DANube macroregion: Capacity building and Excellence in River Systems (basin, delta and sea)

- DANCERS -

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Detailed plans and concepts for a new regional research infrastructure in the field of integrated river- delta – sea management in the Danube – Danube Delta – Black Sea area

Author(s) Name(s): Adrian Stanica, Nicolae Panin, Ionel Andrei, Viorel Vulturescu, Michael Schultz, Chris Bradley, Andrew Tyler, Daniel Parsons, Tom Preston, Helmut Habersack, Angelika Riegler, Thomas Hein, Gretchen Gettel, Jeremy Gault, Panagiotis Michalopoulos, Vangelis Papathanassiou, Manuela Sidoroff, Mihaela Paun, Simona Litescu

Organizations: GeoEcoMar, University of Natural Resources and Life Sciences (BOKU) Vienna, University of Stirling, University College Cork, WasserCluster Lunz, UNESCO-IHE, HCMR, National Institute of Biological Sciences

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Table of Contents

Summary

This document summarises the case for the design and structure of a distributed research infrastructure on the Danube – Danube Delta – Black Sea macro system. Current gaps in our understanding of this environmental system are outlined, focussing particularly on the lack of cross-disciplinary and cross boundary research required to span the wide geographical extent of the Danube River, Delta and western Black Sea. This has led to a failure, to-date, in synthesising environmental process dynamics at appropriate spatial and temporal scales hindering the development of sustainable and integrated catchment management practices across the Danube – Danube Delta – Black Sea macro system.

The document details the technology and infrastructure required to meet these demands, focussing on two EUSDR flagship projects: DANUBIUS-RI and DREAM. Together these initiatives have the potential to maximise opportunities for world leading environmental research in the Danube River Basin, the freshwater – marine transitional zone of the Danube Delta, and the Black Sea. This research will have wider impact outside the Danube region and will address current and emerging societal challenges. Moreover, by embracing new and emerging opportunities it will deliver a platform to enable cross-disciplinary research that integrates the environmental science and engineering disciplines with the social and economic sciences thereby advancing our ability to understand and manage dynamic environments such as the Danube – Danube Delta – and Black Sea.

1. Introduction

Globally, freshwater and marine systems and their transition zones – including deltas and shallow seas - are experiencing growing environmental problems, as a result of increasing population pressure and associated economic development within an increasingly extreme climate. This presents major challenges to balancing economic and societal needs with sustainable environmental management. In Europe, pollution from agricultural and urban centres and hydraulic engineering are widely recognised to inhibit the achievement of good ecological / environmental status in coastal and inland waters. At the same time, economic sectors such as shipping/navigation and hydroelectric power generation depend on minimum water volumes for their functioning while significantly altering complex dynamics associated sediment movement, water flow, and increasing the potential for alien species introduction. These pressures act in concert with climate change, which is driving alterations to return periods and the frequency of extreme weather conditions (e.g. Döll and Zhang, 2010) and in the hydrological regime of freshwater and oceanic systems (Doney et al. 2012; Ruckelshaus et al. 2013). These problems must be solved in an integrated way in order to develop sustainable solutions that balance economic and societal needs with environmental protection and long term sustainability. Current projections anticipate crucial changes regarding extreme weather conditions, altered oceanographic conditions and the overall hydrology and regime of catchments and rivers. These changes will, in turn, severely modify basic riverine and marine processes inducing important physical, geochemical and biological responses. To a significant extent, our approach to problems such as these has been discipline specific and considerably more focus on innovative cross-disciplinary research is essential to address current and emerging environmental problems to deliver sustainable and innovative solutions required to address the major societal challenges, including environmental protection and job creation.

These challenges are exemplified in Central and Eastern Europe by the Danube River - Danube Delta - Black Sea (DBS) system. This region has a complex recent geopolitical history and includes some of the richest and poorest areas of Europe. There are many challenges in environmental management in the region, particularly in balancing habitat conservation and restoration, and addressing the EU 2020 Biodiversity targets, whilst ensuring sustainable economic development. With a basin >800,000 km^2 in area (Figure 1) and a catchment that spans 19 countries, the Danube River is the most international river in the world, connecting people with differing economic, social, cultural, political and environmental heritages. Of the countries that share the Danube catchment, 11 are EU Member States (Austria, Bulgaria, Croatia, Czech Republic, Germany, Hungary, Italy, Poland, Slovakia, Slovenia, Romania). The 8 non-Member States (Albania, Bosnia and Herzegovina, Macedonia, Moldova, Montenegro, Serbia, Switzerland, Ukraine) are members of the International Commission for the Protection of the Danube River (ICPDR) and committed to implementation of the EU Water Framework Directive. The Black Sea itself is >430,000 km^2 in area, and is surrounded by 6 countries: Bulgaria, Georgia, Romania, the Russian Federation, Turkey and the Ukraine. The Black Sea has unique environmental characteristics: as a semi-enclosed sea, the water masses are vertically stratified and it is the largest anoxic basin in the world. Its salinity is significantly lower than the mean of the Planetary Ocean and its water balance is largely controlled by the freshwater inputs from major rivers of which the Danube is the largest.

Figure 1: The Danube – Danube Delta – Black Sea (DBS) Macro- System

Within this context, the EU Coordination and Support Action (CSA) project DANCERS (DANube macroregion: Capacity building and Excellence in River Systems (basin, delta and sea) seeks to mobilize actors and resources from public and private sources to increase investment and research and innovation to enhance river-delta-sea management in the DBS region. A starting point is provided by a number of significant pressures identified in the Danube River Basin District by ICPDR and formulated in the DRB management plan (ICPDR 2009) updated in 2015 (ICPDR 2015), with respect to water quality, hydromorphological alterations, river and habitat continuity interruption, hydrological alteration and newly emerging management issues such as invasive alien species (IAS), protecting all the sturgeon species and increasing the adaption capacity to climate change effects. Hence DANCERS constitutes a supporting action, which it is envisaged will ultimately help achieve the environmental objectives for the DBS Region by identifying the knowledge and technological requirements to develop a specific strategy for the science, economic development and sustainable management of the Danube Delta area.

One of the key aims of the DANCERS Project was to provide strategic guidance on how to improve cooperation in research and innovation in the DBS Region so as to better exploit scientific outcomes for the benefit of the economy, environment and society in general and inform both policy makers and stakeholders in particular.

To this end, DANCERS work package 3 [Design] was tasked with devising processes and building upon the outputs of work packages 1 [Mapping] and 2 [Understanding] to work with stakeholders in producing three discrete but interconnected outputs:

(1) A regional strategic research and innovation agenda (SIRA) – to provide scientific direction to underpin integrated management of river-delta-sea systems in the DBS region.
(2) A detailed plan and concept for a new distributed research infrastructure – to link with existing infrastructure in the natural sciences across the DBS region and with the wider European domain.
(3) Human capital development programme – to provide recommendations for the

development of undergraduate, MSc, PhD education and postdoctoral training programmes to build capacity for the proposed integrated management approach. This is also framed within the context of life-long-learning.

This document focuses on the research facilities required to address the above challenges in the DBS region. It summarises the current position with respect to the research agenda, identifying specific challenges and opportunities that the research infrastructure must be able to address. In particular, it highlights the potential to draw upon two current research infrastructure Flagship Projects of the European Union Strategy for the DBS Region: DANUBIUS-RI (International Centre for Advanced Studies on River-Sea Systems, the proposed pan-European distributed research infrastructure that includes a substantial focus on the DBS System), and DREAM (Danube River Research and Management). The project DREAM will provide an umbrella and the infrastructure for a set of research topics. The intention of these Flagship Projects is to grow the capability of existing regional infrastructures, and facilitate development of new research initiatives that will drive and enhance the capability of the European research community to undertake world-leading research. This research will have global reach and impact in the context of populations that are increasingly distributed in coastal margins, and hence vulnerable to coastal/marine hazards, and confronting emerging challenges within the food-water-energy nexus, at a time of rapid environmental change.

2. Research Infrastructure needs in the DBS System

Development of the Strategic Research and Innovation Agenda (SRIA) was produced by the DANCERS Project Partnership (see Table 1 below) in consultation with experts and stakeholders from the DBS Region who have backgrounds in scientific research, education, government and industry (Table 2.1).

Table 2.1. Members of the DANCERS project partnership (2013 – 2015).

INSTITUTE	COUNTRY	FIELD OF EXPERTISE
Institutul National De Cercetare-Dezvoltare Pentru Geologie Si Geoecologie Marina (GeoEcoMar)	Romania	Geology, sedimentology and gephysics of the Danube River – Danube Delta – coast – Black Sea ICZM Global climate change
Consorzio Per La Gestione Del Centro Di Coordinamento Delle Attivita Di Ricerca Inerenti Il Sistema Lagunare Di Venezia (Co.Ri.La)	Italy	Environmental Impacts Geomorphology Biodiversity
Zentrum Fuer Soziale Innovation (Zsi)	Austria	Network management, Policy dialogue, Comms & dissemination
Institutul National De Cercetare Dezvoltare Pentru Stiinte Biologice Romania	Romania	Biodiversity Environment risk Biology & ecology
Wassercluster Lunz - Biologische Station Gmbh (WCL)	Austria	Ecosystem science Environment-society Interface challenges
Universitaet Fuer BodenKultur Wien (BoKu)	Austria	Natural sciences, Engineering Economics,
Consorcio Centro Internacional De Investigacion De Los Recursos Costeros (CIIRC)	Spain	Hydrodynamics Water quality, Coastal morphodynamics
Hellenic Centre For Marine Research	Greece	Oceanography/Hydrology Marine Biology Fisheries / Aquaculture
The University Of Stirling (with Birmingham and Hull Universities)	UK	Human behaviours, Biological, environmental, aquatic and morphodynamic systems
University College Cork (UCC)	Ireland	Governance Geomorphology Aquatic environments

Bundesanstalt Fuer Gewaesserkunde	Germany	Quantitative hydrology, Ecology
Institut Francais De Recherche Pour L'exploitation De La Mer (IFREMER)	France	Ocean Resources Marine Monitoring Sustainable development
United Nations Educational, Scientific And Cultural Organization –Institute of Water Education (UNESCO-IHE)	Netherlands	Hydrological modelling Nutrient impacts, and Basin Management
Univerzitet U Novom Sadu	Serbia	Stakeholder identification Web-based tools Gap analysis
Szechenyi Istvan University	Hungary	Data collection & analysis Integrated management of rivers-deltas-seas.

The process involved three key steps (1) Mapping national, EU and international research/initiatives on river-delta-sea systems; (2) Understanding the needs in knowledge transfer among science, economy and policy makers; and (3) Reviewing the State of the Art within River-Delta-Sea Systems. The approach resulted in a SWOT, presented in the following section.

2.1 Strengths Weaknesses Opportunities and Threats (SWOT)

A SWOT analysis of existing research infrastructures (RI) in the DBS Region was undertaken as part of the FP7 DANCERS project. Existing RIs span the DBS System but currently there is a lack of coordination and there are a number of specific gaps as highlighted in Table 2.2. For example, the lack of standard observation protocols across the freshwater – marine continuum is a significant barrier to environmental research and a mechanistic understanding of DBS System. Further difficulties arise from the continual need to upgrade facilities given ongoing technological advances, whilst ensuring compatibility and cross-referencing with respect to existing observational systems, analytical and modelling facilities, and e-infrastructure, across the region.

The SWOT analysis identified several major opportunities that demonstrate that it is now timely to consider how to develop and enhance RIs across the DBS to capitalise on the potential to undertake innovative inter-disciplinary research. In so doing, the RI has the potential to nurture business partnerships and further the opportunities to maximise the impact of applied science in managing the DBS system.

During the DANCERS workshops and dialogue conference the participants identified that:

i) Existing RIs from the DBS System lack effective coordination and there is no system granting systematic transnational access to existing facilities.
ii) Harmonisation/standardisation of scientific data both between academic domains ad within the same field within the catchment is needed, including the Danube Delta and the NW Black Sea coast.

iii) The existence of different and fragmented regional and/or national priorities along the length of the river, from its headwaters to the Black Sea limit their contribution to the understanding of the DBS Sea system.

2.2 Online Survey

In addition to the SWOT Analysis, an online survey undertaken by the DANCERS project confirmed the need to strengthen research facilities in the DBS Region. In total, 83% of the respondents considered that there was a need for a new RI in the field of river to sea macro systems and perceived that this would be an invaluable EU/international resource. The need to upgrade the existing RIs and improve transnational communication was also identified as very important. The respondents considered access to experimental facilities, the availability of expert analysis / consultation, coordination within the DBS Region and collaboration with infrastructures from other river-delta-sea systems to be of high importance. The survey also showed that the respondents considered the major priorities for the Distributed Research Infrastructure for the DBS system to be: (i) maintaining ecosystem sustainability, (ii) assessing and managing ecosystem resilience to environmental change, (iii) hazard mitigation, (iv) developing safe water systems for citizens, (v) closing the water cycle gap, and (vi) promoting environmental stewardship.

All these points confirm the general conclusion of Bloesch et al. (2011), that future development in the DBS system is threatened by the lack of integrated, comprehensive system level planning.

Table 2.2. Strengths Weaknesses Opportunities and Threats (SWOT): Research Infrastructures

Strengths	**Weaknesses**
• Existing “natural transnational laboratory” (the Danube River – Danube Delta – Black Sea System) • Some existing national infrastructure with different focus of action (from analytic facilities – laboratories to research vessels); Experience from EU Flagship Projects for Research infrastructure (DREAM and DANUBIUS-RI). • Experience in the use of the Structural funds eg for CBC (Cross Border Cooperation) or in other sectors • Data availability (collected by research projects; individual countries or by the ICPDR); and existence of pan-European e-infrastructures that can be of service	• Current dispersion of existing research infrastructures, facilities and data, with no coordination or clear information accessible • Lack of systematic transnational (and sometimes even national) access to existing infrastructures • Lack of harmonisation/ standardisation of scientific data – either between domains or in the same field within the catchment and including the delta and NW Black Sea • Existence of different and fragmented regional and/or national priorities for Research Infrastructures in the Danube Region

Opportunities	**Threats**
• Proposed pan-European distributed RI on River- Sea Systems • Proposed distributed RI: DREAM Danube River Research and Management – EUSDR Flagship Project • Existence of ESFRI and its roadmap • Existence of dedicated calls for Integrated Activities for Infrastructures at European level (H2020) • Coordination of existing national research infrastructures (national roadmaps) • Environmental and social research centres lining up to global initiatives, such as collection of long term data series • Existence of the GEOSS and the COPERNICUS programmes	• Lack of security of long-term funding • Subcritical funding (constancy and size of funding) endanger the visibility and significance in the region and globally • Focus on a very limited research domain – avoiding thus interdisciplinarity • Limited funding for maintenance of regional and national infrastructures • Life cycle of infrastructures

2.3 Reviewing the State of the Art within River-Delta-Sea Systems

A series of review papers were submitted to a special issue of the International Journal *Science of the Total Environment* which together sought to identify the state of the art and best practice in river-delta-sea systems in both knowledge within the physical, chemical and biological aspects of river delta sea systems, their observation, and the social and economic aspects including educational requirements. These articles were peer reviewed by independent international experts through the normal editorial channels, and together provide a third source of evidence to inform development of the tools and instruments required to boost knowledge transfer, enhance Research and Innovation cooperation for the environment at the more integrated strategic level in the DBS region.

2.4 Needs Analysis

The SWOT analysis demonstrated that while there is common recognition of the environmental problems among stakeholders in the Danube Basin, coherency in approaches between countries and amongst stakeholders requires improvement. Integrated basin management requires expansion of these already good collaborations to broader participation in order to create a perspective of the entire DBS macrosystem. The analysis also noted that harmonization of methodologies for data collection and QA/QC are needed in order to implement the Water Framework Directive (WFD), the Floods Directive (FD) and the Renewable Energy Directive (RD). These observations present an opportunity to align a research agenda that is relevant to EU 2020 Societal Challenges, the EUSDR and other strategic research agendas such as Water EIP, Water JPI and JPI Oceans.

In addition to disparate national research efforts in the Basin, stakeholder involvement is essential to ensure that the scientific results have practical utility to policy and industry. This observation is supported by the analysis of the FP7 DANCERS Project metadatabase (www.dancers-fp7.eu) which indicated that coordination between upper, lower, and middle Danube with respect to economic development – particularly for navigation and hyropower - is needed. For example, national and international projects which aimed to remove navigation bottlenecks (e.g. TEN-T) may have damaging consequences to sensitive and high-value ecological areas downstream. Another example of the need for greater integration is in addressing the damaging effects of invasive species. The Danube is linked to the North Sea basin by the Rhine-Main-Danube Canal (Southern Invasive Corridor), which increases the vulnerability of the basin to invasive species. However, most studies in this area have been conducted in the Black Sea region. Freshwater studies have increased since 2009 (Feldbacher et al. Submitted), but increased transportation between the two basins requires whole-basin awareness among stakeholders as well as research that addresses these challenges at the basin-delta scale. These are only some of the examples that informed the conclusion that a greater integration between stakeholders along the DBS continuum with better scientific understanding is needed to enable sustainable development in the region. In particular, projects that address these complex dynamics along the continuum of the River-Delta-Sea system in an integrated way, and which include stakeholders, are required to achieve integrated, sustainable management that balances societal needs with environmental protection.

One of the pillars of the EUSDR is “connecting the region”. One way to do this, via robust and holistic, system level sustainable management, is by maintaining a habitat continuity throughout the Basin, both longitundinally and laterally – conserving and restoring the Danube “Green Corridor.” Impoundment, water flow and water quality, sediment transport and the effects of human alteration of the hydrogeomophology are key components that need to be addressed in an holistic manner, from source to sink. Specifically, upstream-downstream linkages in sediment dynamics must be understood at multiple scales. For example, impoundments cause sediment starvation on local and at basin scales. At local scales, the river reaches downstream from impoundments often become incised with increased bank erosion. This in turn increases bank-full capacity thereby reducing river-floodplain connection, as well as increasing the likelihood of flooding downstream. Furthermore, habitat quality in these reaches changes: macrophytes, can no longer survive in deeper, faster-flowing water, and habitat for invertebrates and fish are lost (Hein et al. Submitted). At the basin scale, sediment retention can deprive the Delta from much needed sediments to maintain the unique habitat (eg. Panin 1998). Dredging channels for navigation can also cause unintended changes in habitat downstream by changing erosion dynamics and flow rates (eg. Panin 1998, Giosan et al., 1999, Panin & Jipa, 2002, Stanica et al., 2007). In addition to the proximate controls on sediment transport, climate change also has the potential to alter sediment transport and hydrogeomorphology at longer time scales (Hein et al. Submitted). To address these complex process interrelationships, innovative research in sediment and water management is needed to determine how to maintain an acceptable habitat quality and connectivity while achieving the economic and societal needs for navigation, hydropower, and flood protection.

Habitat continuity must also be considered with respect to maintaining appropriate water flows and connectivity particularly related to endangered and economically species such as the sturgeon. The lack of knowledge on habitat condition and change, along with trends in fish fauna, are a major hindrance in developing effective environmental management strategies (Doru et al., submitted). Whilst a programme for the protection of Sturgeon is being implemented by the Danube Sturgeon Task Force (DSTF) and the EUSDR, supplementary data on habitat quality, environmental change drivers and prediction are required. Furthermore, research into the effectiveness of fish passageways in restoring populations and the spatial variation in population is required. These research tools should include state-of-the-art DNA and isotope studies to fully understand population dynamics, changes in diet and food web structure, and the effect of conservation measures. These techniques are also applicable to the Delta region where aquaculture and over-fishing also present challenges when seeking to maintain viable fish populations and biodiversity. Such research presents strong opportunities for empowering key stakeholders such as, e.g., fishermen, in citizen science activities, and can provide another way to connect the region while improving properity through the sustainability of livelihoods.

Understanding the potential pathways for invasive species and factors that influence their success is critical. In other regions, invasive species have benefited from human-disturbed systems, including the introduction of hard substrate, altered nutrient regimes, or altered food web structure through predator-removal caused by, for example, over-fishing (ICPDR, 2009). Attention since the early 2000's has focused on the Black Sea where the introduction of invasive species at multiple trophic levels has considerably altered the original food web structure, and research is only now starting to be considered in the upper part of the Danube (Hein et al. Submitted). Unintended species introduction and the risk for proliferation of alien species also needs to be understood along the whole corridor, especially as new shipping channel connect the Danube, and the Black Sea Basin, to the Rhine River (Baltic/North Sea Basin) (Hein et al. Submitted). The need to address this critical issue in an integrated manner and at a basin scale, has also been identified by the ICPDR (2009).

Agricultural intensification, urbanization, and increased tourism are also important pressures that affect water and habitat quality in the basin. The effect of these developments on nutrient loading and organic matter processing needs to be understood, taking into account the social and cultural contexts and economic drivers. Tourism is particularly important given that the popularity of the Danube for ecotourism; this has increased in importance in recent decades and requires careful management. Agricultural intensification, encouraged by EU Common Agricultural Production (CAP) and the desire for increased subsidized food production also drives nutrient loading, especially in the western part of the basin (Schreiber et al. 2005). These changes in land use and land cover all have implications for diffuse and point-source pollution.

Analogous to understanding sediment transport and processing dynamics, nutrients, organic matter, and pollutants need to be understood at both local and basin scales. Locally, both diffuse and point sources may play an important role in, for example the over-enrichment of reservoirs. However, at the basin scale, complex retention mechanisms within the basin (including by reservoirs) may mitigate the export of materials to the Black Sea. Transport, retention and processing are expected to change in coming years along with climate change and increased frequency of extreme weather events, which have the potential to prolong and perhaps intensify the eutrophication problems and the nature of “hot-spots” associated with other types of pollution. It is critically important to understand these processes because source and transport dynamics must be targeted in any effective management strategy that aims to reduce loading to the Danube Delta (and Black Sea). A fundamental limiting factor for basin wide investigation in this dynamic system is the lack of harmonized measurements with respect to the methodology and observation frequency with adequate spatial and temporal coverage in the basin. Thus, research is needed in the most cost-effective and strategic measurement schemes for pollutants, including nutrients, at the basin level, as well as process-based models to represent hydrological and biogeochemical cycling and transport dynamics.

When new areas are opened for restoration or for investment tourism, e.g. through efforts to re-connect river floodplains to the river, or to open important acheological sites to tourism, research on the effectiveness of these activities in terms of key ecosystems services is required. This includes carbon storage, nutrient retention and biodiversity (including e.g. the Bird Directive), as well as the historical and cultural values associated ancient and historical sites present in the basin. Research into the societal response along with the economic and cultural benefits is required. This research also provides opportunities to connect the region through shared cultural, historical, and ecological heritage.

In summary, new tools are needed for an integrated understanding of how pressures from human modifications in hydrogeomophorphology, species deletions and introductions, nutrient loading, and pollutants (including micro-plastics, nanoparticles and pharmaceuticals) are propagated downstream and laterally into the riparian zones and floodplains. Such tools should include model development for the basin which includes aspects of habitat quality relevant to the WFD and Floods Directive, including nutrients, macrophytes, invertebrates, and fish. Models should be able to quantify the effect of multiple pressures (specifically hydropower, nutrient inputs, navigation, known and emerging pollutants) on habitat quality in the Danube. This should be a tool for managers to assess effects on the river’s ecological status in relationship to the WFD and provide a basis for decision making and discussion about management choices with stakeholders.

3. Opportunities

Recent technological advances and aligned programmes mean that this is an opportune time to address the challenges identified above, by a cross-disciplinary distributed Research Infrastructure on freshwater – marine systems. The RI can potentially build upon the world-leading capabilities of the European environmental science community to deliver the necessary step change in our understanding. This includes: (i) Earth Observation and the development of in-situ technologies through EC Framework Programmes and ESA funding, building on ESA's Copernicus Programme; (ii) near real-time processing and management of Big Data; (iii) advanced geo- and biochemical analytical platforms, the latter describing genotypic and phenotypic diversity in increasing detail. These advances, together with developments in data capture, processing and modelling, enable us to quantify the extent of environmental change (and system dynamics) at rates and resolutions far in advance of those that were previously feasible even 10 years ago. The challenge lies in how to utilize these advances to their greatest potential, and ensure environmental sustainability in the context of growing human-induced stresses.

The initiative to develop RI in the DBS system is further enhanced by the coincidence of the following factors:

i. Political framework. EUSDR and ESFRI;

ii. Timeliness of technical advances (analytical capabilities in, for example, mass spectrometry, DNA sequencing, satellites sensors, mesocosms, numerical modelling);

iii. Resource exploitation;

iv. European e-infrastructures initiatives (Geant & PRACE);

v. Existence and recent enhanced funding of the GEOSS and the COPERNICUS programmes.

3.1 Political framework

3.1.1 The European Union Strategy for the DBS Region (EUSDR)

The EUSDR aims to implement an integrative policy in the region and enhance cross-border cooperation to achieve the overarching EU goal of sustainability (COM 400, 2009). The objectives of EUSDR are fourfold: i. connectivity; ii. protecting the environment; iii. building prosperity; and iv. strengthening the DBS Region. This strategy considers environmental protection for the first time in the DBS system when developing social and economic policies.

The EUSDR was adopted by the European Commission in June 2011, and comprises 11 Priority Areas:

1. To improve mobility and intermodality
2. To encourage more sustainable energy

3. To promote culture and tourism, people to people contacts
4. To restore and maintain the quality of water
5. To manage environmental risks
6. To preserve biodiversity, landscapes and the quality of air and soils
7. To develop the knowledge society
8. To support the competitiveness of enterprises
9. To invest in people and skills
10. To step up institutional capacity and cooperation and
11. To work together to tackle security and organised crime.

The existence of the EUSDR is a major catalyst for the better focus of the efforts made by the funding agencies, in a way that allows the fulfillment of these priority areas.

In Priority Area 7, the specific action *"To strengthen the capacities of research infrastructure"* envisages a secondary action: *"To establish joint international research centres for advanced studies*" to attract world-class scientists and provide modern research infrastructure. It is under this action that both DREAM and the Danube component of DANUBIUS-RI achieved their status of Flagship Projects of the EUSDR. According to the provisions of the Strategy, Flagship status will support a smoother and faster implementation, as it recognises the political importance of the selected projects for the strengthening of the entire Region.

3.1.2 European Strategy Forum on Research Infrastructures

ESFRI is the European Strategy Forum on Research Infrastructures. According to its own definition, ESFRI is a strategic instrument to develop scientific integration in Europe and strengthen its international outreach. The competitive and open access to high quality Research Infrastructures supports and benchmarks the quality of the activities of European scientists, and attracts the best researchers from around the world (http://ec.europa.eu/research/infrastructures/index_en.cfm?pg=esfri).

The mission of ESFRI is to support a coherent and strategy-led approach to policy-making on research infrastructures in Europe, and facilitate multilateral initiatives leading to the better use and development of research infrastructures, at EU and international level. ESFRI's delegates are nominated by the Research Ministers of the Member and Associate Countries, and include a representative of the Commission, working together to develop a joint vision and a common strategy. This strategy aims to overcome the restrictrions arising due to fragmented individual policies and provides Europe with the most up-to-date Research Infrastructures, responding to the rapidly evolving Science frontiers, advancing also the knowledge-based technologies and their extended use.

Pan-European Research Infrastructure projects which are judged of relevance are accepted on the ESFRI Roadmap. The first Roadmap was published in 2006, and was subsequently updated in 2008 and 2010. 6 projects were initially included on the list of major RIs in the field of the Environment, increasing to 10 in the 2008 update. Two projects stepped back from the Roadmap since then whilst most of the remainder are already being implemented. The new ESFRI Roadmap – to be published in 2016 – had a new competition for major pan-European RIs of global importance. DANUBIUS-RI is one of the submitted proposals.

3.2. Timeliness of technical advances

Recent decades have witnessed rapid scientific and technological developments. New generations of equipment and computing facilities appear with a great speed. From a society where scientific data were formerly scarce, we are now living in a period when new technological capabilities provide enormous quantities of new information in all academic domains. Given constraints of space, this report briefly summarises some of the latest oportunities in two domains, however comparable technological developments are occuring in all scientific domains.

3.2.1 Technical advances in biochemical analysis

Each year sees significant advances in the capabilities of state-of-the-art biochemical instrumentation. Mass spectrometry (MS) is the prime example of this ongoing technological revolution. Major improvements in resolution, sensitivity and throughput, combined with a revolution in data handling have worked together to serve a huge demand from biomedical sciences. Proteomics (peptides and proteins) and metabolomics (small molecules) have spread from their origins in medicine and pharmaceutical science, to be applied throughout the life sciences. Along with advances in spectroscopy, the demand to handle 'big data' from MS spawned the discipline of bioinformatics. Rapid throughput 'omics' approaches are clearly going to be applied more widely in ecology and environmental science. Furthermore, metagenomics (DNA sequencing) and metatranscriptomics (RNA sequencing, including next gen) tools have revolutionised the speed and scope of genomics applications. Temporal and spatial biological surveys can now be accompanied by an extremely powerful modern toolkit to describe system diversity (genotype and phenotype), temporal changes and the impact of invasive species or pollutants. Furthermore, parallel developments in several related MS techniques to detect xenobiotics at ever lower limits, to characterise metallic elements with greater speed and sensitivity and to measure natural isotopic abundance as unique indexes of ecosystem function and elemental flux are continuing apace.

In short, a well-found multidisciplinary environmental research centre should aspire to host a full array of modern instrumentation in addition to conventional biological technologies in order to permit an enhanced capability to describe and to predict trends in the flora and fauna of complex ecosystems. A well found laboratory would support a full range of conventional ecological techniques to describe organisms from the smallest microbe, plankton, macrophytes and terrestrial plants, to zooplankton, molluscs and arthropods, through fish and birds to larger mammals and their terrestrial and aquatic food sources. The major task of predicting future trends in the complex river-delta-sea ecosystem will be aided by experimental facilities (such as large mesocosms) that will allow controlled experiments modifying the physico-chemical environment in order to inform the development of numerical or predictive models. The conventional observational approaches would be enhanced by modern genomics and proteomics methodologies. Describing the diversity of natural systems, their temporal and spatial variability and the response to global change or regional events, requires a full suite of technology. Nowhere is the need for a research presence more pressing than in those environments, most likely those on the Southern borders of Europe, that may be the first to observe the appearance of invasive species that will impact environmental and human health.

3.2.2 Advances in synoptic approaches

Over the last decade significant advances have been made in the development of algorithms for atmospheric correction of satellite image data over inland and coastal waters and for the reliable retrieval of a suite of functionally relevant indicators of water quality and ecosystem condition at local and global scales (Tyler *et al.,* submitted). In-water biogeochemical optical active constituents that can be retrieved from optical Earth observation (EO) platforms include chlorophyll-a (Chla), C-phycocyanin (PC), suspended particulate matter (SPM) and coloured dissolved organic matter (CDOM). In addition, parameters such as salinity can be retrieved from L-band radar data and thermal infrared imaging is being successfully used to recover surface water temperature. The next decade will witness a revolution in Earth observation (EO) capabilities with new missions with potential for inland and coastal observation (Sentinel-2/-3) due to be launched as part of ESA's Copernicus programme and by other space agencies such as NASA (e.g., PACE mission).

The availability of this next generation free-to-access data consistent and long-term EO data with advances in the spectral, radiometric, spatial and temporal observational capability will provide a step change in our ability to observe and understand highly complex and dynamic environments such as the DBS transitional environment. Complementary data acquired from sensors on buoys (within the catchment) can provide highly the high temporal resolution data on water quality to demonstrate basin scale connectivity and response times. In addition, super-buoys (in the delta) fitted with radiometers (e.g. AERONET-OC) are highly desirable for EO data calibration and validation activities and regionally tune water constituent retrieval algorithms. The combination of state of the art *in situ* and EO data will provide hitherto unachievable insights into these complex physical and biological exchange environments. Such data will provide new paradigms of understanding both of the influence of the regional (Danube catchment) and global environmental change pressures on the DBS system. Investigations in these areas can also be supplemented by airborne data acquisition for targeted remote sensing campaigns for higher spatial and temporal resolution time series (minutes to hourly) analysis of these dynamic systems (Hunter et al., 2009; Wakefield et al., 2011). Similarly, unmanned aerial vehicles now provide the capability of localised phenomena relatively cheaply and with fewer logistical challenges.

3.3 Resource exploitation

Surface-water eutrophication poses a significant challenge to scientists and water managers, resulting in excecessive plant biomass around the world. This has been driven by agricultural intensification in response to pressures driven by concerns over food security (Harris and Heathwaite, 2012). However, in an economic climate which threatens shortages in essential nutrients by 2050 (Cordell et al., 2009; Quilliam et al., 2015) during a period of climate change which is likely to result elevated nutrient transfer from land to aquatic environments with consequential economic implications (Reichwaldt and Ghadouani 2012). There is great potential for nutrient resource recovery from both aquatic plants and algae for fertiliser, livestock feed and biofuels, whilst also delivering multiple ecosystem benefits including habitat restoration (Quilliam et al., 2015), although algae to fuel production is likely to be reliant on open ponds or closed photobioreactors (De La Cruz, 2013).

In reviewing the potential for harvesting aquatic plant biomass, Qiuilliaum et al., (2015) recommend an integrated ecosystem approach, by evaluating the economic, social, environmental and health-related dimensions of resource recovery from aquatic plant biomass. They advocate that the recycling of aquatic plant biomass is coupled to the remediation of eutrophic waters resulting in the sustainable production of feed and fertiliser, which provides multiple downstream benefits whilst minimizing environmental trade-offs. Research priorities include: i) in the short term, assessing the resource potential and environmental health hazards related to cyanotoxins and metals, processing requirements to ensure product consistency, and raising stakeholder awareness; ii) in the medium term, assessing the ecological damage by harvesting, relative merits of wild harvesting compared with deliberate cultivation, and the ecosystem benefits of preferential harvesting of invasive species; and iii) in the long term maximizing the potential economic, social, environmental and ecological benefits, develop modeling approaches to identify opportunities for resource recovery.

3.4 European e-infrastructures initiatives (Geant & PRACE)

Europe hosts a number of major e-infrastructure initiatives that are extremely important for the successful development and implementation of distributed RIs in the DBS Region, as well as elsewhere in Europe. Major e-infrastructures such as GRID offer opportunities for data transfer, computing facilities such as PRACE support the enhancement of data processing capabilities. Since large amounts of data are gathered in environmental monitoring, DANUBIUS-RI will need to have computing capability to analyse big data collected. The partnership with the pan-European RI infrastructure PRACE is sought, as it will provide access to the BlueGene system JUQUEEN (which was one of the top 8 supercomputers globally at the beginning of 2014, with a peak performance of 5.9 Petaflops).

The EGI (European Grid Initiative) is another example of how Europe offers opportunities to develop performant and successful RIs. The INSPIRE directive supports the maintenance of data quality and compatibility between the various RIs from all over Europe.

3.5 GEOSS and the COPERNICUS programmes

Whilst not exhaustive, the combination of the above opportunities, indicate that it is timely to consider how existing infrastructure can be developed to advance the goal of sustainably managing the DBS System. Advancing management at the freshwater – marine interface is encouraged by LOICZ (the Land-Ocean Interactions in the Coastal Zone Project of the UN International Geosphere Biosphere Programme) and is facilitated by the capabilities offered by the European Space Agency`s COPERNICUS programme and the Global Earth Observation System of Systems (GEOSS). This new integrated approach to large RS systems will address the recommendations of the World Business Council for Sustainable Development: supporting environmental health means also securing the economy because ultimately *“business cannot function if ecosystems and the services they deliver—like water, biodiversity, fiber, food, and climate—are degraded or out of balance.”* (MEA 2005).

4. Realisation

It is important to look forward and consider the degree to which the research needs identified in Section 2 (SWOT analysis and conclusions from DANCERS workshops) and the opportunities summarised in Section 3, can be addressed by the two new EUSDR flagship research initiatives in the DBS Region. Together these initiatives (DREAM and DANUBIUS-RI) have the potential to provide world-leading facilities that will facilitate inter-disciplinary research in the DBS system. Both projects will build capacity and benefit from active engagement with the European research community.

4. 1 DANUBIUS-RI

DANUBIUS-RI seeks to provide a world-leading RI to enable interdisciplinary research on linkages between freshwater – marine systems. In so doing it aims to identify and implement solutions to reconcile conflicting human uses within several river-sea systems in Europe, comprising the DBS system. These solutions require a holistic basin approach (from source to the sea), that spans the DBS system.

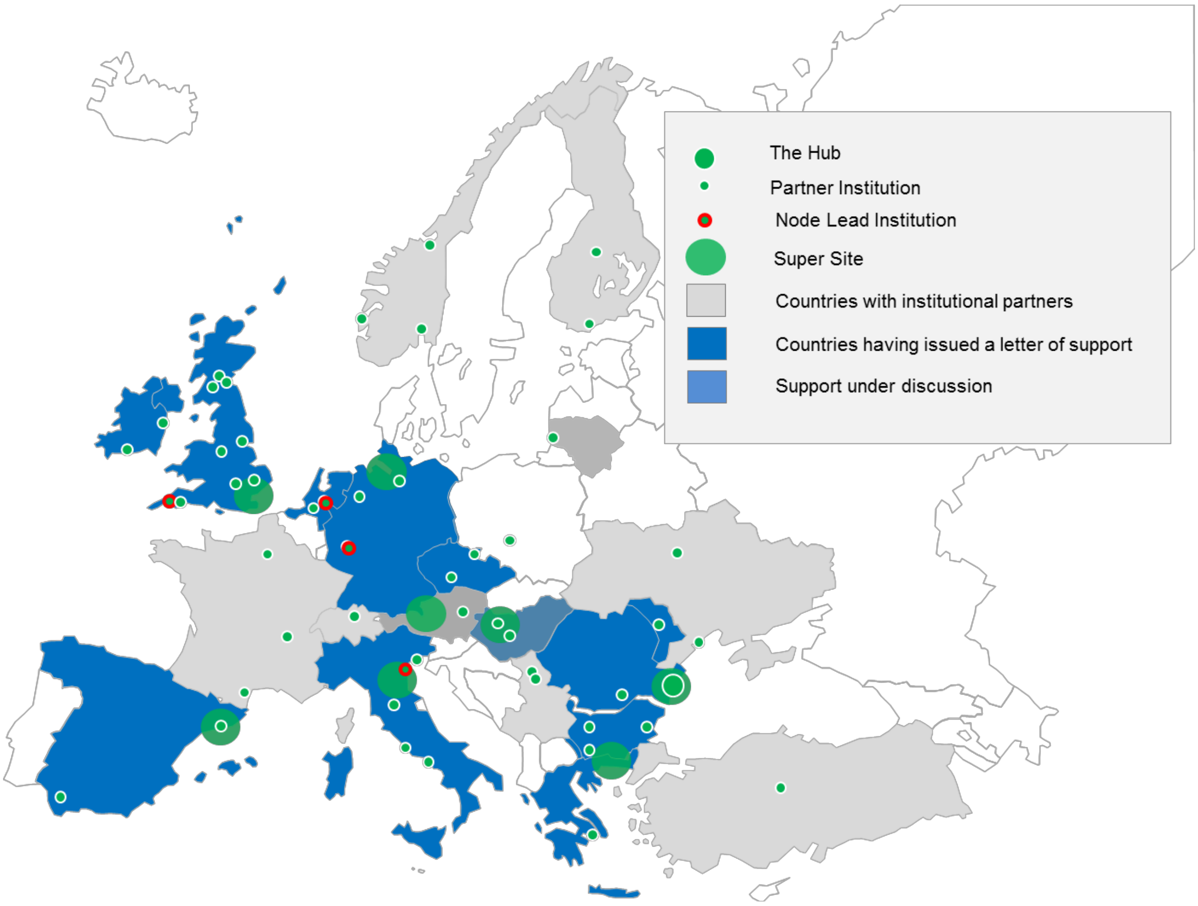

Figure 4.1 *DANUBIUS-RI pan-European distributed infrastructure architecture. Map showing the location of the Supersites, the Hub, Nodes, key partners and the Technology Transfer Office (situation – March 2015).*

DANUBIUS-RI evolved from consideration of the required scope of an RI to study the Danube Delta. Given the nature of this unique area (essentially a natural laboratory) at the interface between the freshwater (Danube River Basin) and the marine (Black Sea) environments, the infrastructure must span the range from catchment to coast and ultimately to the marine system. The project has evolved to include facilities from other river – sea systems in Europe (the Thames, Elbe, Ebro – Llobregat, Po, Nestos) in addition to the DBS system, as shown in Figure 4.1

DANUBIUS-RI is now envisaged as a new pan-European research infrastructure (RI) dedicated to research in the freshwater – marine sciences. It will **optimise** the use of existing world-leading expertise and facilities and enhance the potential to undertake interdisciplinary research on freshwater – marine systems, and hence understand, characterise and manage these diverse systems.

The RI will comprise a Hub, Supersites, Nodes, a Data Centre and Technology Transfer Office. Project co-ordination will be the responsibility of the Hub, situated in the Danube Delta, Romania. The infrastructure will be linked by the *DANUBIUS Commons*: a set of harmonized methods, protocols, instruments data acquisition and management to ensure quality assured and comparable data acquired across DANUBIUS-RI, to guarantee the consistency and quality of scientific output.

Supersites (field laboratories) are designated natural sites for observation, research and modelling at locations of high scientific importance. Initially three are planned for the DBS system, covering the upper and middle sections of the River Danube and the Delta. The Supersite at Lake Lunz (Austria) will focus on the effects of climate change on aquatic systems while the Supersite at Szigetköz (Hungary) will investigate surface-groundwater interactions and impacts of major human interventions (eg. dam) on natural river ecosystems. The third Supersite will be in the Romanian part of the Danube Delta. Each will have a hosting laboratory providing field facilities and access.

Nodes will provide expertise, advice, facilities and services such as data storage and provision of experimental, measurement and analytical facilities. Each will have lead laboratory. They will be based on institutions with world-leading facilities and expertise, will ensure disciplinary rigour. Although located outside the DBS Region (Observation: Plymouth Marine Laboratory, UK; Analysis: BfG, Germany; Modelling: ISMAR, Italy; Social/Economic: Deltares, Netherlands), they will work to build capability and capacity in the DBS Region (and elsewhere in Europe). They will do this by appointing other laboratories (Accredited Service Providers) in the DBS system that conform to the *DANUBIUS Commons* and meet a need in the provision of facilities and services.

There will be access to DANUBIUS-RI for all categories of users in EU Member States, other European countries and internationally. Open access for academic and publicly funded researchers will be based on competition and excellence through peer review. There will be a pricing policy of market-based access. Access to dta will be compliant with EU Directives.

DANUBIUS-RI provides a unique opportunity to bring together European expertise and facilities with an internationally leading focus on understanding, characterising and managing freshwater and marine systems globally. Opportunities provided by research in the natural laboratory of the DBS system, will be maximised by building capacity with a new

RI with wider engagement from European researchers and institutions. This exemplar will provide research outputs that will be transferrable to other river – sea systems globally.

4.2. DREAM (Danube River Research and Management)

DREAM aims to improve research infrastructure in the DBS system in order to develop measures to improve the actual situation in river engineering, flood risk management, hydropower, navigation and protecting the Danube River ecosystems. It envisages the construction of two new laboratories in Romania and Austria, the upgrade of existing laboratories throughout the DRB, the development of a network that spans the joint usage (and application) of numerical models, the installation and running of field study sites, and the construction of a research vessel. DREAM furthermore seeks to foster improved cooperation between research organisations in the DBS as well as research groups based outside the region.

There is an urgent need to integrate use and protection of the Danube River in a sustainable way. Research is of fundamental importance to derive monitoring strategies, modelling and engineering solutions to improve measures suited to reach a win-win situation between economic use and environmental protection of the Danube River. This will be strongly related to the Danube River Basin Management Plan.

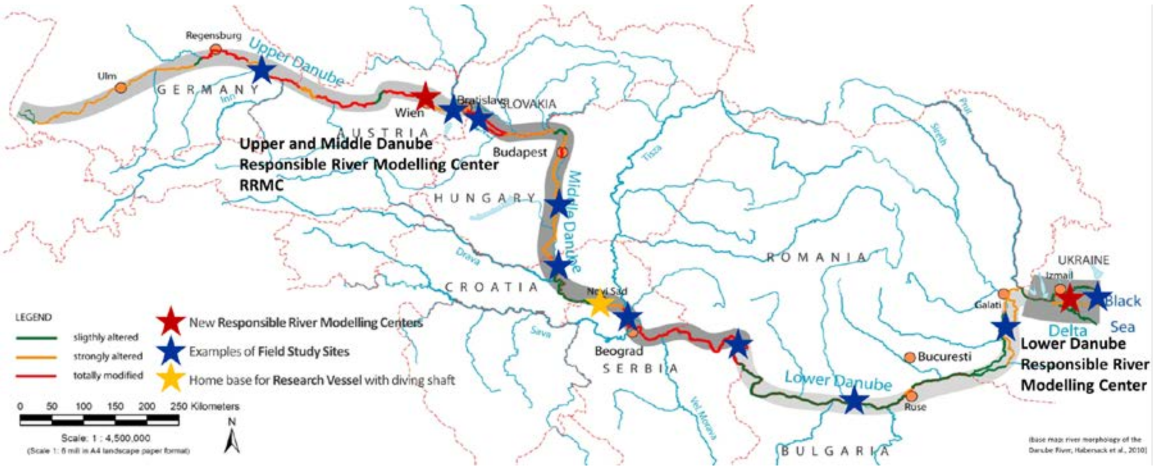

Figure 4.2 DREAM EUSDR Research Infrastructure proposed architecture. Map showing the location of the proposed new facilities to be developed (situation September 2014).

DREAM will provide an improvement of research infrastructure and cooperation between research institutions in the DBS system. The two new laboratories combined with existing ones offer unique possibility for large-scale physical laboratory investigation allowing fundamental and applied research. One is situated in the Upper Danube in Vienna. It uses the water level difference between the Danube and the Danube Canal of 3 m to reach a laboratory free flowing discharge of up to 10 m^3/s. This will be a unique facility in Europe. The focus of research will be steeper slope reaches, coarse sediment transport interacting with flood risk management, hydropower, navigation and ecology, thus the Upper and Middle Danube are mainly investigated there. The new Romanian Laboratory will concentrate on low slope and fine grained sediment transport, including the Delta and estuarine conditions.

DREAM provides an umbrella and the infrastructure for a set of research topics. These topics are interconnected and cover several disciplines, from basic research, to be represented by advanced hydraulic laboratories and sophisticated 3D models on high computational technology, to applied research, providing field data to mitigate hydrological extremes and to improve existing situations in water regimes, sediment regime, flood risk, drought problems, hydropower, revision of bio-engineering measures, restoration of streams and flood plains, etc.

The DREAM partnership includes all DBS Countries and further research institutions outside the basin.

4.3 Comparison of DANUBIUS-RI and DREAM

<table>
<tr><td>DANUBIUS-RI</td><td>DREAM</td></tr>
<tr><td colspan="2" align="center">Scope</td></tr>
<tr><td>DANUBIUS-RI will be an interdisciplinary research infrastructure spanning the Environmental Sciences (Biological, Earth, & Chemical sciences), and the Social and Economic sciences. It will bring together research on different environmental sectors, in an interdisciplinary and holistic scientific approach to river-sea systems, made possible through the collective expertise of teams of interdisciplinary researchers.</td><td>The following themes can be studied in cooperation with the partner countries and institutions using DREAM infrastructure:
• Basic research on sediment transport, flow conditions, ecology, human impacts and possible future measures
• Integrated flood risk management (dams, mobile flood protection etc.)
• River engineering (focusing on sediment regime)
• Renewable energy (especially hydropower)
• Traffic and transport (infrastructure in the waterway Danube, navigation)
• River ecology (river restoration)
• Development of riverine landscapes</td></tr>
<tr><td colspan="2" align="center">Capabilities</td></tr>
<tr><td>DANUBIUS-RI will provide the research infrastructure to underpin an interdisciplinary approach to research on the Danube-Black Sea System and other river-sea systems:
1) dedicated observatories (Supersites) for interdisciplinary data acquisition, processing and modelling, providing a Pan-European context
for assessing change, hazard and opportunity for societal benefit;
2) state-of-the-art analytical facilities to quantify processes, natural and anthropogenic impacts, sediment dynamics, and assess ecological condition and environmental health; and
3) facilities to enhance knowledge exchange (interdisciplinary dialogue; stakeholder engagement; education; and dissemination).
DANUBIUS-RI will provide the platform to review and synthesise our state of</td><td>DREAM will provide an umbrella and the infrastructure for a set of research topics and activities:
(1) Construction of two large Responsible River Modeling Centres/hydraulic engineering laboratories (up to $10m^3/s$)
(2) Cooperation of existing hydraulic engineering laboratories
(3) Formation of a cluster/network of river engineering simulation tools
(4) Establishment of a network of field study sites along the Danube River and tributaries
(5) Construction and operation of a research vessel with diving shaft for the whole Danube
(6) Establishment of a network of existing and extended Danube River Research Institutions throughout all riparian countries</td></tr>
</table>

knowledge and develop and implement the research and innovation agenda, advance fundamental research in RS systems and find solutions to critical, timely and controversial issues.	
Objectives	
DANUBIUS-RI will offer the infrastructure required to: • understand their origin and natural evolution of these systems; • quantify the impact of anthropogenic changes; • determine their vulnerability and/or resilience under a changing climate; • characterise biogeochemical cycles; • identify emerging pollutants and pathogens and understanding their input pathways and fate in large RS systems as well as related adverse effects or associated risks; • advance integrated management of catastrophic floods/droughts and hazardous materials; • investigate the consequences of morphological change (e.g through channelisation, embankments, damming) and developing measures for hydromorphological restoration; • conserve and restore biodiversity; • enhance and protect the capacity of ecosystems to deliver services to society; • provide scientific expertise to develop, improve and test tools to advance policy and guidelines for environmental protection and for the development of integrated management plans; and • explore business opportunities for sustainable wealth generation.	a) to enable research of hydrodynamic, sediment transport, morphodynamic and ecological processes in the various reaches of the Danube River by means of adequate hydraulic laboratories, that provide a significant discharge (up to 10 m^3/s without pumping) and space (large scale models). b) On the basis of an improved process understanding, derived by the large scale physical models in the labs, computer based simulations should be improved, leading to hybrid models. A further aim is to establish commonly agreed field study sites and stations along the Danube River to calibrate and validate physical and computer based models as well as to develop and test advanced river engineering measures under 1:1 conditions. c) The cooperation of research institutions and laboratories along the Danube River is intended to improve scientific progress and to stimulate the transfer from Basic Research to the Knowledge Society.
Legal aspects	
For a pan-European RI the most suitable legal governance system is likely to be ERIC (ec.europa.eu/research/infrastructures/pdf/eric_en.pdf). DANUBIUS-RI will apply for ERIC status, registered in Romania at the Hub, and with governance arrangements following ERIC guidelines. ERIC Membership	There is no formal legal status intended. Concerning the goals of DREAM the legal boundary conditions are (examples): EU - Water Framework Directive 2000 (WFD), EU - Floods Directive 2007, EU NAIADES / Navigation, Korridor 7, 2008, EU - Renewable Energy Directive 2009 (Climate

will be open to countries within and outside Europe. Observer status may be given to intergovernmental organisations and other countries under defined conditions. Although the ERIC is the preferred legal structure, we will consider other possibilities during the Preparatory Phase.	Change).
Financial situation	
Funding commitment has to date been given by three countries: **Romania** – a letter of commitment has been signed by the Prime Minister. This is additional to 40 M€ for construction of the Hub and Data Centre earmarked in Programme Competitiveness already approved by the DG Regio (Structural Funds). Special ITI programme exists for the Danube Delta, and it acknowledges the strategic role of the DANUBIUS-RI Hub. **Italy** – five research organisations have signed letters of commitment with funding of 3,1 M€, and one regional government has signed letters of support. **Germany** – two research organisations have signed letters of intent with funding commitment of 0.47 M€ / year. Besides these three countries, **Spain** has already committed to financially contribute to DANUBIUS-RI with a sum to be computed after the accession on the ESFRI Roadmap.	Various funding sources e.g. ERDF CBC projects, ERDF national funded projects, with national co financiers, DANUBE program, H2020 etc.
Conformity with EUSDR	
The Danube component of DANUBIUS-RI was granted the status of Flagship Project in the European Union Strategy for the Danube Region (EUSDR) in September 2013. It will contribute to at least seven of the eleven EUSDR Priority Areas: * to encourage more sustainable energy; * to restore and maintain the quality of water; * to manage environmental risks; * to preserve biodiversity, landscapes and the quality of air and soils; * to develop the knowledge society; * to invest in people and skills; and	In September 2012 the DREAM project was elected for the first „Label Priority Area 7 Flagship Project” within European Union Strategy for the Danube Region (EUSDR). The Priority Area 7 Flagship Projects are outstanding projects which are expected to make a significant impact on the Danube Region as a whole in the field of research, education and/or information technologies. DREAM contributes significantly to the following Priority Areas: * to improve mobility and multimodality Inland Waterways

* to step up institutional capacity and cooperation. A specific action of the Priority Area to develop the knowledge society is "to strengthen the capacities of research infrastructure". This envisages a secondary action: "To establish joint international research centres for advanced studies" to attract world-class scientists and provide modern research infrastructure. DANUBIUS-RI, will have its Hub on the Danube Delta, and other components of the infrastructure in the Danube Basin.	* to encourage more sustainable energy * to restore and maintain the quality of waters * to manage environmental risks * to preserve biodiversity, landscapes and the quality of air and soils * to develop the knowledge society through research, education and IT

5. Proposal for a partnership between the two flagship projects to fulfil the needs of the region

5.1 Proposed partnership

DANUBIUS-RI and DREAM are complementary RI projects: while they have different objectives, there are areas of interface, and potential synergy, between the two flagship projects. DREAM focuses on hydrodynamics, sediment transport, river morphodynamics, flood risk management and engineering in the DBS system. DANUBIUS-RI has a wide disciplinary scope (physical, chemical, biological, social and economic sciences) and covers not only the DBS macrosystem but other large European River-Sea systems. The two projects have a number of partner organisations in common across Europe. The opportunities for partnership include:

- collaboration and sharing of field sites (DREAM field study sites; DANUBIUS-RI Supersites and other field sites) in the DBS system;
- use of DANUBIUS-RI facilities in the Danube Delta, and elsewhere, for DREAM activities;
- use of DREAM facilities for DANUBIUS-RI activities;
- collection and sharing of data using the same protocols;
- facilities provided by both facilities to be used for research on the main common point of interest - dynamics of sediments in the Danube River – Delta – Black Sea;
- DANUBIUS-RI Data Centre will provide support on request to DREAM;
- DREAM facility in Vienna has the potential to become a Node of DANUBIUS-RI on river hydraulics, or establish a clear agreement to cover this role; and
- DANUBIUS-RI Technological Transfer Office will support specific requests coming from the DREAM project.

5.2 Detailed picture of the facilities

An inventory of the two proposed facilities is indicated in Table 5.1 below.

Table 5.1 Inventory of the two projects

DANUBIUS-RI	DREAM
1. Hub located in the Danube Delta 2. Data Centre located in lower Danube basin 3. Supersites for observation, sampling, experimentation and modelling planned for Danube Delta and other locations in middle and upper Danube basin; analysis facilities developed in the Danube Delta Hub. 4. Facilitated access to Danube Delta, lower Danube River and Black Sea	Two large Responsible River Modelling Centres/hydraulic engineering laboratories (up to 10 m^3/s); one in Vienna, one in Romania in the Danube Delta 2. Network and upgrade of existing hydraulic engineering laboratories 3. Cluster/network of river engineering simulation tools 4. Network of field study sites along the Danube River and tributaries

5. Thematic Nodes at Centres of Expertise across Europe providing expertise, facilities and services for observation (United Kingdom), analysis (Germany), modelling (Italy) and economic and social sciences (the Netherlands) 6. Supersites across Europe, in the Thames Estuary, Ebro – Llobregat – Catalan Deltas, PO Delta – Venice Lagoon, Nestos River-Delta – Aegean Sea, Elbe Estuary. 7. Dedicated Technology Transfer Office	5. Research vessel with diving shaft for the whole Danube 6. Network of existing and extended Danube River RIs throughout all riparian countries

5.3 Means of cooperation, data accessibility

DANUBIUS-RI and DREAM intend to develop and maintain a close level of cooperation on all major topics, from strategic research directions to data sharing, joint projects, and agreements towards common use of several facilities. This cooperation is helped by several key participant institutions from Romania (GeoEcoMar – coordinating the ESFRI process of DANUBIUS-RI) and Austria (WCL, BOKU) being present in both RI initiatives.

On-going collaboration will be ensured by DREAM representatives being invited to participate in the DANUBIUS-RI ESFRI Preparatory Phase (subsequent to the access on the 2016 ESFRI Roadmap). DANUBIUS-RI representatives are participating in the DREAM project meetings. These joint actions will contribute to the final and detailed decision to strengthen the long lasting collaboration between the two RIs.

DANUBIUS-RI will be open to all interested researchers, based on competition and scientific excellence (including social and economic relevance) evaluated by an international peer-review panel. This access policy of DANUBIUS-RI is designed to ensure open access for academic research.

DANUBIUS-RI will provide a range of services, facilities and expertise, including access to platforms, assistance at field sites, chemical and physical analyses, and access to data. Access modes will follow the European Charter for Access to Research Infrastructure (www.earto.eu/fileadmin/content/04_Newsletter/Newsletter_3_2014/13_may__Draft_ European_Charter_for_Access_to_Research_Infrastructures.pdf).

DANUBIUS-RI will allow both on site and virtual access. It will have an open access data policy, in compliance with the AIE and INSPIRE directives. The data management system will facilitate the seamless connection of all partners. The archiving facility storing the data will be certified. Data standards and exchange scenarios (distribution schemas) for data and services will be defined using existing open standards (ISO/OGC) in compliance with INSPIRE. Depending on the requirements arising from the community, data specification document(s) will reuse either INSPIRE, OGC or other relevant modular specification documents. When defining the data formats, special attention will be devoted to ensure compatibility between data resulted from DANUBIUS-RI and DREAM. This will provide the required joint use of data and information, to be made available to each project`s user community. It is planned that the DANUBIUS-RI Data Centre will serve as the central point for the collection and dissemination of data and metadata, and interface with the Global Earth Observation initiative GEOSS via the GEOSS Common Infrastructure (GCI).

The Preparatory Phase of DANUBIUS-RI, after acceptance on the ESFRI Roadmap, will allow agreements to be developed on the use and time given by each of the facilities of each RI to the community of users and agree associated reciprocal relationships and principles. Agreements of use will deal both with direct use, involving work at the facilities of each infrastructure, and remote use and accessing of the new and archived data.

The DREAM labs, computer models, field study sites and research vessel will be in principle open to partners for fundamental river research but also management issues to solve concrete problems along the Danube River.

6. Addressing challenges and risks

Two critical actions must be taken at the earliest possible opportunity to manage the many challenges and risks faced in planning and operating new RIs, especially alliances / permanent collaborations of RIs. The first is to develop effective lines of communication with all potential partner research groups and countries. The second is to establish a community of partners, including an international advisory and coordination group to steer the collaboration between the two RI initiatives.

6.1 Financial Security/Funding

Several steps should be taken in the planning and development of the alliance of the DREAM and DANUBIUS-RI projects to maximise funding and financial security. The first step is to demonstrate how the projects align with H2020 and EUSDR priorities; this is important to ensure eligibility for national and EU funding opportunities. Secondly, early engagement with all potential partner countries is needed for each project. This process should be at several organisational levels: political, funding, and research, with individual approaches tailored to the different circumstances and structures in each country. The third step is to develop a timeline and outline budget, clearly distinguishing between construction and operational costs (both capital and resource funding). This step is particularly important to give confidence of project maturity. Harmonisation of the two projects is essential to save costs, make best use of existing and new resources, and to avoid fragmentation. As DANUBIUS-RI has applied to the 2016 ESFRI Roadmap and has dedicated funding available as a special chapter under Structural Funds in Romania, the Hub can provide facilities for the Romanian part of DREAM which may facilitate access to EU funding. Since partners of DANUBIUS-RI are also partners of DREAM the cooperation and planning of joint research activities will be possible (e.g. within FP7 DANCERS the coordinators of DREAM and DANUBIUS-RI are partners).

6.2 Organisation Structure

The basis of governance of a new RI will be influenced by whether it is located in a single country or distributed between several countries. When located in a single country the governance is likely to follow a national basis. For distributed RIs there are different options with respect to the organisational structure. For the suggested alliance, the details will be discussed between the two consortia. While DANUBIUS-RI plans to apply for an ERIC (European Research Infrastructure Consortium), the DREAM organisation structure is aligned along the EUSDR and EFRE funding schemes, meaning that DREAM functions as umbrella, supporting bilateral and multilateral research initiatives. The final organisational structure of the RI will depend upon the decision of DREAM and implementation of the DANUBIUS-ERIC. There are clear guidelines for structure that have to be followed if the RI is accepted as an ERIC, and modalities to connect with other RI initiatives.

6.3 Clarity of Scope/ Direction

The two proposed RIs have very clear scopes and directions. Although each RI aims to facilitate integrated management in the DBS Region, DREAM focuses mainly on the complex tasks of hydroelectric engineering, navigation, flood risk management and ecology, aiming to achieve a balance between environment protection and sustainable use of the Danube. DANUBIUS-RI spans a wide disciplinary range, from ecology, biodiversity, to sediment dynamics in the entire river-delta-sea system, with a focus on the transitional environments.

Since representatives of each RI are members of the management board of the other RI, any change in scope and/or direction will be discussed and analysed together.

i) Quality of Staff-Facilities/ Appeal to targeted end-users

The DANUBIUS-RI consortium plans to develop intensive training programmes for its own staff in all domains, from technicians and researchers operating the facilities, to experts in data who need to achieve best expertise in big data management. The managers from each RI component (Hub, Nodes, Supersites, Data Centre, and Accredited Service Providers) will receive training on how to deal with major distributed RIs.

DREAM partnership consists of experts from research and management. The experts cover fundamental hydrodynamics, sediment transport, morphodynamics, ecology, hydropower, navigation, flood risk management and integrated river research and management. The inter- and transdisciplinary character of the consortium guarantees the achievement of DREAM to transfer fundamental research to knowledge society.

Joint DANUBIUS-RI and DREAM Staff training will be ensured. Common courses and exchange of experience and practice exchange will be systematically organised between the 2 RIs, as means to provide compatible products and data.

ii) Obtaining continuous support/endorsement from regional national/international stakeholders

iii) Both DREAM and DANUBIUS-RI need to have a permanent support and endorsement from the regional, national and international stakeholders as they evolve. This is why major stakeholders, from the academic community, representatives of business community and members of decision and policy makers in the DBS Region but also the whole Europe will be kept informed about the continuous development of the RIs. Their feedback is of uppermost importance also in any strategic decision regarding any new activity domain that might be chosen by any of the 2 RIs.

Interconnection with European and global research communities

- DBS Region

  As they grow to become fully operational RIs, both DREAM and DANUBIUS-RI will seek to make best use of existing research facilities from the DBS Region. Discussions will be held in order either to collaborate with, or to involve them in one of the 2 projects, according to the main aim of activity (for integration in DANUBIUS-RI they must comply with the DANUBIUS Commons). Working methodologies and data compatibility are the key topics to be settled during the discussions.

- European infrastructures

  After being accepted on the ESFRI Roadmap, the DANUBIUS-RI Preparatory Phase foresees a process of harmonization with other ESFRI RIs, as well as with other major initiatives. As a partner RI, DREAM will also benefit from this process. For example, discussions with the HYDRALAB IA Consortium will also contribute to harmonize the future development activities for both RIs.

iv) Linkages to industry – PPP (Public Private Partnerships)

Ongoing participation of business community and major industry stakeholders will ensure for both projects a development path that will encourage the creation of Public Private Partnerships as means for an efficient practical implementation of the research outcomes.

7. Implementation strategy and funding sources

The implementation strategy for both projects is that all funding sources must be sought and used for the building of the various planned facilities.

DANUBIUS-RI

After obtaining ESFRI Status, DANUBIUS-RI will be eligible for Structural Funds. Romania dedicated a chapter for the building of the Hub from Structural Funds – the Competitiveness Operational Programme (for RIs) 2014 – 2020 – and part of the facilities to be developed in the Danube Delta as DREAM - Romania are also eligible here. Structural funds and national funding in all European countries hosting parts of DANUBIUS-RI are available for construction, and such funds were already identified under adequate Smart Specialisation Strategies in each EU country where Nodes and Supersites are being developed. National funds and other sources are also sought where necessary to supplement the financial resources, both for construction and for operation. The ITI (Integrated Territorial Investment instrument is currently being designed for the Danube Delta in Romania. The plans under development cover also the creation of the DANUBIUS-RI Hub and the role of the Danube Delta as "Natural Laboratory" and Supersite.

DREAM

DREAM aims to use all funding opportunities in the DBS Region, from national to specific programmes and structural funds. The CBC (Cross Border Cooperation) Programmes existing between all the DREAM consortium countries are excellent opportunities to build most of the hard infrastructure required for the project.

The newly launched programme DANUBE is crucial for both projects and may become a major funding source to continue the already established collaboration.

8. Current state of DANUBIUS-RI and DREAM Research Infrastructures (as of May 2015)

At the present time the DANUBIUS-RI proposal has been submitted for possible inclusion in the 2016 ESFRI Roadmap. The first Romanian national investment at the Hub (first building, main facilities) is to due to be completed by September 2015, after an initial construction phase of two years. Most of the other facilities from the Nodes already exist and funds are needed for coordination and integration within the distributed RI. In several supersites the basis of the measurement equipment is already functional, but subsequent efforts are needed for the final definition of the DANUBIUS *Commons*.

DREAM facilities in Vienna are already under construction and the water supply channel is already functional. Funds are yet to be granted to the other 2 pillars of the distributed RI.

9. Conclusions

To conclude, on the evidence collected by the DANCERS project, it is suggested that:

- Existing Research Infrastructures in the DBS system have limited coordination and transnational access, and require upgrading.
- Interdisciplinary research is needed to address the transnational environmental challenges in the DBS system. This is of international importance and for it to attract leading researchers from across Europe, an improved, interdisciplinary and harmonized research infrastructure is needed.
- There is a coincidence of political, technological, scientific and funding factors makes it timely for the development of new distributed RIs to address these needs.

Significantly, two developing RIs (DREAM and DANUBIUS-RI), have already received the status of Flagship Project in the EU Strategy for the DBS Region (Priority Area 7 – Knowledge based society) and they represent the best way of providing the required world-leading infrastructure to satisfy this regional requirement, and also to help better connect the DBS Region with the rest of Europe.

During the DANCERS process, the coordinators of the two RIs agreed to collaborate and to develop an alliance, seen the complementarities and thus considerable opportunities for synergy and collaboration between DREAM and DANUBIUS-RI.

Plans for collaboration have been agreed, ranging from the joint use of all facilities of the two RIs, to common actions to harmonize the data, ensure data sharing and open access principles, open access to data provided by each RI, and to joint training of permanent personnel.

The joint facilities that include both RIs cover all domains of integrated water management of the DBS system and offer excellence of facilities throughout entire Europe.

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Annex 1: Official letters for the Flagship Projects of the EUSDR PA 7

DREAM Flagship

DANUBE REGION strategy
Knowledge Society

EUSDR Priority Area 7:
To develop the Knowledge Society through research, education and information technologies

In reference to the minutes from the fourth PA7 Steering Group meeting

LABEL PRIORITY AREA 7 FLAGSHIP PROJECT

The project proposal ***Danube River Research and Management – DREAM***, proposed by Prof. Dr. Helmut Habersack and Prof. Dr. Herwig Waidbacher, the BOKU University, Vienna, with the partners from 13 Danube region countries (Hungary, Serbia, Bulgaria, Romania, Croatia, Slovak Republic, Czech Republic, Austria, Germany, Slovenia, Bosnia and Herzegovina, Moldova, Ukraine) was unanimously elected for the ***'Label Priority Area 7 Flagship Project'*** within European Union Strategy for the Danube Region, Priority Area 7, at the fourth PA7 Steering Group meeting held on 28 June 2012 in Vienna, which was attended by the official representatives of 7 EUSDR countries (Austria, Germany-Baden Wurttemberg and Bavaria, Bulgaria, Hungary, Slovenia, Slovakia and Serbia).

The Priority Area 7 Flagship Projects are outstanding projects which are expected to make a significant impact on the Danube Region as a whole in the field of research, education and/or information technologies. To be eligible for the Label the project must be jointly developed by a minimum of three Danube Region countries, having a decisive impact in at least five Danube regions.

The 'Label Priority Area 7 Flagship Projects' acknowledges the extraordinary importance of a project for the Danube Region Knowledge Society.

Novi Sad, 7 September. 2012.

no1 01-273/6

On behalf of EUSDR PA7 Coordinators
Dr. Lubomir Faltan and Prof. Dr. Miroslav Veskovic

Prof. Dr. Miroslav Veskovic,
Rector, University of Novi Sad

1

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DANUBIUS-RI Flagship letter

DANUBE REGION strategy
Knowledge Society

EUSDR Priority Area 7:
To develop the Knowledge Society through research, education and information technologies

In reference to the minutes from the sixth PA7 Steering Group meeting

LABEL PRIORITY AREA 7 FLAGSHIP PROJECT

The project proposal ***DANUBIUS*** **- DANUBE INTERNATIONAL CENTRE FOR ADVANCED STUDIES FOR RIVER-DELTA-SEA SYSTEMS**, proposed by Dr. Adrian Stanica, Scientific Director of the National Institute of Marine Geology and Geoecology – GeoEcoMar Bucharest, Romania, was unanimously elected for the "Label Priority Area 7 Flagship Project" within European Union Strategy for the Danube Region, Priority Area 7, at the sixth PA7 Steering Group meeting held on 24 September 2013 in Ulm, which was attended by the official representatives of 7 EUSDR countries (Germany: Baden Wurttemberg and Bavaria, Austria, Czech Republic, Slovakia, Hungary, Serbia and Romania).

The Priority Area 7 Flagship Projects are outstanding projects which are expected to make a significant impact on the Danube Region as a whole in the field of research, education and/or information technologies. To be eligible for the Label the project must be jointly developed by a minimum of three Danube Region countries having a decisive impact in at least five Danube regions.

The "Label Priority Area 7 Flagship Projects" acknowledges the extraordinary importance of a project for the Danube Region Knowledge Society.

Novi Sad, 2 October, 2013.

On behalf of EUSDR PA7 Coordinators,
Mr. Stefan Chudoba and Prof. Dr. Miroslav Vesković

Prof. Dr. Miroslav Vesković,
Rector, University of Novi Sad

1

Annex 2: List of partners of DANUBIUS-RI and DREAM

DANUBIUS-RI	DREAM
Romania Ministry of Education and Scientific Research and Romanian Academy Consortium of scientific and industrial Community led by the National Institute for Marine Geology and GeoEcology – GeoEcoMar and the National Institute for Biological Sciences **Bulgaria** Bulgarian Academy of Sciences, National Institute of Meteorology and Hydrology Bulgarian Academy of Sciences, National Institute for Geophysics, Geography and Geodesy Bulgarian Academy of Sciences, Institute of Oceanology Bulgarian Academy of Sciences, Space Research and Technology Institute Bulgarian Academy of Sciences, Institute of Biodiversity and Ecosystem Research Bulgarian Academy of Sciences, Geological Institute **Czech Republic** Academy of Science, Institute of Landscape Ecology Silesian University in Opava, **Germany** Terrestrial Environmental Observatories - TERENO Federal Institute of Hydrology - BafG Institute of Coastal Research, Germany, Zentrum Geestacht Centre for Materials and Coastal Research (HZG) **Greece** Hellenic Centre for Marine Research - HCMR **Ireland** University College Cork, School of Biological, Earth and Environmental Science **Italy**	**Austria** Universität für Bodenkultur WasserCluster Lunz **Bulgaria** University of Ruse University of Sofia **Croatia** University of Osijek University of Zagreb **Czech Republic** Czech University of Life Sciences Prague University of Technology Brno **Europe** UNESCO-IHE Institute for Water Education **Germany** Bundesanstalt für Wasserbau, Hydraulic Engineering Technical University Munich **Hungary** University of Technology and Economics Budapest EDUVIZIG **Romania** GeoEcoMar National Institute of Research and Development for Biological Sciences Technical University of Civil Engineering Bucharest **Serbia** University of Novi Sad **Slovakia** Slovak Academy of Sciences Water Research Institute Bratislava **Slovenia** Institute for Water of the Republic of Slovenia

National Research Council of Italy, Institute of Marine Science ISMAR National Institute of Experimental Oceanography and Geophysics, OGS National Research Council of Italy, Institute for Coastal Marine Environment, IAMC Consortium for Coordination of Research Activities Concerning the Venice Lagoon System - CORILA, National Institute of Geophysics and Vulcanology, INGV **Moldova** Academy of Sciences of Moldova, Institute of Geology and Seismology Academy of Sciences of Moldova, Institute of Chemistry **Netherlands** Deltares UNESCO-IHE, Institute of Water Education, **Spain** Politehnic University of Catalunya, SARTI Research Group, OBSEA Underwater Observatory Politehnic University of Catalunya, Civil Engineering of Barcelona Politehnic University of Catalunya, Departament d'Ingineria Hidraulica Instiuto del Ciencias del Mardel Consejo Superior de Investigaciones Cientificas, Centre for Advance Studies of Blanes **United Kingdom** University of Stirling, School of Natural Sciences University of Birmingham, School of Geography, Earth & Env Sciences Science and Technology Facilities Centre, Astronomy Technology Centre University of Hull Plymouth Marine Laboratory - PML University of Cambridge, Department of Geography Scottish Universities Environmental Research Centre Centre for Ecology and Hydrology – CEH <u>Expression of interest and support from the Scientific Community in</u> <u>Europe and non-European countries</u>	University of Ljubljana **Ukraine** Ukrainian Center of Environmental and Water Projects Furthermore DREAM is related to the UNESCO World´s Large Rivers Initiative, where there exists a network of about 4500 scientists of over 100 countries, a link between the major international scientific organisations (e.g. IAHR, IAHS, WASER, IAG…)

Austria WasserCluster Lunz **Finland** University of Eastern Finland, Faculty of Forestry Environment **France** Perpignan University - CEFREM Research Centre Lille Nord Europe - INRIA, National Centre for Scientific Research - CNRS Institute for Ecology and Environment - INEE National Centre for Scientific Research - CNRS Institute for Universe Science - INSU **Hungary** Hungarian Academy of Sciences, Centre for Ecological Research Hungarian Academy of Sciences, Institute for Geological and Geochemical Research (IGGR) Eotvos Lorand University of Budapest, Institute of Geography and Earth Sciences Szechenyi Istvan University of Gyor **Lithuania** Klaipeda University, Infrastructure and Developement Affairs **Norway** Norwegian University of Science and Technology, Faculty of Natural Sciences and Technology Norwegian Institute for Water Research NIVA Norwegian University of Life Science, Faculty of Veterinary Medicine and Biosciences **Poland** Wroclaw Medical University, Department of Pharmaceutical Biology **Serbia** University of Novi Sad, University of Belgrade **Switzerland** Federal Institute of Aquatic Science and Technology - Eawag **Turkey** Gazi University, Faculty of Pharmacy	

Ukraine Ukrainian Hydrometeorological Centre Black and Azov Seas Ukrainian Centre of Ecology of the Sea - UkrSCES, Odessa National Mechnicov University of Odessa Odessa State Environmental University State Agency of Fisheries of Ukraine, Odessa Centre of Southern Research Institute of Marine Fisheries and Oceanography National Academy of Science of Ukraine, State Institution "Hydroacustic Branch of Geophysics S I Subbotin" **Azerbaijan** Geology and Geophysics Institute, National Academy of Sciences **China** Huazhong Universty for Scence and Techology **India** EIRC Consulting Pvt. Ltd **Morocco** University Hassan II, Casablanca, Faculty of Science and Techniques Mohamedia **USA** Water Institute of the Gulf	

Annex 3: DANUBIUS-RI supplementary information

Topics to be addressed by researchers using the DANUBIUS-RI Facilities

System	
Origin and evolution of RS systems	Genesis of the river & basin; geological structure; Earth crust dynamics and river evolution; interactions between the river and the sea (relation to sea- level changes and connections to other basins; delta formation; evolution of
Geodynamic processes	Neo-tectonics; uplift processes in orogenic zones and formation and evolution of river terraces; subsidence and sediment compaction; correlation with system evolution.
Hydrology, hydrodynamics and	Water and sediment fluxes in RS systems; the sediment cycle (source– transfer–sink); bio– & geo-chemistry of water & sediment throughout the system; hydrodynamic processes at the
Pollutants and Ecotoxicology	Identifying and characterising existing and emerging pollutants and pathogens; establishing inputs and fate; assessment of adverse biological effects (e.g. genotoxicity, mutagenicity and endocrine disruption); assessing inputs and fate in RS systems; assessing
Ecosystem assessment and function	Evaluation of the biotic and abiotic status of RS ecosystems; system pollution, eutrophication, toxicity, biodiversity; energy transfer via food- chains, population dynamics and ecosystem function; the role of RS system in biogeochemical cycling, greenhouse gas fluxes in wetlands, lakes & sea; ecosystem
Environmental	
In-situ ecosystem observations	Real-time and permanent environmental quality assessment in RS systems; application of new types of on-line sensors and equipment (including micro- and mesocosm techniques); use of
Earth observation and remote sensing	Characterizing land and water in RS systems; monitoring morphological & hydrological changes; reconstructing change over the last ca. 20 years from archived data; studying and monitoring
Geo-hazards and risk assessment	Understanding extreme events, their natural & anthropogenic triggering mechanisms at different scales, such as floods, draughts, landslides, storms; earthquakes; slope instability on the continental margin; geo- hazards originating from gas-hydrates.
Modelling, simulation and hypothesis testing	Predictive tools to assess environmental response; climate and environmental change modelling including impacts on the RS system; effects of extreme events on the system; impacts of sea-
Anthropogenic impact on ecosystem goods and services	Damages induced by anthropogenic activity on ecosystems; evaluating the social dynamics of local communities & identify economic opportunities for sustainable development while minimizing biodiversity loss; assessing catchment and climate
Adaptive and sustainable management	

Adaptive and participatory ecosystem management	Provision of the scientific basis for sustainably managing of RS systems using an appropriate range of methods and models.
Nature conservation and restoration	Improve the ecological status, habitat restoration, bioremediation, restoration of connectivity; guidelines to conserve endangered species & habitats; implementation of EU
Natural resource	Studies advancing the sustainable management of biotic and abiotic resources through knowledge-based development and use
Evaluating development	Interdisciplinary and holistic approach to developing new strategies for sustainable management. Develop methods for and

Summary of the Supersites and their characteristics

Super Site Title	Country	Characteristics
Danube Delta	Romania	Exemplar of river delta sea system impacted by geopolitical complexity in a catchment of >800,000 km^2. The system connects 19 countries of contrasting economic, social, cultural, and environmental heritages, as well as different political
Szigetkoz	Hungary	Providing a typical environment to characterize surface and subsurface water interactions impacting downstream environments including the Danube delta, with a special focus on the effects of river diversion with similar
Lake Lunz	Austria	Providing long-term observation sites and experimental facilities to analyse ecosystem responses to climate change and multiple pressures in pre-alpine environments and gravel
Elbe Estuary	Germany	A contrasting system to the Danube, in northern temperate Europe, draining a catchment of 148,270 km^2 through Germany with headwaters in the Czech Republic. The tidal Elbe River serves as an important transport channel for large vessels on their way to the port of Hamburg, ~130 km inland from the sea, and along with the adjacent German Bight, it is the most heavily used shipping route in

Ebro-Llobregat Deltaic System	Spain	Provides one of the largest wetland systems in the Western Mediterranean and has a catchment size of 85,363 km^2. The catchment has minor contributions from Andorra
Nestos	Greece	A relatively pristine, sparsely urbanized, small to medium mountainous river (catchment ~7000 km^2, mean altitude 1006 m asl) flowing through Bulgaria and Greece into North Aegean Sea, forming an extensive microtidal delta and transitional environments (coastal lagoons, lakes, saltmarshes), impacted by sediment retention due to damming, agriculture, water abstraction, deforestation, river flow modulation. An ideal end- member system for studying the
Po Delta– Venice Lagoon	Italy	The Po River drains a watershed of 74,000 km^2, discharging into the North Adriatic Sea, where the Venice lagoon (the largest lagoon in the Mediterranean), is situated. This fragile
Thames Estuary	UK	The Thames with a catchment area of 12,935 km^2 has a highly impacted and modified estuary including London

DANUBIUS-RI project organization and structure

The DG and executive team will be based at the *Hub*. The DG will have overall management responsibility, delegated through the executive team of directors. The Administrative Director will ensure the proper and efficient use of funds across the RI. The Operations Director will have responsibility for the *Nodes* and *Supersites* through local managers at the host organisations, while the head of the *Technology Transfer Office* will report to the Business Development Director.

An independent, international Advisory Board will assist in the identification of needs and opportunities at an early stage, contributing to the enhancement of DANUBIUS-RI's capabilities and future development.

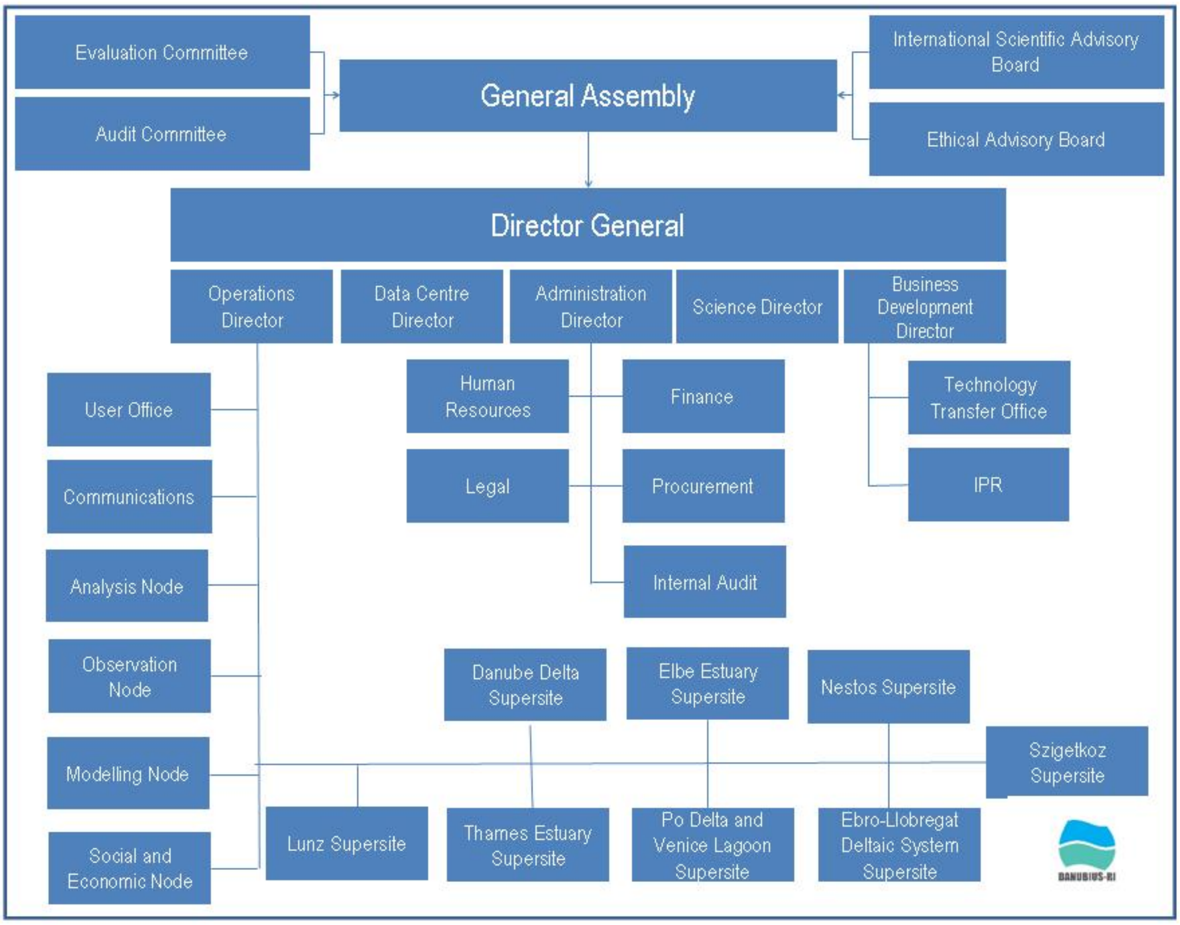
The *Hub* will supervise, manage and administer the operations of the RI and of the ERIC. These will include:

- activities of the component parts (*Data Centre, Technology Transfer Office, Nodes and Supersites)*
- quality control
- communication with other organisations
- marketing of the RI
- strategy and policy development and implementation

- monitoring and reporting of KPIs
- financial management (KPIs include: submission of audited annual accounts on time and balancing annual budgets)

A cyclical evaluation process is foreseen during the entire life of the RI. KPIs related to all these activities will be assessed and when needed revised annually by the General Assembly.

DANUBIUS-RI Organogram



Amount of access to the DANUBIUS-RI facilities

DANUBIUS-RI *Hub*, access unit: 5-day week per laboratory, opened 42 weeks/year, 14 laboratories, available at 100% for DANUBIUS-RI = 588 weeks/year, average duration of user work: 4 weeks = 147 user access per year

All *Nodes*, access unit: 5-day week, opened 42 weeks/year, available at 100% for DANUBIUS-RI = 42 weeks/year/*Node*, average duration of user work: 4 weeks, i.e. 31.5 user access per year x 4 *Nodes* in the present configuration = 126 user access per year

All *Supersites*, access unit: 5-day week, opened 42 weeks/year, available at 100% = 42 weeks/year/*Supersite*, average duration of user work: 3 weeks, i.e. 28 user access per year on average x 7 *Supersites* in the present configuration = 196 user access per year

Total Physical and Remote access to *Hub*, *Nodes* and *Supersites* (estimated average): 469 user access granted per year. 35% on pure *quality-based access* mode (174 access granted), 55% on mixed *quality/quota-based access* mode (273 access granted), and 10% on *market-based access* (50 access granted). Considering the size of the scientific communities involved and the number of field works/experiments performed every year (as approximated by the number of publications), this represents around 60% of the expected demand. However, the access to DANUBIUS-RI is subject to meeting certain criteria (scientific excellence, socio-economic relevance, track-record of applicants, DANUBIUS Commons compliance, interdisciplinarity).

Access to data, unit: Gigabyte downloaded, capacity: up to 20Gb/s (DANUBIUS-RI Data Centre will use RoEDU and GEANT network capacities). The transfer capacity allows for servicing all the expected demand with a comfortable safety margin.

The precise number of teams which can be granted an access simultaneously on a given *Supersite* or *Node* cannot be defined yet due to the complexity of the science objectives of DANUBIUS-RI and to the large variety of activities to be done. Averages are based on partners' experience. *Supersites* are natural sites on which several teams can work simultaneously, provided they do not need the same instruments and their field work does not interfere with each other.