EUROPEAN COOPERATION IN SCIENCE & TECHNOLOGY

Brussels, 17 May 2024

COST 073/24

DECISION

Subject: Memorandum of Understanding for the implementation of the COST Action "Effective Lake management: reducing cyanobacteria by actions in the catchment" (CYANOACTION) CA23160

The COST Member Countries will find attached the Memorandum of Understanding for the COST Action Effective Lake management: reducing cyanobacteria by actions in the catchment approved by the Committee of Senior Officials through written procedure on 17 May 2024.

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MEMORANDUM OF UNDERSTANDING

For the implementation of a COST Action designated as

COST Action CA23160
EFFECTIVE LAKE MANAGEMENT: REDUCING CYANOBACTERIA BY ACTIONS IN THE CATCHMENT (CYANOACTION)

The COST Members through the present Memorandum of Understanding (MoU) wish to undertake joint activities of mutual interest and declare their common intention to participate in the COST Action, referred to above and described in the Technical Annex of this MoU.

The Action will be carried out in accordance with the set of COST Implementation Rules approved by the Committee of Senior Officials (CSO), or any document amending or replacing them.

The main aim and objective of the Action is to broaden capabilities throughout Europe for effective and sustainable management of water resources suffering from cyanobacterial blooms applying a catchment wide approach. CYANOACTION will protect human and environmental health by creating an interdisciplinary network of experts, living labs, stakeholders, managers and decision makers. This will be achieved through the specific objectives detailed in the Technical Annex.

The present MoU enters into force on the date of the approval of the COST Action by the CSO.

TECHNICAL ANNEX

OVERVIEW

Summary

The increasing occurrence of toxic cyanobacterial blooms as a consequence of anthropogenic nutrient pollution in fresh water ecosystems threatens water security and quality worldwide for humans, animals and severely disrupts ecosystem balance. Therefore, the implementation of thorough monitoring strategies for cyanobacteria along with evaluation of the risks of bloom incidents and a plan for prevention and control measures are now required in water safety plans by water suppliers. The significant economic losses to water companies, fisheries, recreational activities and businesses caused by cyanobacterial blooms require greater attention from policymakers. A suite of in-lake control methods exists, but there is little guidance on their efficiency. Decreasing nutrient input from the catchment is crucial for long-term prevention/ reduction of blooms and would be possible by the transition towards a more sustainable low nutrient leakage agriculture, but needs implementation strategies. The proposed COST action aims to increase and broaden capabilities throughout Europe for effective and sustainable management of water resources with a catchment wide approach by creating a unique network of experts, end users and stakeholders. Gathering and distributing information on early warning detection methods and experience in the effectiveness on both long and short-term control methods will underpin Decision Support Tools for water managers and authorities ensuring selection of appropriate methods for a specific waterbody. The overarching goal is a close exchange between scientific knowledge and management practices in order to decrease cyanobacteria blooms taking into account the different characteristics of the water body and its catchment and the regulation throughout Europe.

Areas of Expertise Relevant for the Action	**Keywords**
● Biological sciences: Environmental and marine biology ● Agriculture, Forestry, and Fisheries: Sustainable Agriculture ● Earth and related Environmental sciences: Terrestrial ecology, land cover change ● Chemical sciences: Analytical chemistry	● Cyanobacterial blooms ● Catchment ● water security ● preventive control actions ● curative control actions

Specific Objectives

To achieve the main objective described in this MoU, the following specific objectives shall be accomplished:

Research Coordination

- To raise awareness of citizens and end-users on cyanobacterial issues including occurrence, impacts and management.
- To determine economic losses of monitoring and control of cyanobacterial blooms at a regional/national/EU level, developing international guidelines for a more comparable approach in state-of-the-art economic valuation. This will include costs of increased drinking water treatment, provision of alternative drinking water, and economic losses to recreation, tourism, fisheries and agriculture.
- To provide guidance on selection of monitoring methods for cyanobacteria and cyanotoxins in EU waters based on existing overviews including new methods such as use of drones, citizen science and remote sensing.
- To asses knowledge gaps and needs of water managers concerning monitoring of cyanobacteria and cyanotoxins, tools for lake system analysis and the effectiveness and use of management tools to control cyanobacteria and/or restore lakes to a good ecological status.

● To gather, adapt and distribute knowledge about methods to decrease nutrient losses from farmland including possible financial supports for the agricultural changes.
● To consolidate and harmonize existing actions taken controlling cyanobacteria in EU based on Visser et al. (2016) into one integrated Open Access (OA) database, included on the COST Action webpage (www.cyanoaction.eu) contributing to knowledge dissemination on effective management strategies.
● To evaluate the cost-effectiveness of methods controlling cyanobacteria and cyanotoxins. Development of fact sheets and an online toolbox on lake system analysis and individual methods with pros and cons for waterbody types, usages, geohydrological catchment conditions and climate types.
● To create an effective communication and technology transfer network between scientists, water managers, environmental agencies and health authorities at regional/national/ EU on advice and feedback from experience in cyanobacterial/ cyanotoxin monitoring and management.
● Development of Decision Support e-Tools for choosing suitable and sustainable methods for monitoring and controlling cyanobacteria and their toxins in waterbodies using also LCA according to ISO 14040. The tools will be open access to be used by water laboratories and authorities.

Capacity Building
● To promote citizens' involvement in identifying monitoring and communicating risks. Citizen science activities will be organized, e.g. through phone-based cyanobacteria alert systems, etc.
● To develop and share expertise to choose adequate detection methods for cyanobacteria and cyanotoxins for water-, environment- and health-managers and translate guidelines and regulations into practical monitoring methods.
● To develop and transfer expertise on the importance of detailed knowledge of water and nutrient sources and how to determine water and nutrient budgets for specific lakes/reservoirs.
● To develop and disseminate of expertise for lake system analysis and for choosing adequate methods controlling cyanobacteria. Collating information about mechanisms of action and impacts of these methods on aquatic organisms other than cyanobacteria, applying a web-based DSS.
● To develop and transfer expertise on nutrients leaking from the catchment, methods how to reduce nutrient loss from agricultural fields and how to motivate and support farmers (financial tools) and to control effort or success.
● To harmonize capacities and expertise across Europe from which countries that are less advanced in the field, including COST Inclusiveness target countries (ICTs), will profit. In all activities, participation from COST Inclusiveness target countries will be promoted.
● To contribute to development of Water Safety Plans and EU Bathing Water Directive. Incorporation of benthic cyanobacteria and pico-cyanobacteria in guidelines.

TECHNICAL ANNEX

1. S&T EXCELLENCE

1.1. SOUNDNESS OF THE CHALLENGE

1.1.1. DESCRIPTION OF THE STATE OF THE ART

The **increasing occurrence of cyanobacterial blooms** in fresh water ecosystems threatens water security and quality across the globe (Ho et al., 2019). Cyanobacterial booms severely disrupt ecosystem balance, and they are hazardous to humans and animals due to the production of **cyanotoxins**. Out of 183 poisonings from toxic cyanobacteria, 63% involved animals and 32% involved humans (Svircev et al., 2019). **Eutrophication**, (excess phosphorus and nitrogen) from anthropogenic activities has been identified as main driver (Zepernick et al., 2022), with additional stimulation from **climate change**. Extreme weather events like heavy rains increase nutrient runoff from land, further exacerbating eutrophication (Sinha et al., 2017). Global warming and droughts extend stratification in lakes, which favours buoyant, potentially toxin-forming cyanobacteria (Paerl & Huisman, 2008) and longer summers prolong their growing season (Wagner & Adrian, 2009). Cyanobacteria thus pose an increasing threat to both, environment and society by impairing surface water quality and safety for drinking water production, for fishing, for recreational activities, and for their good ecological status according to the Water Framework Direction (WFD, European Community 2000; Huisman et al. 2018).

The presence of cyanobacteria causes significant **economic losses** to water companies, fisheries, recreational activities and businesses needing pure water (e.g. Hamilton et al., 2014; Sanseverino et al., 2016). Additionally, indirect exposure from contaminated food following irrigation with water containing cyanotoxins has alerted the European Food Safety Authority (EFSA) (Testai et al., 2016). Cyanotoxins led to the 2014 Toledo (Ohio, USA) drinking water crisis requiring a distribution of bottled drinking water (Steffen et al., 2017). Reducing the societal and economic costs of eutrophication requires much greater attention from policymakers. These costs exceed billions of dollars each year in OECD countries (OECD, 2017), and a comprehensive analysis will be provided by this COST action.

Based on available toxicological data, the WHO established a provisional health safety guideline value for drinking water of 1 $\mu g\ L^{-1}$ for one of the most potent and commonly occurring cyanotoxins, microcystin- LR (MC-LR, Chorus & Bartram, 1999; WHO, 2003 and 2011; Chorus & Welker, 2021). Recently, the EU included MC-LR in the updated **Drinking Water Directive** DWD (**2020/2184**). Therefore, a risk-based approach using **water safety plans** (WSPs) must be developed by water suppliers, leading to the implementation of thorough monitoring strategies for cyanobacteria along with evaluation of the risks of bloom incidents to public health and a plan for prevention and control measures. This COST action will support all water-related stakeholders.

Cyanobacterial and cyanotoxin detection methods, derived from the WHO guidelines, are essential in implementation of national monitoring strategies, however with great variation between countries (Ibelings et al., 2014). Harmonisation of key methods is needed to advise on monitoring approaches and guidelines across the EU. The **Bathing Water Directive** of 2006 (2006/7/EC) addresses the monitoring of cyanobacteria to timely identify risks and to take measures to inform and protect the public. There is however, still a lack of clarity and consistency needing improved guidance on monitoring and management (Brouwer & Deblois, 2008). Both for drinking and bathing waters, a comparative review including an evaluation of existing methods for monitoring and management measures evaluation is essential. A goal of this action is to provide sufficient information to support the goals of these two directives. Moreover, all existing guidelines in Europe deal with planktonic cyanobacteria, though **benthic cyanobacterial** blooms have also been associated with animal poisonings (Wood et al. 2020). **Picocyanobacteria** despite being potential cyanotoxin-producers are often overlooked in monitoring due to their smaller size (Jakubovska & Szeląg-Wasielewska, 2015; Wood et al., 2020; Chorus & Welker, 2021). The international consortia of the proposed Cost action will advance developments by exchange of techniques and knowledge including benthic and pico-cyanobacteria.

To prevent or mitigate cyanobacterial bloom development, water managers are faced with many potential methods but there is little guidance on their efficiency. **Decreasing nutrient input from the catchment** is crucial for long-term prevention/ reduction of blooms. Nutrients originating from agriculture, industry and domestic effluents require catchment wide solutions (Le Moal et al., 2019; Chorus & Zessner, 2021). While targeting input from point sources is possible (e.g. improvement of waste water treatment by sequential biofiltration-sedimentation systems), the biggest challenge is to control diffuse introduction via agricultural activities. Amelioration is possible by the transition towards a more sustainable low nutrient leakage agriculture (reduction of fertilizer use, implementation of buffer zones, including biogeochemical barriers) the realization of these methods comes along with economical burdens. The proposed COST action will identify obstacles and solutions to reduce nutrient inputs from the catchment, in collaboration with specific groups (farmers, fishermen, different associations …).

Actions reducing nutrient input can be very effective in reducing cyanobacteria, although the response may be delayed/limited due to internal loading from legacy nutrients in sediments (Sharpley et al., 2013; Ascott et al., 2021). To enhance recovery, or address lakes where external nutrient reduction is not feasible, there are a suite of **in-lake control methods** (Visser et al., 2016), e.g. sediment dredging, hypolimnetic aeration, hypolimnetic withdrawal or artificial mixing. Moreover, chemical lake restoration is possible by addition of modified clays where metal ions bind the phosphate, and the addition of oxidizing products (e.g. hydrogen peroxide) to inhibit cyanobacterial growth (Burford et al., 2019). Many Companies are marketing in-lake remediation products such as ultrasound devices, chemicals or 'effective microrganisms' of which the constituents are not disclosed, whilst promising a high success rate in reducing cyanobacteria with minimal negative long-term ecosystem impacts. Mechanisms and efficiency of many of these products and their potential side effects however, have not been independently verified. Experiences of successes and, equally important, of failures in bloom control strategies have not been shared internationally. Even if water managers are aware of the multiple treatment options, the selection of the most **cost-effective method(s) to combat cyanobacteria** needs to take into account **the conditions for a good success rate** including historical uses, hydrogeochemical, biological factors including characteristics of the dominating cyanobacteria and operational properties of each waterbody**.** Moreover, an overview of investment, annual running and maintenance costs, and economic depreciation over time is beneficial (Ibelings et al., 2014; Meriluoto et al., 2017a). The proposed COST action will provide decision support tools of in-lake methods with their possibilities and limits, costs and conditions for a successful application, taking into consideration the variability of situations within the partner countries.

Successful lake restauration projects typically combine in lake methods with reducing nutrient input by amelioration in the catchment. Hence, an efficient **collaboration of water authorities, health and environment agencies AND specific groups (farmers, waste water treatment, and fishermen)** can prevent or **reduce cyanobacterial blooms in the short- and long-term.** It is essential to **identify** and **quantify** the **blooms** and their **toxins,** when they occur, to assess potential **health risks** for people and animals**,** preferably at an early stage. Subsequently, a **comparative analysis of methods** to control cyanobacteria is required, followed by effective **communication to water managers**, and authorities throughout Europe. **The overarching goal of the proposed COST action is to reduce the gap between scientific knowledge and management practices in order to decrease cyanobacteria in the long run with accessible guidance on the selection procedure from the suite of available in- lake and catchment wide methods.**

1.1.2. DESCRIPTION OF THE CHALLENGE (MAIN AIM)

The main **aim** of CYANOACTION is **to increase and broaden capabilities throughout Europe** for effective and sustainable management of water resources with a catchment wide approach. CYANOACTION aims to **protect water resources, human and animal health** from cyanobacterial blooms and cyanotoxins by **creating an unique interdisciplinary network of experts, water living labs, end-users and stakeholders** including managers and decision makers.

Gathering information on **early warning detection methods and experiences of the cost- effectiveness of both long and short-term control methods** from different countries will be the foundation of two **Decision Support Tools (DSTs)**. The **DST for in lake measures** will function as an adaptive management approach providing an overview of the possible monitoring and management strategies for a particular lake or reservoir and determining the most (cost) effective options. A website
with an online Tool-Box providing information (including further links) on the different methods will assist water managers in decision-making. **CYANOACTION will thus grant access to a wealth of information on water management that is until now inaccessible to many water authorities**. This will improve effective use of financial resources and deliver more sustainable, ecological management of waterbodies in EU. The **DST for reducing losses in the catchment** will provide information of how to identify the main sources of nutrients, to select areas where actions would be most efficient. An online Tool-Box will help identify the most appropriate methods to reduce nutrient loss from the catchment. This Tool-Box will particularily gather information developed in collaboration with specific groups and their associations to increase acceptability and to identify the (financial) requirements for implementation and evaluation of measures to tackle the most

challenging diffuse sources of nutrients.

The main **gaps** identified by the proposers are:

1. **Limited awareness of the public and policy makers** in the recognition of cyanobacterial blooms, and their associated **health risks, economic losses and social costs** including costs spent on monitoring and mitigation to protect recreational activities, and additional costs for drinking water purification and catchment measures.
2. Lack of **links between cyanobacteria and cyanotoxin quantification methods,** and **alert levels**, particular for benthic and picocyanobacteria and the urgency to harmonize practical methods.
3. Lack of **efficient knowledge transfer** between scientists and water managers and limited insight into **factors influencing decision making** by water managers to control blooms and cyanotoxins.
4. Lack of **strategies to include specific groups in a catchment wide approach** in order to efficiently implement mitigation strategies at the source of eutrophication.
5. Lack of accessible reports on actions taken in different countries and the cost-**effectiveness (successes and failures) of methods to control cyanobacteria in lakes and reservoirs**.

The realization of CYANOACTION aims to answer a number of challenges:

1. Significant contribution to the **implementation of the new EU Drinking Water Directive (**2020/2184/EC) that adopts risk-based approaches by incorporating early detection methods of cyanobacteria/ cyanotoxins and their management as key elements in Water Safety Plans and **Bathing Water Directive**.
2. **Consolidation of the fragmented scientific and water management experience** in detection methods and management strategies to enable an integrated risk-management approach that will improve the water quality and health-safety of lakes and reservoirs.
3. Establishment of an **European platform on management of cyanobacterial blooms and cyanotoxin risk management** for cross-sector transfer of knowledge and expertise.
4. Development of in lake and catchment **Decision Support e-Tools** that can be widely used to guide water managers, environment and health authorities in evidence-based decisions to cost-effectively and sustainably combat cyanobacterial blooms and -toxins in natural and controlled waterbodies.
5. Increase **awareness and involvement of citizens of all age**, in recognising and reporting cyanobacterial mass developments (blooms, scums mats) thereby supporting European citizen's initiatives to achieve universal **access to clean and safe water**.
6. Identify point and diffuse sources of eutrophication and increase knowledge and awareness on best agricultural practices and grants to reduce nutrient losses from the fields, including information about political support tools to encourage the necessary agricultural changes.
7. This COST action directly addresses the UN Sustainable development goal 6: Clean Water, goal 3: Good health and well-being, and particularly 14: Life below water.

1.2. PROGRESS BEYOND THE STATE OF THE ART

1.2.1. APPROACH TO THE CHALLENGE AND PROGRESS BEYOND THE STATE OF THE ART

By identification and dissemination of information to all groups concerned (water managers, decision makers and end-users) of the sources and possible application of **multiple control methods**, CYANOACTION increases the understanding that reducing cyanobacterial blooms will only be achievable via a **joint responsibility approach**.

Direct response to limited awareness of the public and policy makers in the recognition of cyanobacterial blooms, their health risks, economic losses and social costs, costs on monitoring and mitigation as well as additional costs for drinking water purification **(gap 1).** To increase public **awareness** of the issue and deliver information for risk management, especially in response to heat waves (Funari et al., 2017), the Action will strengthen the role of the public (i.e. 'citizen science') in the field of cyanobacterial bloom detection via smart-phone applications, such as Bloomin'Algae (https://www.ceh.ac.uk/algal-blooms/bloomin-algae) or Cianobakterije v Sloveniji (www.ciano.si). Significant **economic costs** caused by cyanobacteria (e.g. due to monitoring, bloom control or drinking water treatment) and **losses** to businesses (agriculture, recreation, fisheries and other industries) need better documentation. Few international overviews of these costs (OECD, 2017) exist. For example, costs of eutrophication were estimated to be between 403 and 754 million euros in The Netherlands, while € 150 million in Spain. In

CYANOACTION, we will gather information from EU countries on these incurred costs. These costs will be compared with the costs of in-lake and catchment actions reducing cyanobacteria to **encourage investments preventing cyanobacterial blooms**.

Direct response to the lack of **links between cyanobacteria and cyanotoxin quantification methods,** and **alert levels**, including **benthic and picocyanobacteria** and the urgency to translate guidelines into practical methods **(gap 2).** Risk assessment of cyanotoxins varies with **national guidelines/regulations** despite the fact that WHO published a provisional Guideline Value of 1 µg L^{-1} for MC-LR in drinking water in 1998 (WHO 1998) still using chlorophyll or cyanobacterial cell numbers rather than biovolume (as in many EU WFD assessments) as a proxy (Ibelings et al., 2014; Chorus & Welker, 2021). Underpinned by an excellent overview in the books produced during the CYANOCOST Action (Meriluoto et al., 2017b; Kurmayer et al., 2017) and the new edition of 'Toxic Cyanobacteria in Water' by Chorus and Welker (2021), CYANOACTION will evaluate novel detection and quantification methods and advise on a **reliable and feasible risk assessment of cyanobacterial blooms** with respect to the characteristics of the waterbodies. Attention will be given to benthic and pico- cyanobacteria. Methods, advantages and limitations, of conventional and novel **early detection methods** (earth observation, remote sensing, drones, citizen science, fluorescence) and the possibilities to use modelling for risk assessment will be shared. CYANOACTION findings and recommendations will inform environmental policy, and relevant management literature. **Practical methods quantifying cyanobacterial abundance and/or toxin concentrations will be disseminated** for implementation by local/regional/national authorities, increasing comparability across EU. Moreover, by advising on **creating interactive maps** as a basic early warning system, CYANOACTION will increase possibilities to inform the public locally. CYANOACTION will provide information for incorporating **cyanobacteria and cyanotoxins as key elements of the water safety plans** (WSPs) in the new DWD.

Direct response to the lack of **efficient knowledge transfer between scientists and water managers** and limited insight into factors influencing decision-making by water/environment managers for **controlling blooms and cyanotoxins (gap 3).** The prevention, control and mitigation of cyanobacterial blooms should be preceded by a **system analysis of the particular water body,** including its morphology, a water and nutrient budget identifying all external sources from the catchment as well as internal sources from the sediment, coupled to the ecological and operational context of the system. This will facilitate the decision of the most efficient action(s) to combat cyanobacteria. The proposed COST Action offers a unique opportunity for conducting an **in-depth comparative analysis** which can form the basis of DSTs at EU scale. The scope of LCA (Life Cycle Assessments) will be extended to lake management techniques, providing a holistic evaluation of full environmental impacts of the various alternatives thus supporting cost effective decision making. CYANOACTION will create **a science- policy-practice collaborative platform** to exchange and advance knowledge beyond state-of-the-art.

Direct response to the lack of knowledge to **reduce catchment eutrophication** and strategies to include farmers to efficiently **implement mitigation strategies at the source** to the benefit of both, water safety and farmers' economy **(gap 4).** The most sustainable way to prevent cyanobacterial blooms is to reduce nutrient loadings into freshwaters. A systematic analysis and evaluation of actions taken to motivate and remunerate farmers for reducing nutrient loss (N, P) from their fields will be conducted in the participating countries. Methods to reduce runoff could include implantation of hedges, buffer strips and permanent vegetation cover. The augmentation of soil health by increasing its carbon content offers great potential as it increases water infiltration and nutrient holding capacity. Promising results from projects like EU INTERREG CPES (Channel Payments for Ecosystem Services, https://www.cpes- interreg.eu/en/) or EU INTERREG FABolous Farmers (https://www.fabulousfarmers.eu/en) as well as and Horizon Europe NORDBALT-ECOSAFE (https://cordis.europa.eu/project/id/101060020) will be evaluated to build the base for a DSS for a catchment wide approach to efficiently reduce nutrient inflow to lakes and reservoirs at their source. Efficacy is attained in double sense, by selection of the **methods and targeting high risk areas.** This action will translate knowledge into a DSS adapted to the geohydrological conditions of the respective catchments, and communicate it in vulgarized form to the appropriate channels (chambers of agriculture, farmers' associations, journals etc). The possible financial support tools for farmers to fund these changes shall be gathered and disseminated.

Direct response to the lack of **accessible evaluations of 'in lake' actions** taken and the **cost-effectiveness** of methods to control cyanobacteria and reduce cyanotoxin concentrations in different countries **(gap 5).** Despite the high social and economic costs involved, **information about the outcomes of preventive or control actions** in many cyanobacteria-dominated waterbodies **is scattered** and may only be available locally (some water managers, authorities) or in the scientific literature. In the proposed COST

Action, experiences with the application of different cross-disciplinary evaluation methods will be identified and shared with stakeholders. This includes catchment measures, methods to manage the sediment load and in-lake control actions. Moreover, shedding light on the **mechanisms** by which short-term treatments reduce cyanobacterial growth will improve understanding to optimize and evaluate solutions. The proposed Action will create a network and open platform for sharing **experiences on successes and failures** which will contribute to **Decision Support Tools** (integrating cyanobacterial ecological demands and their densities, hands on lake system analysis tools, lake and catchment history and characteristics, as well as the economics of remediation/management efforts and increasing public awareness). This will improve the selection of cost-effective actions in water management, ensuring health protection, and rapidly expand knowledge across sectors and countries.

1.2.2. OBJECTIVES

1.2.2.1. Research Coordination Objectives

The following Research Coordination Objectives (RC) have been defined in order to achieve the main aim of CYANOACTION and to fill existing gaps (outlined in 1.1.2). Objectives will be achieved by coordination of a trans-disciplinary network of experts, end-users and stakeholders.

RC-1: Raise awareness of citizens and end-users on cyanobacterial issues including occurrence, impacts and management. Making or distributing of videos and E-based mobile applications.
RC-2: Determining the **economic losses** involved in monitoring and control of cyanobacterial blooms at a regional/national/EU level, developing international guidelines for a more comparable, tailored approach in state-of-the-art economic valuation, in particular the use of non-market valuation procedures following state-of-the-art guidelines (e.g. Johnston et al., 2017). This will include costs involved in increased drinking water treatment, provision of alternative drinking water supplies, and (the avoidance of) economic losses to recreation, tourism, fisheries and agriculture.
RC-3: Providing guidance on selection of monitoring methods for cyanobacteria and cyanotoxins in EU waters based on existing overviews (Meriluoto et al., 2017b; Kurmayer et al., 2017; Chorus & Welker, 2021) including **new methods such as use of drones, citizen science and remote sensing**. Development of **standardized protocols** to translate alert guidelines and regulations into practical monitoring methods.
RC-4: Assessing knowledge gaps and **needs of water managers** concerning monitoring of cyanobacteria and cyanotoxins, tools for lake system analysis and the effectiveness and use of management tools to control cyanobacteria and/or restore lakes to a good ecological status.
RC-5: Gather, adapt and **distribute knowledge about methods to decrease nutrient losses** from farmland including possible financial supports for the agricultural changes. **Develop a DST** to chose most efficient **methods to reduce nutrient losses**.
RC-6: Consolidation and harmonization of existing actions taken to control cyanobacteria in EU based on Visser et al. (2016) into **one integrated Open Access (OA) database**, included on the COST Action webpage (www.cyanoaction.eu) contributing to knowledge dissemination on effective management strategies.
RC-7: Evaluation of the cost-effectiveness of methods to control cyanobacteria and cyanotoxins. Development of fact sheets and an online toolbox on lake system analysis and individual methods with pros and cons for waterbody types, usages, geohydrological catchment conditions and climate types. **RC-8:** Creation of an **effective communication and technology transfer network between scientists, water managers, environmental agencies and health authorities** at regional/national/ EU on advice and feedback from experience in cyanobacterial/ cyanotoxin monitoring and management.

RC-9: Development of **Decision Support e-Tools** for choosing suitable and sustainable methods for monitoring and controlling cyanobacteria and their toxins in waterbodies using also LCA according to ISO 14040. The tools will be open access to be used by water laboratories and authorities.

1.2.2.2. Capacity-building Objectives

CC 1: Promotion of citizens' involvement in identifying monitoring and communicating risks. Citizen science activities will be organized, e.g. through phone-based cyanobacteria alert, as discussed above.

CC 2: Development and sharing of expertise to choose adequate detection methods for cyanobacteria and cyanotoxins for water-, environment- and health-managers and translate guidelines and regulations into practical monitoring methods. Organization of **training schools** (> 20 trainees) of Early Career Investigators (**ECI**s) and young water and environmental health professionals in **detection methods**.

CC 3: Development and transfer of expertise on the importance of detailed knowledge of water and nutrient sources and how to determine water and nutrient budgets for specific lakes/reservoirs. Organization of **training schools** on **waterbody analysis** (> 20 trainees), **international mobility, particularly for ECIs**.

CC 4: Development and dissemination of expertise for lake system analysis and for choosing adequate methods controlling cyanobacteria. Collating information about mechanisms of action and impacts of these methods on aquatic organisms other than cyanobacteria, applying a web-based DSS. Training of a new generation of researchers and water and environmental health professionals in **in lake control methods** using workshops > 20 trainees.

CC 5: Development and transfer of expertise on nutrients leaking from the catchment, methods how to reduce nutrient loss from agricultural fields and how to motivate and support farmers (financial tools) and to control effort or success. Organization of **training schools in catchment amelioration** for > 20 trainees including policy makers, farmers, and representatives from their associations. Include international exchange for ECIs.

CC 6: Harmonize capacities and expertise across Europe from which countries that are less advanced in the field, including COST Inclusiveness target countries (ICTs), will profit. In all activities, participation from COST Inclusiveness target countries will be promoted.

CC 7: Contribution to development of **Water Safety Plans** and **EU Bathing Water Directive** (review beginning in 2023). Incorporation of benthic cyanobacteria and picocyanobacteria in guidelines.

2. NETWORKING EXCELLENCE

2.1. ADDED VALUE OF NETWORKING IN S&T EXCELLENCE

2.1.1. ADDED VALUE IN RELATION TO EXISTING EFFORTS AT EUROPEAN AND/OR INTERNATIONAL LEVEL

The proposed COST Action will build on outcomes from CYANOCOST (ES 1105) which included the scientific understanding of cyanobacteria occurrence, driving factors, monitoring and cyanotoxin analysis. Europe has excellent scientists working in this field and vast experience has been gained by water- and environmental managers on preventive and control actions. CYANOACTION will take it a step further, by providing an EU wide overview of methods and strategies, and advising on the best practise to control and mitigate blooms, bridging science to management.

We are aware of **several EU and international research projects related to cyanobacteria**, for example the projects ‘Mantel’: on the impact of extreme climate events on lake water quality (2017-21); ‘CyanoAlert’: a space-based application for assessing cyanobacterial bloom occurrence in lakes (2016- 20); Project CYANOTECH: management system for toxic cyanobacteria blooming of surface waters with combined energy production, sustainable agriculture, and food safety; EU-LIFE project ‘Algae’ – economy based ecological service of aquatic ecosystems (2017-2020); IP LIFE PL Pilica Basin CTRL ‘Implementation of River Basin Management Plan in the Vistula basin on the example of Pilica river catchment’ (2021-2030); EKOROB “Ecotones for reducing diffuse nutrient pollution from agriculture” (LIFE08 ENV/PL/000519). A collaboration will be established with the participants of WATERTOP (COST Action CA18225, 2021-2023) focussing on taste and odour compounds that can be formed (partly by cyanobacteria) during the production of drinking water. The Action will benefit from results obtained in the international project ‘Developing Guidance for Assessment and Evaluation of Harmful Algal Blooms, and Implementation of Control Strategies in Source Water’ which has similar aims as this proposed Action but is situated in Canada, USA and Australia, finalised 2022. The proposed Action will also collaborate with the UNESCO ‘GlobalHAB’ programme. Concerning the studies in the catchment and improvement of agricultural practises, COST Action will profit from results of two EU-INTERREG projects: CPES (Channel Payment for Ecosystem Services, 2017-2022) for monitoring and incentive payments, and FAB (Fabulous Farmers 2018-2023) for monitoring, as well as from other projects such as the Farm Carbon Toolkit and AZOSTOP, which develops and implements innovative biotechnological products for agriculture and wastewater management (e.g. (Patent PL 241 486 B1 Sequential
Wastewater Biofiltration System; Patent PL 235 338 B1 Modular Organic Manure Plate). For in lake methods: amongst others ALGICYDY will be contacted, aiming at isolation, identification and characterization of algicidal bacteria as a potential factor controlling the occurrence of freshwater toxic cyanobacterial blooms.

2.2. ADDED VALUE OF NETWORKING IN IMPACT

2.2.1. SECURING THE CRITICAL MASS, EXPERTISE AND GEOGRAPHICAL BALANCE WITHIN THE COST MEMBERS AND BEYOND

Evaluating the risks to the environment, animal and human health along with combatting cyanobacterial blooms requires expertise and contributions from different scientific disciplines as well as interaction with stakeholders to raise awareness facilitating wide uptake of the best available tools and techniques. Moreover, there is an urgent need for rapid, cost-effective and reliable methods of cyanobacterial risk assessment for implementation of the upcoming revision of the European Bathing Water Directive (beginning of 2023) and of the Water Framework Directive. It is essential to harness fragmented expertise into an international multidisciplinary network focused on water management. The network of proposers encompasses all disciplines and expertise that were identified as essential to achieve the Action's objectives, as well as a balanced participation of researchers and end-users (see table 1). Several of the proposers are closely involved in national expert groups advising governments and stakeholders on cyanobacterial monitoring and control.

Table 1: Necessary expertise already included in the network of proposers

Bloom detection methods	Microscopy, taxonomy, fluorometry, remote sensing, drones, molecular methods, chemical analysis of cyanotoxins and other bioactive compounds,
Integrated preventive ecosystem approaches	Physiology and ecology of cyanobacteria, analyses of physicochemical and hydrogeolocical parameters in lakes and catchments, lake system analysis, reduction of nutrients loss in catchments, establishing of nutrient balances, assessment of catchment nutrient budgets
Health, economics and social sciences	Health hazard and risk assessment, costs and benefits of risk mitigation strategies associated with blooms, citizen science, phone applications on blooms. Support in DST development, design and testing of web-based tools incl. website manager support on making and editing scientific videos for stakeholders and the general public.
Control actions	Short-term control and long-term prevention approaches

The network of proposers has a good geographical distribution throughout the EU and beyond to ensure wide experience of different climatic, environmental and social factors. Moreover, it ensures involvement of and dissemination of information between science, management and society. The already large size of **the team of participants, from throughout Europe (23 full member European countries) and beyond (4 international partners), presents an unprecedented opportunity creating an environment for exchange and breakthrough**. It encompasses more than 50% ITCs and has defined involvement of ECIs as a priority. This is to exchange experiences of successful and unsuccessful tested methods of catchment management and in-lake control measures. This exchange of methods and experiences from different countries, may include modern methods where trials have been carried out, to better disseminate conditions for success. Due to the urgence of the challenge (water safety), **it is expected that during the 1st year all COST countries and more NNC-IPC countries will join the Action, as the network will remain open**.

2.2.2. INVOLVEMENT OF STAKEHOLDERS

Key experts, end-users and stakeholders who need to be involved in order to achieve the objectives and to maximize the Action's impact include: Scientists (environmental science, aquatic ecology, toxicology, engineering and technologies), Water authorities (responsible for water quality in lakes), including water managers, Drinking water companies and authorities, Water quality laboratories (contract laboratories, water authorities, living labs), Local communities and authorities responsible for a water body and its catchment, Competitiveness clusters specialised in the water sector, Farmers and their associations, Operational Groups of European Innovation Partnership-Agri and EIP-Water.Public health authorities and organisations, Experts on environmental impacts, economists, Water treatment engineers and national environment agencies/associations, citizens interested in water quality for recreation (watersports, anglers, dog owners).

The Action proposes a **multi-disciplinary approach** that is required to solve the complex problems of detection and mitigation of cyanobacteria and cyanotoxins. Researchers from the above fields, and water management experts are included in the core group of proposers from multiple European countries, while **additional expertise** will be included when and where needed during the course of the Action, as **the network will remain open and inclusive. Water companies and monitoring enterprises are already involved in the network. Industrial sectors** relevant to the Action's objectives concern analytical technology and instrumentation, and companies involved in different short- term control measures and ICT technologies (for mobile app for citizen science). Workshops dedicated to the European water sector are included in the Action's work plan. **Water authorities** across Europe are the key end-users targeted by the Action and are already within the group of proposers and more will be invited to become Action members. Local meetings will be organised to actively include water managers. **Water quality laboratories**, are also identified as end-users and will be invited to become members and/or join the local meetings organized by the Action to benefit from a guidance in detection and monitoring methods which can increase comparability between the water bodies. Connection to Water Europe (http://watereurope.eu/), a platform for water technologies, and Global Water Partnerhip (https://www.gwp.org/) will enable a wider dissemination of the results to end-users. Farmers and their associations are in the center of the target groups in order to support necessary changes of agricultural practices. Following the kick-off meeting, participants will be assigned roles and additional stakeholders invited to ensure balanced network.

3. IMPACT

3.1. IMPACT TO SCIENCE, SOCIETY AND COMPETITIVENESS, AND POTENTIAL FOR INNOVATION/BREAKTHROUGHS

3.1.1. SCIENTIFIC, TECHNOLOGICAL, AND/OR SOCIOECONOMIC IMPACTS (INCLUDING POTENTIAL INNOVATIONS AND/OR BREAKTHROUGHS)

Scientific impacts: The multi-disciplinary approach of the proposed COST Action will connect the existing strong research in Europe to stakeholders and practical applications, creating an important feedback loop from their implementation to science. The methods and strategies have been developed by scientists (being experts in various fields, table 1), and an international comparison of the outcomes (positive, negative, conditions) including lake management provides a unique opportunity for adjustments and extending of expertise. Moreover, focusing on the catchment offers the possibility to centralize data of an EU-wide hydrogeological variety to further develop and spread expertise concerning the models identifying high risk areas and the success of preventive methods.

Technological / economic impacts: The Action will promote the development and application of DST for controlling cyanobacteria by preventive and control methods. By using this tool, choosing the most appropriate method will be founded on an evidence-based comparison of the characteristics of the waterbody to similar scenarios already conducted in Europe and via the input of international partners from outside Europe. Both, successful and non-successful trials including reasons for their failure will be included to increase the success rate and save money. This more targeted approach will moreover reduce the impact on the environment. Drinking water purification, recreation, fisheries and agriculture are important economic sectors which will benefit from the outcome of this Action as lake activities and usage of water are frequently banned during the high- (and dry) season due to cyanobacterial blooms. The DST will take into account the associated costs, environmental and total sustainability impacts.

Socioeconomic and environmental impacts: Bringing together and prioritize analytical, diagnostic and predictive capabilities for cyanobacterial blooms and cyanotoxin production (which are not linearly linked), in combination with the evaluation of control and preventive methods will increase understanding in the protection of environmental, human, and animal health. The Action will improve public awareness about eutrophication as driver of cyanobacterial blooms, its sources of and how these can be reduced in collaboration with the farmers. Moreover, that the use of control actions is adequate in emergency situations only, while aiming for long-term restoration actions in the catchment. Hence, the Action will further contribute to the protection of anthropogenic impacted tributaries and farmland by reducing nutrient losses. Development of expertise through training and exchange will provide lake and environmental managers, and also engineers and technicians in the European water sector with valuable additions to their professional skills.

Breakthroughs: The proposed Cost action focusses on **solutions** to reduce the development, size, spread and duration of cyanobacterial mass populations (i.e. blooms and mats), by following a multi- disciplinary approach, with feedback loops from management and society that weren't existing in that way before. It will gather and **disseminate information** about water body restoration that were either scattered or not easily available for the different groups before, or are **of highest actuality** from ongoing projects in different participating countries. This COST Action is thereby contributing to **strengthening European research and innovation capacities**, and supports the COST policy on Excellence and Inclusiveness. CYANOACTION will provide the chance for technical improvement by multiple methods approach, following decision support systems for in lake and catchment methods to improve water quality, with improved efficiency measurements by multiple detection methods (early warning, remote sensing, citizen science and modelling).

3.2. MEASURES TO MAXIMISE IMPACT

3.2.1. KNOWLEDGE CREATION, TRANSFER OF KNOWLEDGE AND CAREER DEVELOPMENT

The Action proposes a major step forward towards connecting societal needs of safe surface water with environmental and health protection by pursuing a holistic approach of targeted waterbody/catchment management to reduce cyanobacterial development. The Action integrates the following knowledge exchange activities (conducted in workshops including stakeholders and working group meetings) to accomplish its goals:

- Transdisciplinary exchange with mutual transfer of knowledge, expertise, experience between scientists including ECIs and specialists in field applications, unifying risk assessment and management of waterbodies, with a particular focus on environmental and human health.
- Transdisciplinary exchange with farmers and their associations and policy makers to identify strategies to implement methods reducing nutrient loss from the fields.
- Creation of an interactive platform assembling evaluated data and experience on the monitoring and treatment of cyanobacteria and cyanotoxins and on agricultural practices via distance learning (mooc, massive open online course) accomplished by workshops and seminars, with high potential for use by practitioners and stakeholders as well as ECIs.
- Integration across different sectors and stakeholders connected to lake and reservoir management, and water industry, water authorities, analytical technologies, IT technologies, recreation- and tourism-related enterprises, and catchment-related activities.
- International collaboration for mutual benefit with top expert groups in the field, e.g. from the USA, Australia, New Zealand and Canada.

The multidisciplinary environment created by the network of CYANOACTION is ideal for career development. Transfer of knowledge and expertise across disciplines and sectors in training schools and workshops will broaden the knowledge and skills of personnel, ranging from analytical skills, risk assessment and IT development to waterbody management including the catchment. The action will use Mentoring for professional development of ECIs setting up a **mentor-mentee program**.

3.2.2. PLAN FOR DISSEMINATION AND/OR EXPLOITATION AND DIALOGUE WITH THE GENERAL PUBLIC OR POLICY

An integrated dissemination/exploitation plan (described in WG 5) includes the scientific community, the general public and the exploitation (IPR management). For the **exploitation** of results and outcomes it will use virtual (e.g. webinar) and in-person activities, dissemination channels, and multiple media to target all stakeholder groups to maximize impact. WG 5 receives input from all WGs, and disseminates the output of joint activities and workshops to stakeholder groups, associations and agencies, e.g. with water managers, local authorities, water, environmental agencies and NGOs involved in lake and catchment management.
A special emphasis is on information targeted to water managers, farmers and stakeholders – in the form of a **web-based platform** raising awareness of cyanobacterial problems, mitigation strategies, informing on activities and outputs, **translated in EU national languages and freely accessible**. Moreover, results and recommendations will be published in vulgarized form in appropriate national journals for the water and agricultural industry.
Scientific review papers will be a joint action of several participants with experience of cyanobacterial bloom and cyanotoxins risk management. The Action will further support authorship by ECIs and published papers resulting from STSMs. The Action will promote and fund OA publications where possible. In addition to publishing in international peer-reviewed academic journals, several of the proposers have a good track record in publishing in the key journals which are consulted by water scientists and managers such as Water Research).
The Action will co-organize sessions at well-known **international scientific conferences** in the field (e.g. the International Conference on Toxic Cyanobacteria, International Conference on Harmful Algae,
Shallow Lakes Conference). These can increase awareness of strategies to reduce cyanobacterial blooms, and foster the exchange of knowledge and ideas within the wider scientific community. Participation of Early Career Investigators, especially those from COST Inclusiveness target countries (ITCs), in such international conferences will be promoted and funded through conference grants.
To communicate to the general public, the proposed COST Action's media will include:
A dedicated **website** presenting the Action's activities & outputs: database including a **toolbox**, publications, videos and **decision support tools**. Targeted information videos will be developed to enhance public awareness and linked to promotion and adaptation of a citizen science-based smart phone application to identify and alert of cyanobacterial blooms will also be carried out.

A Facebook page and a X-account will be integrated to increase visibility to wider audiences. An e- Newsletter distributed to members and subscribers will be distributed regularly. The Action does not have as the main aim to create intellectual property; however, it is possible that certain activities may have results with IPR interest. In these cases, IPR will be identified and agreed between the parties involved throughout the Action.

4. IMPLEMENTATION

4.1. COHERENCE AND EFFECTIVENESS OF THE WORK PLAN

4.1.1. DESCRIPTION OF WORKING GROUPS, TASKS AND ACTIVITIES

Five Working Groups (WG) that are interconnected and interrelated have been defined in the proposed Action (Figure 1): **WG1:** Early warning methods for/and detection of cyanobacterial mass populations (blooms, scums, mats), risk assessment, **WG2:** Catchment management measures (long- term), economic costs. **WG3:** Evaluation of in-lake control methods (short-term), **WG4** Development of web-based tools and Decision Support System, **WG5:** Dissemination**.** Dissemination and exploitation of results are key products of the working plan, and are coordinated by WG5 of the Action but will receive input from WG1-WG4.

A Core Group will be set up (leaders from WG1-4) in charge of monthly virtual WG meetings to organize work flow. Meetings of the whole groups shall be 2 per year, one virtual and one in persona.

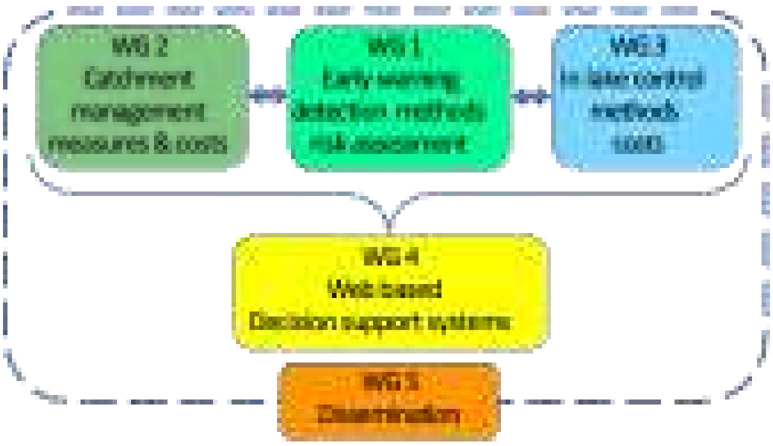

Figure 1: Interactions of the WGs.

We will implement a **novel system to promote the involvement of stakeholders**. The input and training of water managers is crucial in this Action, and need national and/or online meetings in addition to the international ones. **Participants in different countries will join local / national meetings** to which water managers, farmers and other stake holders will be invited. In this way, **many stakeholders can be involved** in the COST Action and a **maximum of exchange** about their needs and transfer and dissemination of knowledge can be achieved.

Working Group 1. Early warning methods for detection of blooms, risk assessment, citizen science
This WG will critically examine the monitoring of cyanobacteria and cyanotoxins highlighting best methods to help water managers assess the risk of their waterbody to cyanobacterial proliferation, in-line with guideline or regulatory alert levels. Methods currently being used to assess cyanobacterial and cyanotoxin occurrence range from *in situ* methods (water sample analyses, fluorescence probes, sensor-based systems) to remote methods (satellite, LIDAR, drone). Cyanobacterial abundance is expressed as cell numbers, biovolume, as chlorophyll a concentration, or as specific cyanobacterial pigment concentrations as proxies of biomass. Cyanobacterial taxa composition has traditionally relied on microscopic identification and taxonomic expertise, while cyanotoxins have been determined using chemo- and bioanalytical methods. Newly developed 'omics' methods based on specific genes or their expression could serve as management tools due to their fast analysis, high accuracy and low costs. Early warning alert methods using autonomous monitoring systems are becoming popular due to their practicality but their reliability needs to be evaluated. Public engagement in detection of cyanobacterial blooms will be achieved (i.e. 'citizen science') via smart-phone applications.

Tasks	
1.1.	Assess knowledge requirements of water managers and other end-users concerning cyanobacterial early warning detection methods. Questionnaires will be used (prepared in WG4) to reach a maximum of end-users.
1.2.	Assemble and assess the available and innovative methods used to detect, identify and quantify cyanobacteria and cyanotoxins (including costs, rapidity of results, technicality).
1.3	Provide standardized practical protocols for risk assessment of cyanobacteria and -toxin detection including links between diagnostic methods and alert guidelines and regulations.
1.4	Identify gaps in detection protocols and European alert guidelines (e.g. picocyanobacteria and benthic cyanobacteria) and how to close them.
1.5	Promote, refine and disseminate existing mobile phone-based alert application for cyanobacterial bloom occurrence and identification.

1.6	Summarize state of the art and progress of cyanobacterial monitoring in a review paper. Vulgarize this review to disseminate in appropriate channels to managers and stakeholders
Activities	
1.1.	Group meeting to coordinate synthesis of pros and cons of detection methods and develop intuitive workflows.
1.2.	Establishing contact to stakeholders and creating, sending and evaluation of questionnaires understand their needs and develop practical detection protocols
1.3.	Group meeting to propose practical and reliable protocols to link detection methods to alert guidelines and regulations, including picocyanobacteria and benthic cyanobacteria.
1.4	Workshops for end-users on practical protocols of detection of cyanobacteria and -toxins including citizen science implementing mobile phone cyanobacterial alert applications and presenting videos on cyanobacterial issues
1.5.	Short Term Scientific Missions (STSMs) and Conference Grants supporting PhD students and ECI researchers from Participating Inclusiveness Target Countries (ITCs) on early warning methods for detection of blooms (at least 5 STSMs, 1 conference grant).
1.6.	Editorial meetings to plan review papers and practical guideline literature (visio).
Milestones (time in months) or number at the end of the action	
1.1.	Mid-term review of WG1 activities in Core Group meeting (24 m).
1.2	Number of end-users and ECIs trained on practical protocols of detection of cyanobacteria and cyanotoxins.

Working Group 2. Catchment management measures (long term), economic costs WG 2 will provide an overview of actions for long-term reduction of blooms by reducing the inflow of nutrients. Activities to reduce nutrient (P and N) losses from fields vary considerably between European countries from non-existent to control by measuring remaining saturation in the soil (e.g. to remunerate farmers' efforts). Also, the reduction of nutrient losses from point sources (e.g. sewage treatment plants, industries, townships, cities) vary among countries. Moreover, most remedial actions come along with financial costs that have to be borne by governmental or private organizations or stakeholders, which adds to the pressure to be cost-effective. Costs can be directly involved in construction or amendment (e.g. waste water treatment, diverting channels) or indirectly by compensating farmers for their efforts (investments in surface cover, lower harvest yields). As this is handled very differently in the participating countries, mutual inspiration can be expected. Outcome of this WG will be a toolbox of available methods and strategies to analyse nutrient losses and methods to reduce these losses with an evaluation of their mitigation capacity and included costs. A Decision Support Tool will be developed with this input which targets farmers and financing stakeholders.

Tasks	
2.1.	Development of a toolbox with available methods and strategies to assess nutrient losses from agricultural land, forestry and point sources (web-based).
2.2.	Development of a database with information on the actions taken and their effectiveness in reducing nutrient losses from the catchment, including diffuse and point sources at different scales, from local to EU. Selection of operational monitoring parameters.
2.3	Generation of a database with costs and economic losses caused by cyanobacteria and actions taken to combat them.
2.4	Summarizing the comparison of the actions taken in various countries in a review and vulgarisation and dissemination of the results to farmers and stakeholders
Activities	
2.1.	Workshops with stakeholders (farmers, water managers, policy makers etc.) on methods and their implementation costs to successfully reduce nutrient loss from farmland and point sources. STSMs and conference grants especially for ECI researchers from ITCs on ecosystem management (< 5 STSMs, 2 conf. grants).
2.2.	Distribution of information on existing strategies and possibilities at national or European level for compensation to farmers for their efforts.
2.3	Assembling information from national water authorities on current cyanobacteria-related activities and associated financial costs/losses. Questionnaires/interviews of water-users (recreation, fishing) assessing the value they allocate to benefit from clean water.
2.4.	Editorial meetings for the development of the database on different actions and their effectiveness, the compensation possibilities and writing of the review.
Milestones (time in months) or number at the end of the action	
2.1.	Mid-term review of WG2 activities in Core Group meeting (24 m).

2.2.	Number of end-users and ECIs trained on the selection of methods which can successfully reduce nutrient loss from farm land and point sources

Working Group 3: Evaluation of in-lake control methods (short term) for cyanobacteria and their economic costs. In this working group, local protocols and results including the criteria for success or failure of the method will be gathered, translated to English to incentivize knowledge sharing and included in the Actions web-page. Most short-term methods either work directly on the inhibition of cyanobacterial growth (chemically) or indirectly decreasing the resources including light (ultrasound, artificial mixing) or phosphate by reducing the internal loading (e.g. flocculation and locking techniques, hypolimnetic aeration and withdrawal). Although experience has been gained with these methods, results are rarely published in scientific literature, especially if they were less successful. If published, guidance and results obtained are described locally, written in the respective language, which makes them almost inaccessible in other countries. Protocols, costs and input for the DST and a review (plus its vulgarisation) comparing various methods will be important outcomes of this WG.

Tasks	
3.1.	Development of a database with information on the actions and effectiveness of short-term in-lake methods to control cyanobacteria. Selection of operational monitoring parameters.
3.2.	Development of a web-based platform with information on every method to be used in the DST including mechanisms of action, success, applicability and costs.
3.3	Writing a critical review comparing actions taken to control cyanobacteria and cyanotoxins in various EU countries and a vulgarised version targeting water managers and stakeholders.
Activities	
3.1.	Workshops/ training schools and STSMs on the use of successful in-lake control methods and the criteria for their successful application and assessment.
3.2.	Editorial meetings for the development of fact sheets and protocols on different measures and writing of a review on how to improve cyanobacterial management.
Milestones (time in months) or number at the end of the action	
3.1.	Mid-term review of WG3 activities in Core Group meeting (24 m).
3.2.	Number of end-users and ECIs trained on the selection of methods which can successfully reduce cyanoHABs

Working Group 4 Development of web-based Decision Support e-Tools (DST) WG4 is central for the action: information from WG1-3 will be incorporated into the DSTs, providing input to WG5 to disseminate their use. Requirements for successful application of different long- and short-term measures will form the basis of the first DST. This DST will provide guidance to end-users on lake system analysis and on best (cost-efficient) method(s) combatting cyanobacteria in a particular waterbody. In this WG, several tools will be developed including questionnaires for water managers and Workshops will be held to prepare these tools and a training school to instruct water managers to use the DST. Importantly, at the same time, **feedback from the end-users** will be received on the usefulness and scope for improvement of the e-tools. The second DST concerns the analysis of agricultural fields regarding their risk to loose nutrients and which methods to implement to increase their nutrient holding capacity, depending on their hydrogeological characteristics and agricultural management. This DST targets farmers and their associations, as well as policy makers and other stakeholders.

Tasks	
4.1.	Development of questionnaires for water managers to identify and collate lacking information for detection and effective management of cyanobacterial blooms.
4.2	Development of DSTs for effective water management to combat cyanobacterial blooms and cyanotoxins.
4.3	Development of DSTs for effective agricultural management to reduce nutrient loss from the fields.
Activities	
4.1.	Workshop on how to compose questionnaires directed to water managers (used in WG 1,2,3).
4.2.	Workshop to implement the outcomes of the completed questionnaire in the DST
4.3.	Interactive local training school for water managers to: 1) instruct how to use the DST, and 2) receive feedback for improvement of the DST.

4.4.	Interactive local training school for farmers and stakeholders to: 1) instruct how to use the DST, and 2) receive feedback from for improvement of the DST.
4.5	2 Reviews and their vulgarisation on the outcome of the questionnaires on public awareness about cyanobacteria, their risk management and in lake as well as preventive actions. Moreover, a policy white paper to drive change in practice.
Milestones (time in months) or number at the end of the action	
4.1.	Mid-term review of WG2 activities in Core Group meeting (24 m).
4.2	Development, distribution (12 m) and evaluation of the answers to the questionnairs (18 m).
4.3	Development, of two DSTs (36 m)
4.4.	Number of water managers / farmers locally trained in the use of the DST.

Working Group 5 Dissemination WG5 will maximize knowledge transfer and exchange between scientists, water managers, farmers and other stakeholders. WG5 lead will be the 'Science Communication Coordinator – SCC' assisted by a technical communication manager who will act as webmaster (a Young researcher and innovator, YRI). WG5 will include WG1-WG4 leaders and other key WG participants to ensure the dissemination of engagement activities of all WGs. WG5 will develop the communication strategy of the Action and will coordinate the development of the website, newsletter, social media, materials for distribution (web-based and printed), dissemination of publications specially targeted to water- and environment managers, multimedia content and media interviews. OA publications will be encouraged as well as publications in national water management journals. The SCC will closely collaborate with the COST Communication team in order to further exploit COST media for promoting the Action's outcomes (e.g. 'success stories' or 'to be avoided'). The SCC will collaborate with Local Organizers of regional/national meetings to invite local stakeholders. WG5 will moreover create contacts and links to past and existing related programs and networks. The list of stakeholders' contact details will be constantly updated to be used for targeted dissemination. WG5 will also monitor the Action's impact (visitors to website and followers on social media, citations and downloads of publications).

Tasks	
5.1.	Development of Action's logo, website, social media accounts (e.g. Facebook, X etc)
5.2.	Publication of Action's quarterly Newsletter, creation of a news-wall on the website
5.3	Production of leaflets, posters, infographics.
5.4	Development of a list of key stakeholders' contact details throughout Europe for targeted communication (constantly updated).
5.5	Publishing Action's 'success stories' and important outcomes (in collaboration with COST Media Officer).
5.6	Coordination of web media content, webinars and videos.
5.7	Coordination of publications in international and national water/env. management journals
5.8	Promotion of Action's open access publications, toolbox and DST
5.9	Monitoring the Action's impact (paper citations, website visitors, social media engagement).
5.10	Coordination of the final e-Book of the Action
Activities	
5.1	Meetings (incl. video) for development of logo, website, social media accounts
5.2	Updates and posts in Action's website and social media.
5.3	Editorial meetings for production of newsletter, leaflets, posters and other media content.
5.4	Coordination with Local Organizers for dissemination on organization and holding of events.
5.5	Communication with COST Media Officer, other networks, projects and stakeholders.
5.6	Editorial meetings for the Action's final e-Book.
Milestones (time in months) or number at the end of the action	
1.1	Launching of website and social media (3m).
1.2	Mid-term review of WG5 activities in Core Group meeting (24 m).

4.1.2. DESCRIPTION OF DELIVERABLES AND TIMEFRAME

No	Key Deliverables	Most relevant Objectives (1.2.2)	WGs	Month
1	Questionnaires and their analysis	RC 4, 9 CC 2, 4	4,1,2,3	12 / 24
2	Review paper updating on guidelines and regulations throughout Europe and beyond plus evaluation.	RC 3,4,8 CC 2,3, 6, 7	1	36
3	Reviews evaluating various early detection methods, protocols including citizen science, and vulgarised forms published in national water management journals.	RC 3, 7, 8 CC 1, 2, 6, 7	1	42
4	Standardized protocols to translate alert guidelines and regulations into practical monitoring methods.	RC 3, 4, CC 1, 2, 6, 7	1	36
5	Review on cost effective agricultural practices reducing nutrient losses from farmland, in all partners languages	RC 5, 7, 8, 9 CC 3, 5, 6, 7	2	42
6	Web-based toolbox with available strategies to assess nutrient losses.	RC 1-3, 5, 7, CC 2-7	2	42
7	Web-base information on individual in-lake curative methods with pros and cons for waterbody types, -usages and climate types in EU.	RC 7-9 CC 4, 5-7	3	36
8	OA database on effective cyanobacteria and toxins monitoring and management in European waters, as part of the Action's website.	RC 2-4, 8 CC 1, 2, 6, 7	3	36
9	Assessment of costs and economic losses associated with cyanobacterial blooms as well as a blueprint of the societal benefits of technologies to control them.	RC 2, 4, 7 CC 2, 4, 7	1,2,3,4	30
10	Review comparing actions taken against cyanobacteria and cyanotoxins in EU and its vulgarization	RC1, 2, 5, 6, 7,8 CC 4, 5, 6	3	48
11	DST for tailor-made decisions by managers to combat cyanobacteria in waterbodies.	RC 4,6-9 CC 4, 6, 7	4,3	36
12	DST for selecting the most efficient agricultural practice to reduce nutrient loss from fields	RC 5, 7, 8 CC 3, 5, 6, 7	4,3	36
13	Policy workshops to ensure active uptake of the deliverables and decision support tools.	RC 1, 2, 5-9 CC 3, 4, 5, 6, 7	4,3	
14	Article in media on a success story of the Action.	All	1,2,3,4	36
15	First issue of the Action's newsletter.	All	5	12
16	Report with impact of published papers, website and social media.	RC 1, 4, 7, 8 CC 1, 4, 5	5	24

4.1.3. RISK ANALYSIS AND CONTINGENCY PLANS

Risk	Level	Measures to minimize risks
Low number of stakeholder participants in activities	Medium to high	Stakeholder contact details will be gathered at national level and will be used to construct the Europe-wide contact list. Local meetings especially for the stakeholders will be organized to promote their involvement. Organize on-line streaming of events. High outreach activity.
Information for WGs difficult to obtain	Low	Local members will be active in the search for information. Most Action members already have good outreach experience at local and national level with stakeholders.
Poor dissemination of outcomes	Low	Dissemination through all media and channels by all partners will enlarge ourtreach. Joint activities with stakeholders (webinars, workshops etc), citizen science with smart phone based cyanobacterial alert applications.
Funding insufficient	Medium	MC meetings will be merged with other already funded activities (e.g. conferences, workshops). Virtual meetings reduce costs.
Poor participation of ECIs-ITCs	Medium	ECIs-ITCs are already in the network, ensuring their participation. A special forum for ECIs, managed by ECIs, will be supported. ECIs-ITCs will be involved in management and leadership roles.

4.1.4. GANTT DIAGRAM

	Year			
	1	2	3	4
Action Management				
First General Action Meeting				
Management Committee Meetings				
Core Group Meetings (including virtual e-meetings)				
Launch of Action Website, Social Media and e-NewsLetter				
Final Action conference				
WG1: Early warning methods for detection of blooms, risk assessment				
1.1. Assessment of knowledge gaps and needs of water managers on cyanobacteria early warning detection methods				
1.2. Evaluation and collation of available and innovative methods used to monitor, identify and quantify cyanobacteria and cyanotoxins (including costs, rapidity of results, technicality)				
1.3. Provision of standardized detection protocols for risk assessment of cyanobacterial abundance including links between diagnostic methods and alert guidelines/regulations				
1.4. Identification of gaps in detection protocols and alert guidelines associated with pico- and benthic cyanobacteria				
1.5. Promotion of existing smart-phone-based applications for cyanobacterial bloom occurrence and identification				
1.6. Writing review paper				
WG2: Catchment management measures (long-term)				
2.1. Development of a toolbox with available methods and strategies to assess nutrient losses from agricultural land, forestry and point sources.				
2.2. Development of a database with information on the actions taken and their cost-effectiveness of reducing nutrient losses from the catchment.				
2.3. Writing review providing an overview on successful methods in reducing nutrient losses and distribute to all partner countries in the respective language				
WG3: Evaluation of methods to control cyanobacteria (short term)				
3.1. Development of database with information on the actions taken and the effectiveness of short-term methods				
3.2. Development of fact sheets and protocols for every method to be used in the DST in local languages.				
3.3. Writing review on comparison of actions taken				
WG4: Development of web-based Decision System				
4.1. Development and analyse of questionnaires for lake managers to synthesize lacking information for detection and effective management of cyanobacterial blooms and cyanotoxins.				
4.2. Development of a Decision Support e-Tool for effective water management of cyanobacterial blooms and toxins				
WG5: Dissemination				
5.1. Coordination and development of web media content				
5.2. Production of leaflets, posters, newsletters, videos				
5.3. Contact list of key stakeholders				

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