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Specific RDI Project 2: “Active measures for Restoring Sweet-Water Lakes and Coastal Areas affected by Eutrophication addressing the Enhancement of Resilience to Climate Change and Biodiversity” (ACT4-Eutrophication)

D2-3.1 REPORT ON HAZARDS AND RISK ANALYSIS, RISK CHARACTERIZATION, PREVENTION AND MITIGATION METHODOLOGIES OF CLIMATE CHANGE IMPACT ON THE EUTROPHICATION OF SWEET-WATER LAKES AND BLACK SEA WEST COAST WATERS. CASE STUDY ON SIUTGHIOL LAKE

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TABLE OF CONTENTS

Contents

1. Introduction

1.1 Scope

The report presents the hazards and risk analysis, risk characterization, prevention and mitigation methodologies of climate changes impact on the eutrophication of freshwater lakes and Black Sea waters. Case study on Siutghiol Lake.

1.2 Document Overview

This document completely follows:

Chapter 1 outlines of the purpose of this document
Chapter 2 lists the applicable and reference documents.
Chapter 3 presents the identified hazards, risks and pressures for the Siutghiol lake
Chapter 4 describes the analysis methodology for the assessment of the risks
Chapter 5 presents the used references

2. References

2.1 Applicable Documents

The following project documents contain provisions which, through reference in this text, become applicable to the extent specified in this document. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply.

[AD01] Financing agreement	CODE Issue: Date:
[AD02] Application Form	CODE Issue: Date:
[AD03] Project Management Plan	CODE Issue: Date:
[AD04] Technical note of use case scenarios and user requirements	CODE Issue: Date:
[AD05] Data cube report	CODE Issue: Date:
[AD06] Technical note on methods algorithms and tools	CODE Issue: Date:

2.2 Reference Documents

The following standards or documents are referenced in this document. Documents which are recognized best practices may be listed for the purpose of information.

[RD01] Space engineering – Software, ECSS-E-ST-40C	
[RD02]	

3. Evaluation of hazards and risks

Eutrophication is a natural process that is manifested by the excessive development of bacterioplankton and phytoplankton, which leads to a change in the structure of associations of animal or plant organisms and to the possibility of the occurrence of the algal bloom phenomenon, which in turn can lead to mass mortality.

The factors that trigger the eutrophication process are - increasing temperature and increasing nutrient input into the water mass. In combination with other factors, which can accentuate their effect, eutrophication can be accelerated.

The area of Lake Siutghiol is characterized by a fairly wide range of impact factors, whose action in the short, medium and long term translates into a series of risks to the natural habitat. Although it is a protected natural area included in the European Natura 2000 network – ROSPA 0057, Lake Siutghiol has not benefited from a management plan that takes into account the requirements established by the network's objectives – those of ensuring the conservation of avifaunal biodiversity. The real estate projects taking place on the lake shore, the recreational activities taking place on the lake, the development of the hotel industry – have constantly ignored the desideratum of an international protection area.

3.1 Impact factors

Climate change is a current phenomenon that no longer needs to be demonstrated and which has led to measures being taken at the European Union level. The last of these measures is represented by the development and publication in February of a report dedicated to climate risk at the Union level.

3.1.1 Lake Siutghiol in the context of climate change

Lake Siutghiol is located in an area sensitive to climate risk, primarily due to the fact that the high degree of eutrophication makes it particularly sensitive to climate change. On the other hand, the explosive development of the real estate sector on the shores of the lake increases anthropogenic pressure and implicitly the risks of increasing eutrophication due to sewage discharges.

Under these conditions, taking into account the data presented in the European Environment Agency report, a series of aspects related to both the impact of climate change on freshwater systems and their impact on coastal marine ecosystems were identified for Lake Siutghiol.

3.1.2. Freshwater systems

As a freshwater lake, resulting from the transformation of a marine bay, Lake Siutghiol is under the influence of factors that, following climate warming, affect small, medium and large water bodies. Its position and depth make it vulnerable to the following factors:

- The increase in temperature favors the development of cyanobacteria, causing algal blooms with socio-economic impact and a decrease in recreational value.
- The increase in temperature also influences the duration of the ice-free period in winter, which leads to changes in water stratification, with direct effects on biodiversity;
- Changes in precipitation levels (respectively their lack or very abundant precipitation over short periods of time) have multiple ecological impacts
- Climate change causes not only eutrophication but also an increase in nutrient loading, which causes a loop effect.
- Increasing temperatures lead to a longer stratification period and a deeper shift of the thermocline, as well as to increased productivity and organic carbon content, but also to oxygen depletion. All these factors combined limit suitable habitats for cold-water stenothermal and oxyphilic species.

- Changes in the lake structure can trigger the recycling of nutrients accumulated in sediments, which exacerbates problems related to autotrophication.

3.1.3 Coastal ecosystems

Lake Siutghiol, being extremely close to the sea, is also influenced by a series of aspects related to climate change related to the coastal environment, which affect not only marine waters. Thus, from this point of view, the lake is under the influence of the following factors:

- Thermal stress, leading to changes in life cycles, physiological rates, phenology and species distribution. Thermal stress has a cascading effect on the functioning of ecosystems, including the absorption of pollutants by organisms, which can have an impact on mortality rates.
- Increased stratification and changes in water circulation, which can lead to hypoxia resulting from warming. Increased stratification leads to eutrophication - the appearance and increase of algal blooms and the development of pathogens
- Habitat degradation due to human activities, overfishing, the introduction of alien species and pollution are also factors to be taken into account, actually present on the surface and in the surroundings of the lake.
- In fact, in the case of Lake Siutghiol, the two categories of factors identified in the EEA report overlap, actually generating an increased risk of eutrophication, stratification and changes in habitat conditions.

3.2 Pressures and threats identified in the perimeter of Lake Siutghiol

Climate change is a current phenomenon that no longer needs to be demonstrated and has led to measures being taken at EU level. Lake Siutghiol is located in an area sensitive to climate risk, primarily because of the high degree of eutrophication that makes it particularly sensitive to climate change. On the other hand, the explosive development of the real estate sector on the shores of the lake increases anthropic pressure and implicitly the risks of eutrophication due to sewage spills.

Taking into account the position of the lake and the development of the inhabited areas on the shores, pressures and threats are present. The impact of these pressures and threats also comes in the context that Lake Siutghiol is in fact also a protected bird area included in the Natura 2000 Network, which requires at least theoretically taking special measures regarding the conservation of its condition in order to ensure the basic objective of the area – namely the protection of waterfowl populations, especially during the migration and wintering periods.

For the impact analysis, the list of pressures and threats developed by the European Environment Agency was used. Due to the fact that the list in question has been updated in recent years, a comparative analysis of the pressures and threats mentioned in the standard sheet of the protected area, in various previous studies and brought up to date following the observations made on the ground in February had to be carried out.

The situation on the ground was analyzed with what is included in the analysis of the European Environment Agency for freshwater areas in the coastal area of Romania, overlapping with the Pontic area. In this case, on the EEA website, the main pressures and threats in the case of coastal freshwaters are from the fields of agriculture, forestry, development of structures related to residential and industrial areas, invasive species, pollution and human-induced changes in aquatic habitats.

Starting from these data, for the particular case of Lake Siutghiol (excluding Lake Tabacarie, which is still part of the same Natura 2000 protected area), a special analysis was carried out, taking into account the reality on the ground.
Following the observations, a list of 63 pressures and threats resulted, coming from almost all categories.

3.2.1 Impact factors - pressures and threats - in the context of climate change risks

Taking into account the position of the lake and the development of the inhabited areas on the shores, different kind of pressures and threats are present. The impact of these pressures and threats comes in the context of the fact that Siutghiol Lake is also a protected area for birds included in the Natura 2000 Network, which requires at least theoretically taking special measures for the conservation of its condition to ensure the basic objective of the area - namely the protection of waterfowl populations especially during migration and winter.

The list of pressures and threats developed by the European Environment Agency was used for the impact analysis. Due to the fact that this list has been updated in recent years, a comparative analysis of the pressures and threats mentioned in the standard data sheet of the protected area, in different previous studies and updated by field observations had to be carried out.

An analysis on the ground, however, shows a completely different situation compared to the one in 2007. The Siutghiol lake area is characterized by a fairly wide range of impact factors, whose action in the short, medium and long term is transposed into a series of risks to the natural habitat. Although it is a protected natural area included in the European Natura 2000 network - ROSPA 0057, Lake Siutghiol has not benefited from a management plan that takes into account the requirements established by the network's objectives - those to ensure the conservation of avifaunistic biodiversity. The real estate projects that take place on the shore of the lake, the recreational activities that take place on the lake, the development of the hotel industry - have constantly ignored the desideratum of an international protection area. It should be mentioned that even at the level of the property type of the area, there are conflicts at the local level between the territorial administrative units (UAT) located in the Siutghiol Lake area - Constanta, Ovidiu and Năvodari - each with distinct economic interests. Without taking into account the fact that the lake is included as a public domain of the state or had a Natura 2000 protected area status, in 2019 one of these UATs tabulated the entire lake basin as a private domain.

For the particular case of Lake Siutghiol, a special analysis was carried out, taking into account the reality on the ground (Table 1).

Table 1 Pressures and threats identified in the Siutghiol Lake area

Code	Pressures/threats	Impact	Impact type
PA	Agriculture related practices		
PA05	Abandonment of management/use of grasslands and other agricultural and agroforestry systems (e.g., cessation of grazing, mowing or traditional farming)	Present	Low risk
PA08	Extensive grazing or undergrazing by livestock	Present	Low risk
PA10	Livestock farming (without grazing)	Present	Low risk
PA11	Soil management practices in agriculture (e.g., ploughing)	Present	Low risk
PA12	Harvesting of crops and cutting of croplands	Present	Low risk
PA13	Application of natural or synthetic fertilisers on agricultural land	Significant	Substantial risk
PA14	Use of plant protection chemicals in agriculture	Significant	Substantial risk
PA15	Use of other pest control methods in agriculture (excluding tillage)	Present	Low risk
PA23	Physical alteration of water bodies (including dams, channels, etc.)	Present	Low risk
PB	Forestry related practices		
PB09	Clear-cutting, removal of all trees	Present	Low risk
PB10	Illegal logging	Present	Low risk
PC	Extraction of resources (minerals, peat, non-renewable energy resources)		
PD	Energy production processes and related infrastructure development		

PD05	Development and operation of energy production plants (including infrastructure)	Present	Low risk
PD06	Transmission of electricity and communications (cables)	Present	Low risk
PD07	Oil and gas pipelines	Present	Low risk
PD08	Energy production and transmission activities generating pollution to surface or ground waters	Present	Low risk
PE	Development and operation of transport systems		
PE01	Roads, paths, railroads and related infrastructure	Present	Low risk
PE02	Shipping lanes and ferry lanes transport operations	Present	Low risk
PE04	Flight paths of planes, helicopter and other non-leisure aircrafts	Present	Low risk
PE05	Land, water and air transport activities generating pollution to surface or ground waters	Significant	Substantial risk
PE08	Land, water and air transport activities generating noise, light and other forms of pollution	Present	Low risk
PF	Development, construction and use of residential, commercial, industrial and recreational infrastructure and areas		
PF01	Conversion from other land uses to built-up areas	Significant	Major impact
PF02	Construction or modification (e.g., of housing and settlements) in existing built-up areas	Significant	Major impact
PF03	Creation or development of sports, tourism and leisure infrastructure	Significant	Limited risk
PF04	Development and maintenance of beach areas for tourism and recreation	Present	Low risk
PF05	Sports, tourism and leisure activities	Present	Low risk
PF06	Deposition and treatment of waste/rubbish from built-up areas	Significant	Critical impact
PF07	Residential and commercial activities and structures generating pollution to surface or ground waters	Significant	Substantial risk
PF08	Industrial activities and structures generating pollution to surface or ground waters	Present	Low risk
PF09	Residential, commercial and industrial activities and structures generating air pollution	Present	Low risk
PF11	Residential, commercial and industrial activities and structures generating soil pollution	Present	Low risk
PF12	Residential, commercial and industrial activities and structures generating noise, light, heat or other forms of pollution	Present	Low risk

PF13	Drainage, land reclamation and conversion of wetlands, marshes, bogs, etc. for built-up areas	Significant	Limited risk
PF17	Active abstraction of water for built-up areas	Present	Low risk
PG	Extraction and cultivation of biological living resources (other than agriculture and forestry)		
PG06	Freshwater fish and shellfish harvesting (professional)	Present	Low risk
PG07	Freshwater fish and shellfish harvesting (recreational)	Present	Low risk
PG08	Hunting	Present	Low risk
PG11	Illegal shooting/killing	Present	Low risk
PG14	Poisoning of animals (excluding lead poisoning)	Present	Low risk
PG15	Use of lead ammunition or fishing weights	Present	Low risk
PG20	Freshwater aquaculture generating pollution to surface or ground waters (including marine)	Present	Low risk
PG21	Introduction and spread of new species in aquaculture (including GMOs)	Significant	Critical impact
PG22	Abandonment of aquaculture	Present	Low risk
PH	Military action, public safety measures, and other human intrusions		
PH04	Vandalism or arson (incl. human-introduced wild fire)	Present	Low risk
PH05	Tree surgery, felling/removal of roadside trees and vegetation for public safety	Present	Low risk
PH06	Closure or restricted access to site/habitat	Significant	Critical impact
PI	Alien and problematic species		
PI01	Invasive alien species of Union concern	Significant	Critical impact
PI02	Other invasive alien species (other than species of Union concern)	Present	Low risk
PI03	Problematic native species	Present	Low risk
PJ	Climate change		
PJ01	Temperature changes and extremes due to climate change	Significant	Critical impact
PJ03	Changes in precipitation regimes due to climate change	Significant	Critical impact
PJ05	Saline intrusion	Present	Low risk
PJ07	Cyclones, storms, or tornados due to climate change	Present	Low risk
PJ11	Desynchronization of biological / ecological processes due to climate change	Significant	Critical impact
PJ12	Decline or extinction of related species (e.g. food source / prey, predator / parasite, symbiote, etc.) due to climate	Present	Low risk

	change		
PJ13	Change of species distribution (natural newcomers) due to climate change	Present	Low risk
PK	Mixed source pollution		
PK01	Mixed source pollution to surface and ground waters (limnic and terrestrial)	Significant	Critical impact
PK03	Mixed source air pollution, air-borne pollutants	Present	Low risk
PL	Human-induced changes in water regimes		
PL06	Physical alteration of water bodies (mixed or unknown drivers)	Significant	Substantial risk
PM	Geological events, natural processes and catastrophes		
PM01	Storm or cyclone	Present	Low risk
PM02	Flooding	Present	Low risk
PM05	Avalanches, landslides and collapse of terrain	Present	Low risk
PX	Unknown pressures, no pressures and pressures from outside the Member State		
PX01	Threats and pressures from outside the EU territory	Present	Low risk
PX02	Threats and pressures from outside the Member State	Present	Low risk

The observations resulted in a list of 63 pressures and threats from almost all categories, as follows (https://cdr.eionet.europa.eu/help/habitats_art17):

- PA Practices related to agriculture – 9 pressures and threats;
- PB Forestry-related practices - 2 pressures and threats;
- PD Energy production processes and related infrastructure development - 4 pressures and threats;
- PE Development and operation of transport systems - 5 pressures and threats;
- PF Development, construction and use of infrastructure and residential, commercial, industrial and agreement areas - 13 pressures and threats;
- PG Extraction and cultivation of living biological resources (other than agriculture and forestry) 9 pressures and threats;
- PH Military action, public safety measures and other human intrusions - 3 pressures and threats;
- PI Alien and problem species - 3 pressures and threats;
- PJ Climate change - 7 pressures and threats;
- PK Mixed sources of pollution - 2 pressures and threats;
- PL Human-induced changes in water regimes - 1 pressures and threats;
- PM Geological events, natural processes and disasters - 3 pressures and threats;
- PX Unknown pressures, no pressures and pressures from outside the Member State - 2 pressures and threats.

4. Risk analysis methodology

Currently, risk assessment methodologies have become a common working tool regardless of whether we refer to the field of information technology, to the development and conduct of business, to the development of industrial structures, of products or of the environment in general.

As regards a risk assessment methodology for Lake Siutghiol, it must start from two premises:

- First, the lake is almost completely surrounded by residential areas and agricultural activities are carried out in the lake's retention basin. Currently, agricultural activities are in decline and the development of the real estate sector has experienced an unprecedented boom in the last 20 years, often constructions not respecting environmental standards. In the immediate vicinity of the lake, but separated from it, there is a waterway, used for the transport of petroleum products as well as other products from the Petromdia refinery. The hotel sector is developing explosively along the entire coastal strip that separates the lake from the sea, and activities related to tourist recreation or sports are carried out on the lake. In conclusion, the lake's riparian area is a dynamic residential area, currently focused on real estate developments, with a decline in agricultural and industrial activities. Taking into account the development trends of the coastal area, it is assumed that this directive will continue in the coming years.
- Secondly, Lake Siutghiol together with Lake Tabacariei is a Natura 2000 protected area, designated for a series of birds included in the annexes of the European Union Birds Directive as well as for the fact that it is a refuge for a very large number of birds during the migration period. In this sense, the protected area has as its main objective to ensure an optimal state of conservation for the populations of these birds.

In conclusion, the socio-economic development objectives of the lake's riparian area conflict with the main objective of the protected area, an objective legislated through legislation that the Romanian state ratified upon accession to the European Union.

From this point of view, the risk assessment methodology must take into account both aspects, balancing both the socio-economic development objectives of the area and the main objective that resides in the lake's protected area status.
Eutrophication, which is the main aspect affecting the waters of Lake Siutghiol, affects both the socio-economic development objectives and the main objective of the protected area.

The methodology we consider for analyzing the risks identified on the lake's surface includes the following steps:

1. – Form a working group represented by stakeholders and representatives of the scientific community
2. – Identify impact factors
3. – Assess the environmental impact of each factor
4. – Evaluate both the potential environmental risk and the possibility of proposing and implementing control actions
5. – Establish priorities regarding impact factors
6. – Finalize the environmental impact analysis and propose management measures
7. – Communicate the prioritization and proposed measures to the stakeholders.

4.1 Environmental Impact Significance Matrix

			Large scale irreversible environment damage of national/ international significance – destruction	**Persistent environment damage of national/ international significance – destructio**	**Environmental impact limited to relative small area, or widespread impact with minimal lasting**	**Limited impact, such as negligible but widespread disturbance of common**	**Impact than can be contained and rectified easily. Impact has an aesthetic, noise or**	**Impact that disperses within an hour or can be rectified using standard emergency response procedures**

			of habitats and endangered species. Contamination of water resorsec and soil	n of habitats and endangered species	damage, temporary damage to common species or habitats, disturbance of endangered species	species	odours impact on local biodiversity or populations but unlikely to lead to complaine	or equipment. No impact on local biodiversity or populations.
		Impact persistence	>10 years	3-10 years	1-3 years	1 month – 1 year	< 1 month	No sustained damage
		Scale	f	e	d	c	b	a
Impact frequency	Frequency range		Critical	Severe	Major	Moderate	Minor	Negligeable
Continuous	Occurring more than daily	6	H	H	H	M	M	L
Recurrent	Occurring less than daily and up to weekly	5	H	H	H	M	L	L
Frequent	Occurring less than weekly and up to monthly	4	H	H	M	M	L	L
Infrequent	Occurring less than monthly and up to annually	3	H	M	M	L	L	L
Occasional	Occurring less than annually and up to once even 10 years	2	M	M	L	L	L	L
Remote	Occurring less than once even 10 years	1	M	L	L	L	L	L

Step 1

The establishment of the working group will involve stakeholders from all areas of activity related to the lake – local administration, representatives of the business environment, representatives of autonomous authorities – Regia Apele Romane – or structures of the Ministry of Environment, experts in the fields of hydrology, climatology, meteorology, biology, ecology. The group will be led by a person with experience in the environmental impact on wetlands.

Step 2

The impact factors that intervene on the surface of the lake and in the immediate vicinity will be identified, factors

that directly or indirectly influence the state of the water body and that influence the eutrophication process. The impact on the lake as a protected area and on the species protected within it will also be taken into account. Environmental aspects (elements, activities, services that interact, or can interact with the environment, producing effects), their inputs and outputs, environmental impacts (a change into the environment, adverse or beneficial, resulting from environmental aspect) will be identified, any stakeholders responsible for these will be identified, and activities that are characterized by multiple environmental aspects and multiple environmental impacts will be highlighted.

Step 3

For each environmental impact, the significance will be assessed taking into account the effects it has on the environment or the eutrophication process. For these environmental impacts, the environmental impact significance matrix will be used. The use of the matrix will target both negative and positive impact factors, so that management measures can be taken accordingly. Severity, frequency, persistence, geographical scale will be assessed and the level of impact – high, medium, low – will be assessed.

Step 4

For the purpose of assessing environmental risk, the fourth step will include prioritization involving environmental aspects and environmental impacts. Defined as a future event, environmental risk derives from an environmental aspect and produces changes in the environment that affect the lake. Three criteria (high, medium, low) will be used to classify environmental risks and to estimate the control capacity, if possible and to estimate whether there are environmental risks associated with environmental aspects previously identified in the prioritization idea.

The environmental risk will be guided by the following potential risk scores:
- High – the environmental aspect/impact produces significant changes in the natural habitat
- Medium – the environmental aspect/impact produces changes that partially affect the integrity of natural habitats
- Low – the environmental aspect/impact does not produce changes or these are insignificant

In the same step, the control capacity or to diminish the influence of the impact factor will be estimated. In this case, the easier it is to control a certain impact factor, the higher the opportunity score will be, according to the following model:
- High – existing methods of impact control and mitigation, easy to implement and inexpensive.
- Medium – existing methods can reduce but cannot eliminate adverse effects and can be implemented at reasonable costs.
- Low – current methods do not allow impact mitigation or cannot be used due to extremely high costs compared to the effects.

Step 5

In this stage, the overall prioritization associated with each environmental impact will be analyzed, by determining the significance of the impact, the existence or non-existence of environmental risks and the capacity to carry out actions that will lead to the reduction of these risks.
Following the completion of this stage, it will be determined which of the environmental impacts can be addressed as a priority in order to reduce the environmental impact.
For those types of impact that received a high degree of impact but which ultimately benefited from a low priority score, the analyses will be resumed periodically.

Step 6

All factors that generate medium or high impact will be evaluated, in order to be included in an environmental management plan for the analyzed area. Also, those types of impact that could generate a significant impact at a given time will be taken into account.

It will be assessed whether the lack of a score revealed by an environmental impact significance matrix signifies

the absence, diminution, cessation of the effect of an impact factor with a positive role or, conversely, the lack of information to decide whether any negative impact on the environment represents a significant risk factor or the information is simply insufficient to decide whether an environmental impact has a negative role.

Step 7

In the 7th step of the methodology, the final report will be drafted, which will include the assessed prioritization for each factor, justifying the prioritization in such a way that stakeholders can act accordingly.
The report should focus on the environmental aspects in which stakeholders who can act to reduce the impact have been identified.

The report will briefly present the procedure for identifying and prioritizing impacts and justify the methodology used, and will present those types of impact that were considered to have a major impact and received a high or medium prioritization score. The scope of the assessment carried out and the competence of those who made the respective decision will be specified.
The report will be verified and accepted by the working group.
Possibly, an environmental impact statement can be issued to inform decision-makers about the essential aspects of the assessment.

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