Brussels, 30 October 2015

COST 045/15

DECISION

Subject: **Memorandum of Understanding for the implementation of the COST Action "Science and Management of Intermittent Rivers and Ephemeral Streams" (SMIRES) CA15113**

The COST Member Countries and/or the COST Cooperating State will find attached the Memorandum of Understanding for the COST Action Science and Management of Intermittent Rivers and Ephemeral Streams approved by the Committee of Senior Officials through written procedure on 30 October 2015.

MEMORANDUM OF UNDERSTANDING

For the implementation of a COST Action designated as

COST Action CA15113
SCIENCE AND MANAGEMENT OF INTERMITTENT RIVERS AND EPHEMERAL STREAMS (SMIRES)

The COST Member Countries and/or the COST Cooperating State, accepting 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 (the 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 new document amending or replacing them:

a. "Rules for Participation in and Implementation of COST Activities" (COST 132/14);
b. "COST Action Proposal Submission, Evaluation, Selection and Approval" (COST 133/14);
c. "COST Action Management, Monitoring and Final Assessment" (COST 134/14);
d. "COST International Cooperation and Specific Organisations Participation" (COST 135/14).

The main aim and objective of the Action is to The challenge of the Action is to concentrate, refine and analyse the currently sparse and fragmented knowledge on intermittent rivers and ephemeral streams (IRES) with the aim to support the incorporation of these prevalent and unique ecosystems into current water resource and biodiversity management and conservation plans.. This will be achieved through the specific objectives detailed in the Technical Annex.

The economic dimension of the activities carried out under the Action has been estimated, on the basis of information available during the planning of the Action, at EUR 56 million in 2015.

The MoU will enter into force once at least five (5) COST Member Countries and/or COST Cooperating State have accepted it, and the corresponding Management Committee Members have been appointed, as described in the CSO Decision COST 134/14.

The COST Action will start from the date of the first Management Committee meeting and shall be implemented for a period of four (4) years, unless an extension is approved by the CSO following the procedure described in the CSO Decision COST 134/14.

OVERVIEW

Summary

More than **half of the global river network** is composed of **intermittent rivers and ephemeral streams** (IRES), which are expanding in response to climate change and increasing water demands. After years of obscurity, the science of IRES has bloomed recently and it is now recognised that IRES support a unique high diversity, provide essential ecosystems services and are functionally part of river networks and groundwater systems. However, they still lack protective and adequate management, jeopardizing the water resource at the global scale.

This Action will bring together hydrologists, biogeochemists, ecologists, environmental economists, social researchers and stakeholders from 14 different countries to develop a research network for **synthesising the fragmented and recent knowledge on IRES, improving our understanding of IRES ecology, and translating this into science-based, sustainable management of river networks**.

Deliverables will be provided through i) research workshops synthesising and addressing key challenges in IRES science, supporting research exchange and educating young researchers, and ii) combined researcher-stakeholder workshops translating improved knowledge into tangible tools and guidelines for protecting IRES and raising awareness of their importance and value in societal and decision-maker spheres.

This Action will be organized within 6 Working Groups to address:

1. The occurrence, distribution, drivers and hydrological trends of IRES;
2. The effects of flow alterations on IRES functions and ecosystem services;
3. The interaction of aquatic and terrestrial biogeochemical processes;
4. Biomonitoring the ecological status of IRES;
5. Synergies in IRES research at the European scale, data assemblage and sharing;
6. IRES management and advocacy training.

Areas of Expertise Relevant for the Action	Keywords
● Biological sciences: Ecology ● Earth and related Environmental sciences: Hydrology, water resources ● Earth and related Environmental sciences: Biogeochemistry, biogeochemical cycles	● climate change ● environmental flow management ● ecological status assessment ● drought ● flow intermittence

Specific Objectives

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

Research Coordination

● To create an extensive research network across river researchers from multiple disciplines to promote the sharing of data and experience and the setup of common experiments;
● To associate researchers and stakeholders to translate current knowledge about IRES into robust, tangible tools and guidelines for improved management and conservation practices and rules.

● To link current on-going research efforts on IRES at the European scale and create synergies for further research.
● To raise social awareness about the values of IRES and train a new generation of researchers.

Capacity Building
● To support data sharing, and the creation of 2 metadatabases containing: 1) details of all past and ongoing research efforts on IRES research across the participants, and beyond, and 2) details of flow gauging stations with zero flows at the European scale.
● To closely associate researchers and stakeholders and generate synergies at the European scale.
● To train a new generation of Early Stage Researchers (ESRs), provide them with a significant network platform, and creating a Forum of Young Researchers (FYR).
● To support, in particular for ESRs, visits to participating research institutions within the network for training on targeted technical or methodological aspects.

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DESCRIPTION OF THE COST ACTION

1. S&T EXCELLENCE

1.1. Challenge

1.1.1. Description of the Challenge (Main Aim)

Traditional flow-gauging systems have vastly underestimated the number of rivers and streams flowing intermittently (i.e. which cease to flow and/or dry up) (1, 2). Recent work has led to the recognition that intermittent rivers and ephemeral streams (IRES) are prevalent in all climates and dominate river networks in many regions (2, 3). For example, IRES represent 30-40% of the larger rivers and 69% of the low-order streams below 60° latitude (4). Over the next century, the number and length of IRES will further increase due to climate and land-cover change, and increasing abstraction for public water supply, irrigation and other economic uses (1, 2, 3).

Historically, IRES have been perceived to be outside of the scope of both terrestrial and aquatic sciences and therefore, have been overlooked by most disciplines. As a result, the persuasive conceptual developments in river research have been generated from and for perennial river systems and are poorly applicable to IRES (2). But after years of near-obscurity, IRES research has been blooming in the last decade, driven by increasing water scarcity issues, climate change effects, and the recognition that IRES are prevalent in river networks (5). Progress has been made in hydrology, with improved modelling techniques (e.g., 6, 7), in biogeochemistry with a better understanding of nutrient and carbon cycling (e.g., 8), and in ecology with an improved understanding of community dynamics in IRES (e.g., 9).

IRES are now known to support high, unique biodiversity and important ecosystem processes, and provide valuable goods and services (1, 10). They are critical, longitudinal paths for water, energy, material and organisms, even when surface water is absent. Subsurface flows can connect perennial sections across dry parts of the networks, providing water supply (2) and offering a refuge for organisms at various points in their lifecycle (11). IRES can also be essential lateral paths for moving water, energy, material and organisms into, and from, adjacent riparian zones, floodplains and wetlands, hence promoting the maintenance of these highly-valuable ecosystems (1, 10, 12). IRES are also essential vertical paths to recharge aquifers, particularly in mesic areas (3). Riparian vegetation of IRES provide valuable wildlife habitat, forage for livestock, wood and other ecosystem services for people (1, 12). IRES can be vital for maintaining native fish populations by preventing non-native species invasions and the threatening of native, endemic species (1). Finally, dry riverbeds can be colonized by numerous terrestrial organisms, some of which are new to science (12). However, despite the recent increased interest in IRES (e.g. 1, 2, 3), interdisciplinary, scientific syntheses and concepts are crucially missing (2).

IRES are being degraded at alarming rates due to hydrologic alteration, including water abstraction, flood harvesting, river impoundment, channel modification, global change and mining (1, 3). In many areas, IRES are used as drains to dispose of mining, agricultural and urban effluents, as corridors for vehicles and livestock, and as sites for gravel and sand extraction (12). IRES can also be buried (e.g. The Ramblas of Barcelona; The Ilissos in Athens) or subject to flow augmentation, leading to unexpected negative effects such as the spread of invasive species (3). These widespread and severe degradations are consequences of the lack of recognition, poor understanding and inadequate management of IRES. These widespread and severe degradations are consequences of their lack of recognition, poor understanding of their function and importance and inadequate management and policies strategies.

While the understanding and recognition of IRES is blooming in academia (2, 5, 10), management practices, protective policies and legislation for IRES lag behind and are mostly inadequate, if not inexistent (1, 3, 7). In part, this is due to the negative perception of the value of IRES by society, but also due to the challenges that IRES represent within the context of the traditional water resource management plans, policies and directives (5,7). These challenges, which

are typically derived from research gaps and a lack of comprehensive, interdisciplinary syntheses (2), are:

1. To locate, map and predict IRES within river networks, spatialize flow intermittence patterns and describe their pulsed regimes, explore historical evolution of these patterns, disentangle natural vs anthropogenic flow intermittence, and identify areas at risk where flow intermittence is increasing (5, 6, 7);
2. To establish the ecosystem services provided by IRES and understand their responses to flow regime alterations, thereby informing definition of environmental flows in IRES.
3. To understand carbon and nutrient dynamics at the catchment-scale in these pulsed systems, where accumulation of organic material and nutrients during dry phases causes pronounced peaks of downstream export during early flowing phases with potentially deleterious effects on water quality (2).
4. To disentangle the effects of flow intermittence on river communities from the effects of other stressors, such as urbanisation, agriculture, etc. Most community metrics used in biomonitoring respond negatively to increasing flow intermittence (e.g. 7, 9, 13, 15) and are inadequate for IRES in the context of the Water Framework Directive (1).

The challenge of the Action is to concentrate and refine the currently sparse and fragmented knowledge on IRES with the aim of supporting the incorporation of these prevalent and unique ecosystems into current water resource and biodiversity management and conservation plans. To achieve this, the Action will join scattered research activities in nationally-funded research projects across COST Member Countries and COST Near Neighbour Countries, and those in past and ongoing European and internationally funded projects. The Action will facilitate sharing of data and experience, bring together researchers and stakeholders from many disciplines, and create synergies through networking. The ultimate aim is a substantial advancement of the knowledge and management of IRES throughout Europe through development of a unifying conceptual framework and robust, tangible tools and guidelines for managers and policymakers.

In this interdisciplinary approach, researchers and stakeholders with scientific and management expertise on IRES of different contexts (spanning humid, temperate, Mediterranean, and arid climates, contrasted land uses, different management practices, etc) from 14 countries (i.e. 13 COST Countries, including 3 Inclusiveness Target Countries (ITCs), 1 Near Neighbour Country(NNC)) will:

1. Address specific challenges, limitations and potentials of IRES management (see 1-4 above);
2. Develop a scientific conceptual framework for IRES based on the recent research knowledge from field and laboratory studies and current network activities;
3. Identify areas at risk of increased flow intermittence;
4. Evaluate the socio-economical values of natural IRES;
5. Identify the impacts of increasing flow intermittence on river ecosystem functions and services;
6. Identify research needs, including interdisciplinary efforts;
7. Raise awareness of the importance of IRES in societies and relevant decision-making spheres.

1.1.2. Relevance and timeliness

Although IRES make up a high proportion of river networks in many European regions, they have been overlooked for a long period. However, recent research into IRES has provided evidence of their high and unique biodiversity, the relevance of their contribution to the control of energy and matter fluxes along fluvial networks, and their provision of valuable goods and services for society. In addition, IRES have been consistently and widely neglected or ignored in management and protection strategies and directives, mainly because in most countries, the legislative definition of a

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"river" implies perennial flows. Recently, passionate debates have been challenging this definition, recognizing that IRES are not only essential to riverine biodiversity and biogeochemical functions, but also to the ecology of adjacent wetlands, riparian zones and floodplains. Therefore, the **compilation and synthesis of existing knowledge and data on IRES** from this consortium will strongly contribute to filling this historical gap on the scientific understanding of IRES and promote the achievement of « good ecological status » in all freshwater bodies, as currently considered in the EU Water Framework Directive. Ultimately this COST Action will increase the social and political value of IRES, which are a key water resource in many European regions

In addition, characteristics of IRES may expand into currently perennial European streams due to predicted patterns of global change (higher human water demand and climate change: 1, 3). The number and length of IRES will increase and many currently perennial systems will cease to flow and/or dry up, resulting in dramatic alterations of flow regimes. This is already happening (2). For instance, areas in central, eastern and southern Europe are already experiencing severe and repeated droughts, and many perennial rivers are shifting into intermittent flows. Conversely, around the Mediterranean basin, where the human density is extremely high, historically intermittent regimes have shifted into perennial flow due to constant inputs from treated and untreated urban wastewater effluents. The flow regimes of headwater streams, the majority of which are intermittent or ephemeral (14), are altered by water abstraction and increasing drainage for farm pond implementations (15). IRES are also highly vulnerable during their dry phases, where dry riverbeds are used for recreational purposes, mined for gravel and sand, or used as landfill sites (3, 12). IRES are part of river networks, and any damage to them will cascade into perennial systems. Threats to IRES and their unknown consequences on river networks and water resources require a joint research effort across the concerned countries.

In the last decade, some research groups have contributed significantly to the advancement of conceptual and empirical knowledge of IRES, as well as in proposing solutions to improve their management. Nonetheless, translating the current bloom in IRES research into tangible tools for water resource managers and stakeholders requires significant attention, interdisciplinary and joint efforts by the scientific community at the European scale.

1.2. Objectives

1.2.1. Research Coordination Objectives

This COST Action aims to develop a multidisciplinary network of scientists and stakeholder experts on IRES from 14 countries to consolidate and expand the current understanding of IRES and translate it into science-based, sustainable management of IRES resources and biodiversity.

The Action has four main coordination objectives:

1. To create an extensive research network across river researchers from multiple disciplines to promote the sharing of data and experience and the setup of common experiments;
2. To bring together researchers and stakeholders to translate current knowledge about IRES into robust, tangible tools and guidelines for improved management and conservation practices and guidelines;
3. To link ongoing research efforts on IRES at the European scale and create synergies for further research;
4. To raise social awareness about the value of IRES and train a new generation of researchers.

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1.2.2. Capacity-building Objectives

The objectives of the Action in terms of capacity-building are:

1. To support data sharing, and the creation of 2 meta-databases containing: 1) details of all past and ongoing research efforts on IRES research across the participants, and beyond, and 2) details of flow gauging stations with zero flows at the European scale;
2. To closely associate researchers and stakeholders and generate synergies at the European scale;
3. To train a new generation of Early Career Investigators (ECIs), provide them with a significant network platform, and creating a Forum of Young Researchers (FYR);
4. To support, in particular for ECIs, visits to participating research institutions within the network for training on targeted technical or methodological aspects.

1.3. Progress beyond the state-of-the-art and Innovation Potential

1.3.1. Description of the state-of-the-art

The first challenge (C1) is **to locate, map and predict IRES in river networks, spatialize flow intermittence patterns, explore historical evolution of these patterns, and disentangle natural vs anthropogenic ones**. Hydrological datasets are produced for and from perennial rivers and the consequently ignore or misrepresent IRES (2, 5, 6). This hydrological gap is a primary limit to the effective study, understanding and management of IRES (5, 7). To overcome this, two approaches are proposed: regionalisation techniques to model the location of IRES in networks based on the limited flow data available (e.g. 6); and frequent observation of flow state at key sites along a river (e.g. 16). However, the regionalisation techniques have very low predictive power due to the limited amount of data, and visual observations are limited in spatial and temporal extent. This is even truer in headwater areas, most of which are IRES (14). Another limitation of both approaches is that they cannot distinguish between natural and anthropogenic IRES. Yet, this information is crucial to further understand and manage hydrological and ecological alterations of IRES. Another strong limitation to IRES management at the European scale stems in the lack of hydrological classification (7).

The second challenge (C2) is to **understand how alterations in flow regimes impair IRES biodiversity, function and services, and consequently, how to define environmental flows in IRES**. Flow alterations have mainly been studied in perennial rivers and their effects on IRES function and services are poorly known (3, 10). It is clear that increased flow intermittence reduces community richness (e.g. 9) and alters ecosystem processes (e.g. 8). Yet, the role of timing and frequency of drying events is unclear. Also overlooked in IRES are the effects of modifying other flow regime components, such as floods, low flows, and mean flows. Lastly, a hydrological classification of IRES is currently lacking in Europe, limiting our capacity to manage these systems, at least within the current scope of the Water Framework Directive, and to predict shifts in hydrological regimes under the future climate change predictions.

The third challenge (C3) is the **modelling of carbon and nutrient dynamics in IRES at the catchment-scale**. IRES are typical pulsed systems, where accumulation of organic material and nutrients during dry phases causes pronounced downstream export peaks during early flowing phases, with potential deleterious effects on water quality (2). While the understanding of the processes occurring during both dry and flowing phases is improving (e.g. 8, 12), there are currently very few attempts to consider and model carbon and nutrient dynamics in both phases. Doing so is essential to predict how dry phases alter water quality during the flowing phase, thereby guiding water quality monitoring schemes, and to accurately estimate how much IRES participate in global carbon and nutrient cycles (2), e.g. by carbon dioxide efflux to the atmosphere (4).

Fourth and finally, **disentangling the effects of flow intermittence on river communities from those of other stressors is an essential challenge to improve our understanding of the**

biodiversity of IRES and develop sound biomonitoring approaches (C4). Current bioindicators used for assessing the ecological status of rivers in Europe cannot be applied in IRES, as most species indicative of alterations are also very sensitive to drying (e.g. 7, 13). The few alternatives proposed to overcome this problem have not been successful within the context of the current Water Framework Directive. However, current bioindicators used in Europe could be adapted for IRES by quantifying and incorporating the sensitivity of species to flow intermittence.

1.3.2. Progress beyond the state-of-the-art

The Action will develop a robust ecohydrological conceptual framework and novel and unique approaches to tackle the 4 challenges. Due to the central role that hydrology plays in setting the characteristics of IRES, C1 will produce the physical, hydrological basis on which C2, C3 and C4 will be addressed. This will ensure scientific robustness and place the Action within the emerging but already well-recognised discipline of ecohydrology. In addition, the geographic coverage of the participants will for the very first time span oceanic, temperate, continental, Mediterranean, and arid climate zones, thereby covering a wide range of situations. Moreover, involving both scientists and stakeholders will allow identification of the management problems and needs to be addressed, and will use them to generate tangible tools for improving IRES management.

C1 will be addressed using various approaches, some of which are novel in this field. The first step will involve collating all continuous hydrological data and associated climatic (e.g. temperature, rainfall) and catchment-scale (e.g. geology, topography, vegetation) data available across the participating countries and produce a meta-database. Regionalisation procedures will be used to predict drying risk at catchment scales and trend analyses will identify areas at risk of increasing drying (i.e. sentinel catchments). Maps of IRES in the participating countries will be produced, and the very first hydrological classification of IRES at the European scale will be generated to identify key hydrological variables and drivers. In addition to these major advancements, novel approaches coupling aerial photography, citizen-sciences and social sciences will be tested and developed. For example, in areas where data are scarce or fragmented, aerial unmanned vehicles (AUVs) and satellite images will be used to locate drying sections (14). In targeted key areas, local community, angler and river technical staff knowledge will be explored and analysed to extract additional information about drying history; notably, this will help to distinguish natural and anthropogenic IRES. The development of a European-scale network of citizen-scientists to monitor, locate and map the state of river flow will also be promoted (e.g. 16) based on smartphone technology, as used, for example, in the point source data application developed in the COST Action “Loss of the Night” and building up on the App being developed in the ongoing TRivers project (www.lifetrivers.eu). All gathered information will be stored in the meta-database.

C2 will be tackled by examining available information on the biological and functional responses of IRES to flow variability and by synthesizing this information into a conceptual model from which management strategies of flow can be inferred. A meta-data base of available information from participating members will be developed to synthesize this information. IRES ecosystem services will be established and economically quantified, along with their link to flow regimes. These actions will contribute to the environmentally sound management of flows in IRES.

C3 will be addressed by a meta-ecosystem modelling approach, which will couple terrestrial and aquatic models of carbon and nutrient cycling at the catchment scale for different IRES. The sharing of scientific information about carbon and nutrient dynamics during dry and flowing phases among the members, together with a deep literature review, will be a keystone step to target this challenge. These data synthesis will be complemented with modelling techniques to explore the influence of spatial and temporal patterns of drying on carbon and nutrient dynamics in IRES and compare them to patterns from perennial streams. This will improve our understanding of the extent to which processes in dry phases influence water quality during flowing phases and will help refine current estimates of the contribution of river systems to carbon processing at the global scale.

To address C4, the different bioindicators developed for perennial rivers will be adapted for IRES. Meta-analyses examining the occurrence of different species across gradients of flow

intermittence will allow to assign a score of “sensitivity to flow intermittence” to each taxon. These scores will be validated using the expertise, data, and knowledge shared among the participants. This approach will be tested in many case-studies from the different participating countries, including targeted catchment from past relevant European projects (see below). When validated, the adapted biomonitoring tools will be delivered to the stakeholders though an online handbook including guidelines and caveats.

1.3.3. Innovation in tackling the challenge

This COST Action is innovative by providing:

1. A meta-database based on a compilation of existing scientific knowledge of IRES at the European level and beyond;
2. A meta-database of flow states for IRES based on data from gauging stations and heuristic knowledge from stakeholders at the European level;
3. A review of existing knowledge and management needs for IRES based on conbined researcher and stakeholder working discussions;
4. A conceptual framework for IRES based on an ecohydrological approach;
5. Novel modelling approaches (e.g., meta-modeling, machine learning) coupling aquatic and terrestrial phases to understand carbon and nutrient dynamics across IRES; ;
6. The ecosystem services of IRES with quantified data;
7. Novel bioindicators and technologies (e.g. AUV’s, smartphones) to assess changes and associated ecological responses in IRES;
8. Tangible tools and scientific-based guidelines for managing IRES in Europe.

1.4. Added value of networking

1.4.1. In relation to the Challenge

The Action will achieve its objectives by:

Creating:

1. An interdisciplinary network of knowledgeable river researchers in order to promote data and experience sharing and a new generation of experiments and projects on IRES;
2. Two European-scale meta-databases;
3. A conbined effort between researchers and stakeholders from the participating countries;

Organizing:

1. Topical and inter-disciplinary workshops involving relevant researchers to address the current state of knowledge, identify research gaps, explore potentials and limitations for IRES management and conservation, develop a unifying conceptual framework to organize and guide further joint efforts, and translate current knowledge into tools and guidelines for water resource managers;
2. Research To Management Workshops (RTMW) linking relevant researchers and stakeholders to share experiences, management limitations and requirements, and to transmit the tools and guidelines produced during the Action.
3. Training Schools (TS) dedicated to the training of ECIs in both fundamental and applied scientific aspects of IRES research;
4. A Forum of Young Researchers (FYR) to generate a European network for ECIs, with smaller topical FYR workshops being organized;
5. Short Term Scientific Missions (STSMs), in particular for ECIs, to visit participating research institutions within the network for training on targeted technical or methodological aspects;
6. Special Topical Sessions (STS) at 4 international conferences focusing on the outputs of the Action;

Producing at least 4 perspectives papers on IRES in high-profile journals, corresponding to C1-4, respectively.

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At present, there are no joint efforts providing networking to synthesise knowledge and link research to management of IRES at the European scale. Incorporating IRES into current water resource management plans is a key challenge, as recently highlighted in a Science policy paper (1). A COST Action is certainly the most promising approach to address this challenge across European and neighbouring and partner countries. This Action will promote collaborations between researchers and stakeholders, translate synthesized knowledge into simple, tangible tools, guidelines and protocols for improving IRES management and conservation, and raise awareness of the ecological relevance of IRES and their significant extent in the landscape.

1.4.2. In relation to existing efforts at European and/or international level

This Action will complement and expand the achievements initiated in two previous European programs to model water quality (TempQsim, 2002-2006) and improve management (MIRAGE, 2009-2011) of Mediterranean rivers. The Action will also build on several ongoing activities in Europe, such as the analysis of the effects of multiple stressors on rivers under water scarcity (European projects GLOBAQUA & MARS), the development of software to improve the management of Mediterranean rivers (LIFE project TRivers), and international initiatives, such as the global analysis and synthesis of IRES biodiversity (International collaborative project IRBAS). Yet, at present, there are no programmes or existing networks in Europe seeking to advance the science of IRES and link up-to-date knowledge to management practices and guidelines.

This Action includes experts from most past and current national and European funded projects related to IRES. This ensures that this Action will function as a unique platform for forum discussion, development of new ideas, and exchange between scientific and heuristic knowledge and needs at the European level. The Action is expected to complement research actions developed under Horizon 2020.

Last, contacts have been made with the Joint Research Centre (JRC) and several JRC colleagues will be invited to participate to relevant workshops to maximise synergies in the European research efforts.

2. IMPACT

2.1. Expected Impact

2.1.1. Short-term and long-term scientific, technological, and/or socioeconomic impacts

The results of this Action are essential to support current initiatives on the ecological understanding of IRES through empirical and modelling approaches, as well as to propose monitoring programmes and management and protection strategies for IRES based on knowledge of their communities, functions and ecosystem services. This will be achieved by the funded network of scientists and stakeholders experts on IRES within this Action.

The Action will have a direct relevance at national, European (and international) level by providing tangible tools, indicators and guidelines for integrating IRES into current management programmes and existing directives. Moreover, additional policy-oriented structures, organizations and consultancies focusing on natural resource management, biodiversity and ecosystem services supported by rivers will benefit from this Action by expanding the current scope of river management by incorporating regimes and dynamics of IRES, which will become even more common freshwater bodies in future years.

The scientific and applied innovative perspective of this Action will contribute to:

1. **Scientific integration and visibility of European experimental research**:
   The Action will establish short and long-term intertwined research efforts and close collaboration with national, European and international research networks, thereby favouring the visibility of European research communities in the hot-topic of IRES;
2. **Data sharing**:
   The Action will produce 2 meta-databases, which will promote short- and long-term synergies among researchers from COST and International Partner Countries (IPC). In addition, the Action will promote the creation of a citizen-science network to monitor river flow states and address the current lack of hydrological data.
3. **Improving river resource management**:
   An online handbook containing management guidelines derived from the four challenges will be produced and distributed to the water management and decision maker structures of the participating countries.
4. **Outstanding scientific position papers**:
   The Action will produce at least 4 perspectives papers outlining state of the art and proposing future research needs within its overall area and the specific objectives;
5. **Raising social and political awareness of IRES importance**:
   The Action will highlight the importance of IRES at the European scale both within the scientific and management community and through workshops, STSM, TS, and RTMW actions. The economic quantification of IRES ecosystem services and the citizen-science network will also contribute to a better recognition of IRES by society.
6. **Improved use of research facilities**:
   The Action will support STSM and between-country access to research facilities by other researchers, especially by ECIs;
7. **Education of a new generation of river researchers in IRES**:
   The Action will provide training for ECIs through workshops, Short-Term Scientific Missions, Training Schools, and Forums of Young Researchers.
8. **Provide guidelines and information to water resource consulting companies**:
   The online handbook will provide regulatory agencies and consultants, who are largely unfamiliar with IRES, with tools and guidelines to facilitate inclusion of IRES in any environmental studies.

The results of this Action are essential to support current initiatives to understand the monitoring, prediction, modelling, management and protection of IRES and their associated communities, functions and ecosystem services. The scientific community participating in nationally funded projects across Europe, and also from current and past specific European projects such as MIRAGE or GLOBAQUA will have considerable interest in the activities of the Action. The Action will have a direct relevance for both national, European and international water resource managers and policy-makers, who will benefit from the translation of current knowledge into tangible tools and guidelines for using in IRES, and thus improve current water resource management plans and practices. Moreover, additional policy-oriented structures, organizations and consultancies focusing on natural resource management, biodiversity and ecosystem services supported by rivers will be greatly interested in this Action.

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2.2. Measures to Maximise Impact

2.2.1. Plan for involving the most relevant stakeholders

The aim of the Action is precisely to proactively involve stakeholders in the synthesis efforts to locate and characterize IRES, identify the associated management problems, and how to tackle them. For this reason, stakeholders (e.g. Water Agencies, Basin Committees, Ministries, and Consultants) from each participating country will actively participate in the different tasks of this Action. To reach these objectives, the action includes reciprocal exchanges and intertwined workshops between researchers and stakeholders throughout the Action.

2.2.2. Dissemination and/or Exploitation Plan

The Action outputs will be disseminated through:

1. Outstanding scientific papers, including a key synthesis paper on IRES management, in high profile journals;
2. A Special Issue on IRES in one international journal;
3. One online handbook with guidelines for IRES management;
4. Publicly available meta-database on IRES research activities, experiments and projects, as well -as a meta-database of flow stations with intermittent flows across the participating countries;
5. A website of the Action which will be continuously updated;
6. The organisation of 4 Special Topical Sessions (STS) at international conferences;
7. The organisation of 3 RTMWs during which water resource managers from the participating countries will be invited to share experiences, concerns, ideas, and concerns, and to be recipients of the tools and guidelines produced during the Action;
8. The organisation of TS dedicated to the training of ECIs related to both fundamental and applied scientific aspects of IRES research;
9. The establishment of a FYR to generate a European network for young researchers;
10. STSM to visit participating research institutions within the network for training on targeted technical or methodological aspects;

2.3. Potential for Innovation versus Risk Level

2.3.1. Potential for scientific, technological and/or socioeconomic innovation breakthroughs

Scientific syntheses of the ecology of IRES are lacking, and this Action will fill this gap hereby guiding future research across the Europe and beyond. Large-scale maps of IRES location are lacking in most countries. Development of these maps based on openly accessible GIS are key to evaluate the extent of IRES within different COST Countries. In addition, identification of sentinel IRES sites within the Action and planning for focussed research based on knowledge gaps will provide a an effective approach to develop science-grounded decisions not only in water resources management and nature conservation (e.g. restoration of flow regimes, adaptation to climate change), but also in the water quality regimes characteristic of IRES. The use of novel techniques (e.g., AUVs and smartphones) can help convincing citizens to the values of IRES and overcome the lack of information about IRES location and distribution. This Action will promote the use of such techniques to increase awareness and the value of IRES at societal level.

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3. IMPLEMENTATION

3.1. Description of the Work Plan

3.1.1. Description of Working Groups – Provide for each WG theObjectives, Tasks, Milestones and Deliverables

The Action is organized in 6 Working Groups (WGs) that build upon each other to develop a global framework. Four science-driven WGs correspond to the 4 challenges of the Action, one WG is dedicated to the networking activities, and one to dissemination and capacity-building activities.

WG 1: Prevalence, distribution, drivers and trends of IRES
Objectives. Compile hydrological data to locate, map and analyse trends in flow intermittence in IRES; spatialize flow intermittence patterns in selected catchments; explore historical evolution of these patterns; develop a citizen-science monitoring network.
Tasks. Assemble all continuous hydrological data and associated climatic and catchment-scale data (e.g. geology, topography) available in the participating countries; identify drivers of flow intermittence on key catchments and identify natural vs anthropogenic ones; synthesis and trend analyses to identify areas at risk of increasing drying (i.e. sentinel catchments) in response to climate change; produce maps of IRES; generate a hydrological classification of IRES at the European scale; produce a hydrological meta-database; Where possible, synthesis information about flow intermittence patterns at the catchment scale; use novel approaches to locate IRES, combining airborne photography using AUVs, citizen-sciences; use social sciences to explore the memories of local people in key areas to extract additional information about drying pattern history; develop a European-scale network of citizen-scientists to monitor, locate and map the state of river flow using smartphones.
Milestones. WG1 will organise 1-2 workshops per year, including one with WG5 and WG6.
Deliverables. Workshop minutes; meta-database of continuous flow hydrological data; maps of IRES at the European scale; identification of sentinel areas; a continuously-developing database of drying occurrence across European river networks; a European-scale network of citizen scientists to monitor flow state in IRES.

WG 2: Flow alterations, ecosystem services and management of IRES
Objectives. Quantify the functions and ecosystem services provided by IRES and explore their responses to flow alterations; define rules for flow management in IRES.
Tasks. Establish the functions and services provided by IRES; quantify their economic value; explore their relationships with flow regime components and alterations using the fragmented knowledge across the participating countries; produce a meta-database of past and ongoing scientific projects in IRES; develop an ecohydrological conceptual framework to guide management of flows in IRES.
Milestones. WG2 will organise 1-2 workshops per year, including one with WG1, WG5 and WG6.
Deliverables. Develop a conceptual ecohydrological framework for IRES; compile existing knowledge on IRES functioning and the influence of flow regime as a controlling factor; identify critical ecosystem services and evaluate their economic value, controlling factors; generate a guideline for managing flows in IRES based on the outputs of these tasks.

WG 3: Coupled aquatic-terrestrial biogeochemistry in IRES
Objectives. Couple aquatic and terrestrial models to predict carbon and nutrient dynamics in IRES at the catchment scale; guide management sampling schemes.
Tasks. Couple aquatic and terrestrial models of carbon and nutrient cycling at the catchment-scale and for different IRES (using metamodeling and machine learning techniques); meta-analyses to estimate rates of storage, processing and export in flowing and dry phases; link with the spatial and temporal hydrological information compiled in WG1; explore the influence of terrestrial processes on

water quality during flowing phases; refine current estimates of how much river systems process carbon and nutrients at the global scale.
Milestones. WG3 will organise 1-2 workshops per year, including one with WG1, WG5 and WG6.
Deliverables. Meta-models of carbon and nutrient dynamics in IRES at the catchment scale; improved understanding of the respective influence of aquatic and terrestrial biogeochemical processes on IRES water quality; refined European scale estimates of carbon and nutrient processing in rivers; guidelines for management sampling programmes.

WG 4: Biomonitoring of IRES
Objectives. Adapt current biomonitoring methods for IRES; produce an electronic handbook including guidelines and caveats for IRES biomonitoring.
Tasks. List the different bioindicators and protocols used in the participating countries to assess the ecological status of rivers, including IRES when relevant; review management practices in countries outside of Europe (e.g. Australia, South Africa); identify issues and limitations; conduct meta-analyses to examine the occurrence of the different taxa across gradients of flow intermittence, to assign a score of "sensitivity to flow intermittence" to each taxon; combine expertise, data, and knowledge shared among the participating countries; test and validate the refined bioindicators on documented case studies (>40), including on the case-study catchments of the MIRAGE and TRivers projects; deliver to stakeholders a online handbook including guidelines and caveats.
Milestones. WG3 will organise 1-2 workshops per year, including one with WG5 and WG6.
Deliverables. Bioindication tools for assessing IRES ecological status; online handbook including guidelines and caveats.

WG 5: Networking
Objectives. to build up the network; to link past and ongoing research projects to IRES; to share experience and information; to synthesize the state-of-the-art and knowledge gap analysis of IRES; to ensure active participation of stakeholders.
Tasks. Organise annual topical and cross-disciplinary workshops; address the challenge of providing open-access information on projects and experiments to facilitate sharing of data and results for general synthesis; conduct meta-analyses and modelling; create a stakeholder committee and ensure a permanent exchanges between researchers and stakeholders.
Milestones. WG5 will organise annual workshops with all WGs, and several smaller workshops for WG1, 2, 3 and 4 on specific networking aspects.
Deliverables. Workshop minutes; synthesis of state-of-the-art and knowledge gap analysis of IRES.

WG 6: Dissemination and capacity-building
Objectives. To disseminate the scientific activities; to train ECIs and stakeholders; to promote SHTM; to deliver the tools and guidelines to stakeholders; to ensure visibility of the Action at the international scale.
Tasks. Organise workshops to produce perspective papers for each of the 4 scientific tasks described above (WG1-4); organize 2-3 TS for ECIs on IRES encompassing the 4 disciplines represented; offer training sites as part of the Short-Term Mission program (>10 STMs); organise dedicated technical workshops with water resources managers and policy makers; develop an interactive website providing information on activities, key findings, document repository, data sharing platform and information from other relevant activities; use social networks (e.g. Twitter, Facebook) to disseminate progress; organise STS on IRES at 4 international conferences in collaboration with other international networks; produce a Special Issue (SI) in one international journal on IRES management aspects; deliver guidelines to stakeholders.
Milestones. WG6 will organise annual workshops to produce key papers; organisation of 4 TS during the life time of the Action; STSM program management, website developmentand update; STS organisation; SI production.

Deliverables. Electronic handbook guidelines for stakeholders of each participating COST Country; STS at 4 international conferences; dedicated workshops with water resources managers and policy makers; annual workshops on WG specific topics for a smaller audience, eventually in relation to annual conferences (4 workshops minimum); 3 TS on IRES hydrology, biogeochemistry, ecology and modelling will be targeted specifically at ECI with both theoretical and applied aspects (e.g. fieldwork); STSMs – Each WG will provide announcements of STSMs. Priority will be on STSMs for data analysis and interpretation for ECIs related to the development of the Action area and with publication potential (>10 STSM).

3.1.2. GANTT Diagram

	YEAR1 Months 1-6	YEAR1 Months 6-12	YEAR2 Months 1-6	YEAR2 Months 6-12	YEAR3 Months 1-6	YEAR3 Months 6-12	YEAR4 Months 1-6	YEAR4 Months 6-12
MC Meetings	X		X		X		X	X
Vidio conferences (MC, SC, SHC)	X	X	X	X	X	X	X	X
WG workshops	X	X	X	X	X	X	X	X
Website	X	X	X	X	X	X	X	X
STSM		X	X	X	X	X	X	X
TS		X		X		X		X
FYR M eetings			X		X		X	
RTMW		X			X			X
STS		X		X		X		X
Meta-database release					X	X	X	X
Papers		X	X	X	X	X	X	X
Electronic handbook							X	X
Citizen-scientist network				X	X	X	X	X

3.1.3. PERT (optional)

3.1.4. Risk and Contingency Plans

Risks on the Action level will be overseen by the Coordinator who will use established methods for the Action planning and control. Initial risks were identified with respect to (i) partnerships (e.g., partner fails to provide access to resource or to assist workshop), (ii) Action management (e.g., too high work load for individual partners), (iii) methodological issues (e.g., failure to provide essential data with a specific method), and (iv) the time plan (e.g., delay in producing deliverables). Risk management will be a continuous process led by the Coordinator and a Steering Committee (SC), and risks systematically identified at each workshop and mitigation measures will be initiated. **Disputes** will be resolved in accordance with a clearly defined process: (i) A solution in agreement with the objectives of all parties is aimed for; (ii) The dispute should be resolved at the appropriate level, with all discussions conducted in an open and honest manner. In case of a dispute the Coordinator shall be immediately informed and will assess the potential effect of the dispute on

the entire Action, and following consultation with experts of the International Research Direction of the PI's Institution and the SC, will decide on the appropriate approach for resolving the dispute. This may be achieved by local intervention or, in extreme cases, calling an emergency meeting where possible courses of action can be discussed and voted upon.

The WG Leaders will compile and regularly update a Risk Statement Form, which describes each risk and its threat to the Action. The Coordinator will then assign the issue to a partner or a group of partners who will then actively work on a resolution. The status of the resolution will be tracked by the Coordinator. After resolving an issue, the process will be documented and shared among the consortium. In case of major problems or delays the Coordinator will immediately communicate with the consortium to ensure that corrective actions are agreed upon and implemented at an early stage.

3.2. Management structures and procedures

Management structures

The organisation and management of the Action will consist of the following entities:

Management Committee (MC): The MC will be responsible for the overall coordination of the Action through annual meetings and regular contact with WG Leaders.
Steering Committee (SC): The SC will be a subset of the MC in charge of following, progress and on-going matters (including risks and disputes).
Stakeholder Committee (SHC): The SHC will represent the stakeholders from the different participating countries. It will have annual meetings and regular contacts with the MC, SC and WG Leaders.
Working Groups (WG): Six WGs will form the basis of the Action. The WG Leader and Co-Leader will be responsible for WG-specific activities such as workshops, Training Schools and Short Term Scientific Missions. Co-Leaders will be ECIs in order to train them to manage a group without having full responsibility.
Short Term Scientific Mission (STSM) panel: The Action is determined to strongly promote training of young researchers, for example through STSM support. The STSM panel will include a delegate from each WG and will manage and evaluate STSM applications. The STSM Coordinator will be elected.
***Forum for young researchers (FYR)*:** An informal forum of young researchers will be formed based on the ECIparticipants and in the Action and the Training Schools. The Leader will be nominated by the FYR.

Meetings and communication

A number of meetings and communication activities will be organised to ensure the activities and the networking. These are:

Workshops: The Action will organise three sets of workshops:

1. **Annual international workshops** (hosted by participants in the Action) bringing together a wider community of researchers to present the "state-of-the-art" and outline future research needs related to the COST Action (20-40 people);
2. **Smaller** (10-20 people) **WG-specific topical workshops** targeted at the deliverables of the WG;
3. **RTMW workshops** organised by SHC/MC and targeted at linking the activity of the Action to the water resource manager and decision-making communities, and delivering them the produced tools and guidelines.

At least 10-20% of ECI participation will be encouraged in all workshops (except the RTMW ones). The WG workshops will be encouraged to produce a high-level perspective paper every 2nd workshop.

MC meetings: Each year, the MC will meet separately to discuss and decide on the progress of the Action, WGs, deliverables and future activities. The MC will specifically discuss potential collaborators and actions that each MC member should take forward to engage to guarantee the transfer of knowledge at national level, e.g. in relation to annual workshops.
Steering Committee (SC) visioconference-meetings: These meetings will be held 4 times each year to discuss progress and on-going matters.
Stakeholder Committee (SHC) visio-conference-meetings: These meetings will be held twice a year to discuss progress and on-going matters.
Website: The Action will establish an interactive website to describe/inform its activities as well as activities of relevance to participating members (meetings, conferences, TS, publications, etc.). The MC will consider the establishment of the Action profile in social networks like Facebook and/or Twitter to promote a continuous dialogue with interested parties.

Milestones

The progress of the Action will be assured by observing the following milestones:

First MC meeting: The first MC meeting at the beginning of the Action, which will involve agreeing on the constituency of the MC and SC, the Election of the Chair, Vice-Chair, Working Group (WG) Leaders, FYR Leader and STSM and RTM panel.
Website: The interactive Website for the Action will provide information on the Action's networking activities.
Annual workshops: A draft plan for annual Action workshops including MC, SC meetings, as well as WG and RTM workshops will be outlined at the first MC meeting. Annual workshops will be outlined one year in advance, including election of an organizing committee. The topical WG workshops will be suggested to the MC for approval 6 months in advance.
Training Schools: Comprehensive plans for Training Schools (content, venue, size, budget) must be presented for discussion and decisions by the MC at the 2nd annual workshop.
Position papers: Plans for position papers and responsible lead authors will be decided at the 2nd annual workshop based on proposals from each WG.
Conferences: A plan for organising Special Topical Sessions at international conferences will be discussed at the first MC meeting.

3.3. Network as a whole

The consortium has several features which are critically relevant to address the objectives and challenges of the Action. First, the consortium is composed of participants working on IRES research in collaboration with JRC, water managers and stakeholders. This joint effortwill contribute to the Action on specific and relevant aspects (e.g., WG1, 2, 4).

The participantshave recently published IRES research related papers in very high-impact journals. The consortium will also benefit from several past and on-going productive and successful collaborations among the participants, which led previously to European funded projects (e.g., MIRAGE, TRivers), international research projects (e.g., IRBAS), Special Issues on IRES in international journals (Aquatic Sciences, River Research & Applications, Freshwater Biology), and Special Sessions on IRES at international conferences (e.g., Symposium for European Freshwater Sciences 2011/2013/2015).

The geographic coverage of the participants extends from Western, Central and Eastern to Southern Europe, spanning notably oceanic, temperate, continental, Mediterranean, and arid climate zones, contrasted land used and water resource management practices and policies, hereby covering a wide range of situations and issues.

The inclusion of NNCs and ITCs will allow enlarging the geographical scope of the Action, notably by including countries of the Balkan Peninsula, which are hotspots of biodiversity where IRES predominates. The participation of IRES experts from 4 IPCs (USA, New Zealand, South Africa, Australia) with whom several participants of the consortium have on-going and productive

collaborations will provide scientific and management expertise, experience and training to the Action participants. This will notably include the coming of several international experts to the Training Schools but also the participation of managers from countries where the management of IRES is the most advanced (e.g., Australia) to some RTM workshop to learn from their experience and share the Action challenges and progresses. This will clearly benefit from the past and on-going collaborations that many participants have with colleagues outside of COST Countries.

The intertwined collaboration in the Action among researchers and managers will be crucial to achieve its overall goal, synthesing current knowledge on IRES and translating this into management tools and guidelines.

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