all indices are used for assessment with best possible values. These percentages come from the replies of the queries as follows: when the reply is yes or no, the percentage results in only two options 0% or 100%, but when the reply has more options, a classification of percentages is raised according to the number of classes. When descriptive assessment is applicable in queries, replies stating amelioration are graded positively, deterioration negatively and stability with half the full grade.
4. In order to visualize the Gap, simple mathematics are applied. The cumulative average statistic is used to assess the final results of every PA for the two fields. A comprehensive presentation is performed regarding the derived percentage value for each question of the two thematic categories. Each one of these questions is equally important for the Gap analysis application and for that reason the calculation formula of final result of each field has no weight coefficients. The same mathematic formula applies for the final percentage value that characterizes each Management Body of PA and each category. This final value is the average of the two thematic results.

3. Results and Discussion

For the needs of a comprehensive presentation of the results, two tables were created (Tables 1 and 2) showing the graded percentages of the questionnaires' answers for the five PAs, regarding the fields of Monitoring Practices and Water Quality and Pressures.

A mean value, for each PA, is calculated for the percentage values of all queries. This application provides a percentage value per field for each PA, as it is shown by the graphs of Figures 1 and 2.

The findings of Gap analysis on Monitoring Practices, in brief, revealed as main problematic areas the compliance with the designation of the water-body limits/type and sampling frequencies according to the Water Framework Directive. It can be seen that almost all the quality elements set by the WFD are monitored as supposed to be, but without the proper frequency trend. Another issue is that 60% of the National Parks have not quantified the ecosystem services their areas are capable of providing and 80% have neither evaluated hydromorphological modifications.

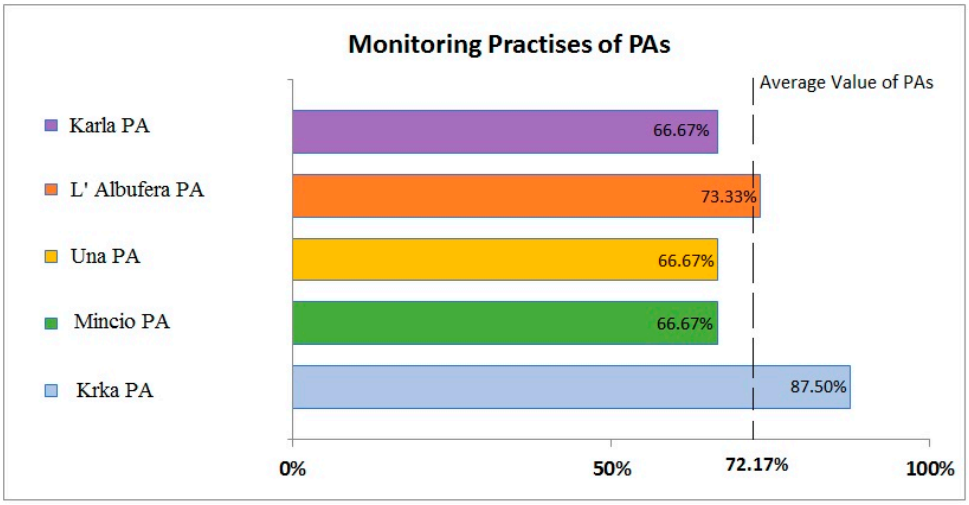

Figure 1. Gap rating on Monitoring Practices for each of the five PAs.

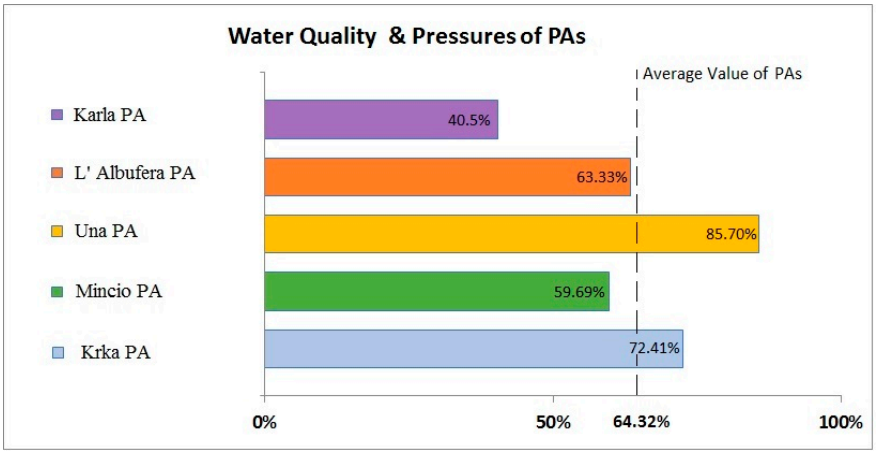

Figure 2. Gap rating on Water Quality and Pressures for each of the five PAs.

Table 1. Percentages of Gap Analysis of the five PAs regarding the Monitoring Practices. 1: L' Albufera, 2: Krka, 3: Mincio, 4: Una, 5: Karla.

Monitoring Practices Queries	1	2	3	4	5
Water Monitoring	0%	100%	100%	100%	100%
Biodiversity Monitoring	100%	100%	100%	100%	100%
Water body identified according to CIS WFD	0%	100%	100%	0%	100%
Water body subject to a monitoring protocol	100%	100%	100%	100%	100%
Monitoring involves chemical water quality	100%	100%	100%	100%	100%
Monitoring involves biological water quality	100%	100%	100%	100%	100%
Monitoring involves hydromorphological modification assessment	0%	100%	0%	0%	0%
Impact assessment	100%	100%	0%	100%	0%
Ecological services assessment	0%	100%	0%	100%	0%
Frequency for hydromorphological modification monitoring	100%	50%	0%	100%	0%
Frequency for hydrological parameters monitoring	100%	100%	100%	100%	100%
Frequency for nutrient parameters monitoring	100%	100%	100%	50%	100%
Frequency for chemical & abiotic parameters monitoring	100%	100%	50%	0%	100%
Frequency for indirect algal biomass monitoring	100%	100%	50%	50%	50%
Frequency for biological parameters	100%	50%	100%	0%	50%

Table 2. Percentages of Gap Analysis of the five PAs regarding the Water Quality and Pressures. 1: L' Albufera, 2: Krka, 3: Mincio, 4: Una, 5: Karla.

Water Quality & Pressures Queries	1	2	3	4	5
Observed Change in Water Quality	100%	50%	50%	100%	0%
Changes in Lake Habitats	100%	50%	50%	-	0%
Changes in River Habitats	-	50%	50%	100%	50%
Changes in conservation activities	100%	100%	0%	100%	50%
Changes in birds' presence	100%	50%	50%	100%	100%
Sewage treatment plants influence in area	0%	100%	50%	100%	100%
Agrochemicals influence in area	0%	100%	50%	100%	0%
Organic waste influence in area	0%	100%	50%	100%	0%
Discharges influence in area	0%	0%	50%	100%	0%
Uncontrolled residues accumul. influence in area	50%	50%	50%	100%	0%
Carlson Trophic State Index	100%	100%	100%	80%	100%
2008/105/EC—Priority Substances Directive	100%	75%	75%	50%	25%
2006/44/EC—Fish-Life Directive	100%	92.3%	84.4%	76.9%	100%
WHO Standards on recreational waters	100%	75%	100%	50%	25%
Other basic optional physicochemical parameters	100%	71.4%	85.7%	42.9%	57.1%

In the field of water quality, Gap analysis revealed several deficiencies, mostly dealing with the series of pressures each PA faces and the not improvement of the status of quality criteria relevant to biodiversity and habitats. Discharges, residues and sediment accumulation pull the average down in a negative manner and this could possibly be connected to the unawareness on Hydromorphological modifications.

In general, the part of data availability in order to produce indices related to water quality received better rating. Furthermore, the results showed possible vulnerability of the surface water bodies of the PAs in connection with the human activities-pressures found in these areas.

As an overall, it showed a relative good state in monitoring practices, providing adequate knowledge on water quality and the pressures upon it. Major distance found in Water Quality and Pressures field attributed mostly to Karla, Mincio and L' Albufera PAs (Figure 3) which host the more eutrophicated water-bodies, suffering from various and multiple human induced pressures. The overall image was mediated by the almost complete knowledge on the water quality related parameters and the extended research. These areas are well-studied, and a large number of scientific papers is available forming a thorough knowledge database [13–15].

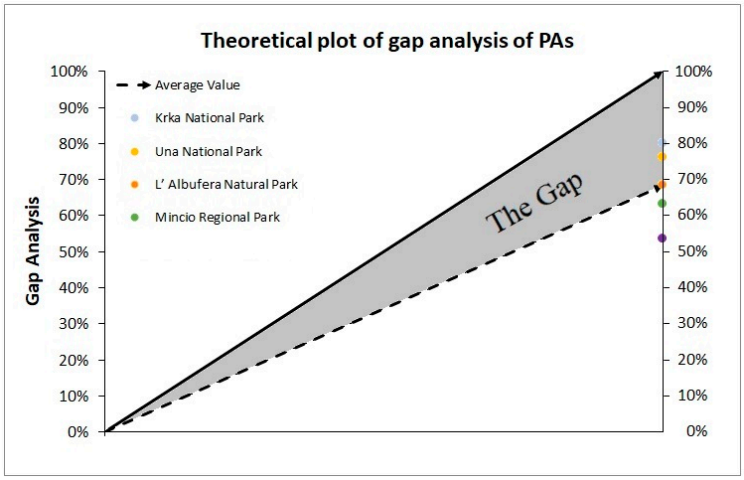

Figure 3. Theoretical plot of average Gap for both fields, for 5 PAs and their individual grading.

As an outcome, it would be favorable if Management Bodies of these PAs could focus on Water Quality and Pressures, a filed interconnected with monitoring practices for generating alert systems and the proper amount of information, extremely valuable for measures design towards pressures alleviation and water quality improvement. It should also be pointed out that if the monitoring/samplings frequency were according to the Directives suggestions, the GAP would be smaller, thus, a possible need for harmonization is highlighted.

Special attention should be paid on the broader thematic of hydromporphological modifications and ecological services assessments. It used to be an area of less concern in the management and scientific circles, as depicted also by the Gap analysis, since the majority of the studied areas have not yet included these in a standardized protocol. Though, during the last years, there is a growing concern for hydromorphological issues resolution, since they are found to be the second most common pressure across EU (EC Staff Working Document vol. 2, Third Implementation Report 2012). On the other hand, in all areas, biodiversity, chemical and biological water quality are all under strict monitoring protocol following the proper frequency.

4. Conclusions

EcoSUSTAIN programme will assist the effort for improvement of monitoring practices through staff training and Information and Communication Technologies (ICT) capitalizing the findings of the Gap analysis. It seems like the PAs that have to put more effort in reaching the favorable/optimal status are Karla, Mincio and L' Albufera, and this can possibly be explained by the water body types these Parks host and the human induced pressures during the last centuries.

In this study, Gap analysis seems like a useful tool in the attempt for horizontal comparison of five very different water bodies, with different traits and characteristics, under different monitoring schemes designed by their management authorities. Despite their differences, such analysis, targeting WFD monitoring and pressure mapping was adequate to group fundamental goals (ones usually set for waterbodies in PAs) and incorporate harmonization with other directives, indexes and Guidances, valuable for the better understanding of monitoring needs and of water quality issues, as for knowledge base building. According to the targets set, the Gap reveals the extra (monitoring and management) effort to be applied in order for waterbodies to reach the desirable state. It seems that this analysis provides significant help in identifying and monitoring gaps and appropriate ways for improving the knowledge, in comparison to the traditional water quality monitoring programmes undertaken by individual agencies that relate to specific objectives, such as meeting quality criteria for wastewater discharges and fail to provide information on basin-scale impacts, especially at cases where other factors as habitats, protected species. Our analysis enables the identification of areas where further efforts are needed to reinforce the existing monitoring systems in the region, revealing also that the existed datasets have limited access so further effort is needed to make them available to policy makers and to meet the requirements of the relevant initiatives.

The lessons learned from this EcoSUSTAIN action will help to design future monitoring plans in order to lead in proper management actions by showing the gaps in each field and revealing shading effects of improper measures taken so far. Our results also confirmed that current practices vary between PAs and further between countries, while attempts should address on the full harmonization of monitoring approaches driven by the common International legislation.

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