

Danube:Future White Paper on Integrated Sustainable Development of the Danube River Basin

*A research community-based White Paper on research and capacity building
needs, challenges and opportunities for the development of the
sustainability-oriented knowledge society of the Danube River Basin*

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Executive Summary

The **Danube River Basin** has a size of more than 800,000 km² and covers approx. 10 % of Continental Europe. The DRB is home to 83 Million people in 19 nation states, speaking 20 official languages. In 2010, it became the beneficiary of a **macro-regional strategy of the European Union**.

The Danube River Basin exhibits a unique natural and cultural heritage, but also abounds with challenging cultural and natural legacies. It can therefore serve as a **model macro region for the Europe-wide transformation to sustainable development**, offering a potential to strengthen Europe's leadership in the worldwide transition to a sustainable society.

To ensure the long-term transition to sustainable development, tertiary education is a prime mover. In acknowledging their important role, the academic community has taken initiative. This White Paper on Sustainable Development of the Danube River Basin (DRB) is the outcome of a **co-operation between Danube Rector's Conference (DRC) and Alps-Adriatic Rector's conference (AARC)**, together representing more than 90 universities in the region.

The Danube:Future initiative has invited the research community to **identify opportunities for research building on the specific strengths of the universities of the DRB in the area of sustainable development**.

The **integration of cultural and natural heritage and legacy challenges** by means of inter- and transdisciplinary approaches has been identified as the **most promising specific avenue** towards sustainable development of the Danube River Basin macro region.

To support the transition, **interdisciplinary co-operation in research** is required. In particular, the **humanities** have not been stimulated enough to **bring their expertise** into the needed interdisciplinary portfolio of knowledge.

The most pressing **challenges** for development of the Danube Basin result from **pollution**, from **alterations of the natural cycles** and from **invasive species**. Environmental challenges have been created or exacerbated by **economic and social inequalities** leading, among other things, to a veritable **brain drain** of much-needed expertise.

Civil society and independent media but also **governments** have **key roles** for the transformation process. **University curricula and trainings based on regional strengths** can support economic development and societal integration.

The **DRB** can then become a **laboratory for region-specific strategy development** in education and research alike, with a high chance of **successful implementation** due to **stakeholder involvement**.

Principles of sustainability research and capacity building have been formulated:

Research to tackle the **threefold social, ecological and economic sustainability challenge** will need to follow **inter- and transdisciplinary principles**. Sustainability Research must be **integrative with a long-term perspective**, such that its results can be **iteratively incorporated in policy formulation and implementation**.

Horizon 2020 challenges (health promotion, securing dignified lives for an aging population, food security and a sustainable bio-economy, secure, clean and efficient energy and green transport in accord with protecting climate and environment by promoting resource efficiency while working

towards a secure, inclusive, innovative and reflective society) can and should be tackled in a form adapted to the specific challenges of the macro-region.

All H 2020 challenges exhibit emergent properties, which results in a fundamental unpredictability. Risk management involving stakeholders becomes key. Decision making under conditions of uncertainty has always been and remains a major challenge for all societies. Research has to tackle the non-linearity of complex coupled-human-ecological systems. Long-term socio-ecological research is necessary to successfully deal with the legacies and valorise the heritage for sustainable development.

The sustainability transition calls for robust knowledge as basis for adaptive co-management of resources. Such knowledge necessarily needs to incorporate traditional, livelihood-based forms but calls for new ways of learning, also of learning from the past. Third-order-learning, which can be summarized as 'Seeing things differently' is needed, as it is transformative or epistemic and can lead to a paradigm shift. The so-created transformative knowledge is heterodox, coming from real-laboratories and from actual processes of transformation. It is clear that such a mode of knowledge production needs cooperative structures.

Opportunities for targeted research include (but are not limited to):

Implementation of the Global Action Program (GAP) initiative for sustainability education:

Following the Decade on Education for Sustainable Development, the UNESCO is calling for implementation of insights gained in its new Global Action Program (GAP) initiative. The DRB has a high potential of cooperation in education, as most countries have well established education systems with many higher education facilities connected in international associations.

Use of sustainability issues to build cultural bridges and foster post-conflict co-operation:

Conflict is a huge sustainability problem. But confronting the past – including war and the havoc it wreaks – can turn into a unique learning opportunity. In an ecologically degraded world, long-term economic development is impossible and social unrest will increase. Sustainability can serve as a common quest and help build cultural bridges in a divided macro-region.

Research on protecting ecosystem services and biodiversity under conditions of global change:

Protecting ecosystem services and biodiversity in a sustainable way is a core task of society as a whole and requires among others considering global change in decision-making. To give one key example: The sturgeon, a flagship species of the DRB once providing livelihood for many communities along the Danube River, faces extinction nowadays due to overexploitation and habitat loss (disruption of migration routes, pollution, hydromorphological changes). Restoring the sturgeon fishery in the Middle and Lower Danube is an important ecological as well as an economic goal.

Protected areas as real-laboratories and core of an international conservation research network

Protected areas, well distributed over the river basin, emerged as promising laboratories and observatories for sustainable development. Current conservation strategies increasingly follow an integrative approach explicitly including sustainable development into their agendas. Thus, numerous synergies are to be expected if protected areas get involved. As the research side of protected areas is very often underdeveloped, a huge potential to increase their intrinsic value for society by turning them into major actors of the knowledge production systems exists. Their use can be an efficient and integrative, international way of designing pilot sustainability flagship projects.

Recommendations for Policy Makers

The context of these recommendations

Often, policy recommendations are delivered as a work package at the end of a larger project. The following recommendations are a product of a bottom-up networking process within an international, interdisciplinary community of researchers and practitioners.

The Danube:Future community's first recommendation therefore is:

- Initiate a funded in-depth assessment of the research and education priorities necessary to investigate the role of natural and cultural heritage for the long-term sustainable development of the DRB and possible avenues to strengthen this role. This recommendation requires concerted action by EUSDR steering groups, DRC and AARC presidencies and ultimately, DG Research and Innovation and DG Regional and Urban Policy, as far as they are concerned with the EUSDR.

The knowledge of the Danube:Future network was sufficient to formulate national and EU-wide recommendations on important prerequisites and organizational measures. These are listed below. They should be the starting point of the thorough assessment mentioned above.

We recommend on national Level

- Secure funding of long-term, integrated sustainability research on the roles of cultural and natural heritage via national research funding instruments using national universities' capabilities.
- Invest in the training and mobility of young researchers in the field by hosting capacity building trainings and by funding participation in similar activities in other countries.
- Establish national contact points to ensure national participation in international sustainability networks such as Danube:Future. Such national contacts points should be located at a university but good contacts to ministries, relevant NGOs and institutions (e.g. companies or organizations involved in cultural and natural heritage but also water management, hydropower production etc.) should be ensured. One contact point should act as a coordinative center. National contact points should collect the needs of universities, researchers and stakeholders and act as a central information point. They should strengthen the collaboration between countries, disseminate, and promote national activities.
- Apply the insights of the European Environmental Agency on long-term legacies and the available data from ICPDR in existing Long-Term-Socio-Ecological Research Platforms via science-policy dialogues.
- Strengthen the capability of Protected Areas as bearers of natural heritage and cultural heritage institutions (such as Museums) by initiating trainings and funding of new kinds of experimental, transdisciplinary co-operation between them.
- Set up local, regional and national stakeholder dialogues for developing program priorities.
- Support local universities to establish and implement common curricula as well as student and training programs for a sustainable development of the Danube Region with a specific focus on long-term, integrated research. This will contribute to pass on innovative research

output. The DRC and the AAC can be important links to and representatives of local universities.

- Provide funds for the identification and compilation of long-term data about natural and cultural heritage in cooperation with the Long-Term Socio-Ecological Research community.
- Support the further development of a joint knowledge base on research and capacity building in the Danube region which can build on existing networks such as Danube:Future or Danube INCO-Net as information brokers and networking agents for example via funding/promoting related research and capacity building projects nationally as well as in trans-national contexts (e.g. ETC Programs).

On the Level of the European Union

- Support the creation of a regionally embedded sustainability program to make the DRB a laboratory for the European transformation to a sustainable future (e.g. via ERA-Net CO-FUND or allowing the use of national structural and investment funds for funding related activities etc.).
- Make funds available for integrated sustainability research using the Danube River Basin as real laboratory via Horizon 2020. Excellent research and innovation opportunities exist for all societal challenges.
- Support the further development of a joint knowledge base on research and capacity building in the Danube region which can build on existing networks such as Danube:Future or Danube INCO-Net as information brokers and networking agents e.g. in supporting the networking and knowledge exchange via the newly created Danube Strategy Point.
- Set up an advisory board to develop appropriate calls with members delegated by ICPDR (International Commission for the Protection of the Danube River), by university networks (e.g. DRC, AARC, ICA-CASEE - ICA-Regional Network for Central and South Eastern Europe), by the European Environmental Agency, by Future Earth and by appropriate scholarly networks, such as ICSU (International Council for Science), ICEHO (international Consortium of Environmental History Organizations), Industrial Ecology (International Society for Industrial Ecology) or Ecological Economics (International Society of Ecological Economics, European Society of Ecological Economics).
- Develop a bottom-up consultation process for real laboratory sustainability research via existing NGOs, Environmental and Protected Area managers.
- Invest in international science-policy dialogue using the potential of the DRB's universities as largest knowledge economy stakeholder in the region. Use the SPIRAL (Science-Policy Interfaces for biodiversity: Research, Action and Learning) Briefs as a model.¹

¹ http://www.spiral-project.eu/sites/default/files/Synthesis-Report_web.pdf

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Context information

This paper is an activity of Danube:Future. It was developed within the framework of the EU Strategy for the Danube Region (EUSDR) and aims to support the member universities of the Danube Rectors' Conference (DRC) and the Alps Adriatic Rectors' Conference (AARC) in their efforts to promote a sustainable knowledge society. The document was initiated by a team from the Core universities of Danube:Future and was discussed and completed at the 1st Danube:Future Workshop in Klagenfurt, Austria, on April 8-10, 2015. The final version will be delivered to DRC and AARC as well as to the EUSDR PA7 Steering Group, and disseminated further to other relevant EUSDR Priority Areas and National Contact Points and to the sustainability researchers of the DRB and adjacent basins.

Introduction

“The path actually taken will rest with the reflexivity of human consciousness: our capacity to think critically about why we think what we do—and then to think and act differently.” (Raskin 2008: 469)

In this document, we identify important knowledge gaps, principles and topics of inter- and transdisciplinary long-term research for the sustainable development of the DRB. We focus on the societal challenges of the Horizon 2020 agenda, taking into account the opportunities and challenges identified in overarching programs of the DRB and in institutions and associations such as the EU-Strategy for the Danube Region, the related Scientific Support to the Danube Strategy of the JRC (Joint Research Centre) or the ICPDR (International Commission for the Protection of the Danube River).

Towards a macro-regional transformation to Sustainable Development

With the enlargement of the last decade, most of the Danube River Basin (DRB) is now a part of the European Union. The integration of Czechia, Hungary, Slovenia, Slovakia (2004), Bulgaria and Romania (2007) and Croatia (2013), together with the acceptance of Bosnia-Herzegovina, Serbia and Montenegro as official accession countries and the envisaged cooperation with Moldova and Ukraine created a particularly dynamic European region.

The Danube River crosses a variety of European landscapes. It is an important west-east corridor and links, for instance, the Alpine regions of the Upper catchment with the Black Sea in the Lower area. Artificial canals enhance the importance of the water corridor and connect the Black Sea to the North Sea.

The river and its basin show gradients, both socio-economic and environmental (see Figures 1 and 2). They unite some of the richest and some of the poorest areas of the European Union. The upper section shows alpine influence, high hydromorphological dynamic and was and is

considerably under anthropogenic influence. The Lower Danube is a slowly flowing lowland river, with many near-natural stretches with high biodiversity. This river stretch and the Danube Delta are connected to the Black Sea including coastal and marine systems and interacting with the Black Sea macro-region. Actively integrating the DRB – which is characterized by so many and profound differences – into the European community, is an indispensable task to ensure a stable, secure and prosperous future. On the other hand, this region, because it faces so many of the challenges that characterize globalized society, can become a laboratory and observatory for pilot projects useful for the entire Union and the world. Comparative approaches encompassing in particular the neighbouring River Basins will be of particular value². Especially the adjacent mountainous areas of South-Eastern Europe are since 1991 increasingly impoverished and suffer from depopulation and economic decline. Research and knowledge are key in overcoming economic, social and political disparities and can create sustained and sustainable development.

A consensus is in the making that sustainable development entails a fundamental change from the current development pathways and will require a general, far-reaching transition. Analysts point to the key role of civil society and independent media but also to the importance of state governments for this transformation process (WBGU 2011). It is clear that (higher) education will play a crucial role for the transitions, but how this role will be designed remains unclear. The experience from the UN Decade for Education for Sustainable Development (ESD) has been positive, as ESD has been put on the global agenda. The Lima Declaration on Education and Awareness Raising for Climate Change Information as a follow up on the Aichi-Nagoya Declaration on Education for Sustainable Development makes clear that an on-going commitment is necessary. The UNESCO is calling for implementation of insights gained in its new Global Action Program (GAP) initiative (UNESCO 2013).

The humanities and social sciences face an interdisciplinary challenge

Sustainability problems transcend disciplinary boundaries and can only be solved by inter- and transdisciplinary approaches. Past European research and higher education funding has not sufficiently focused on interdisciplinary co-operation. Social Sciences have contributed in many ways, but often have been included into projects dominated by natural or technical sciences only in an additive way. The humanities have not been stimulated enough to bring their expertise into the interdisciplinary portfolio of knowledge necessary for a transition to sustainability. Sustainability challenges can be addressed only if all partners show clear commitment and if interdisciplinary cooperation of all the stakeholders is facilitated.

Many plans for sustainability transitions coming from a purely natural science or technical side remain insufficient, as humans, society and governance are equally important for success. These are the domain of the social sciences and the humanities, which are indispensable as they

² River Basins discharging into the Adriatic or the larger Mediterranean basin are particularly relevant because of the similarities of climate, soils and history.

contribute the needed (historical) long-term perspective. Social sciences and humanities can integrate natural, cultural and ethnic heritage and their hybrid forms as well as local traditions and knowledge. Among their contributions to sustainable development is to provide perspective on the societal consequences of unsustainable resource extraction.

Danube:Future seeks to contribute to the sustainable development of the DRB by bringing the humanities and the social sciences into an interdisciplinary dialogue. Environmental humanities are a new, inherently interdisciplinary area of research whose great potential for fostering sustainability transitions has not yet been used.³

The regional context: A river basin

Future development of the DRB, a region with a millennia-long history, poses particular challenges because of its highly dynamic environmental and political systems, and because it is located adjacent to areas with similar dynamics such as the Black Sea region. The river basin is shared by 19 countries with approx. 81 million people, and covers an area of more than 800.000 km² (see Fig. 1). The differences in altitude and topography together with the different climatic, ecological and biogeographical regions result in a high diversity of aquatic and terrestrial habitats (Fig. 2). The Black Sea needs to be included into a holistic view of the DRB for ecological as well as for socio-economic reasons.

Large socio-economic disparities, a veritable brain drain and migration issues together with demographic change and peripheralization of rural areas characterize the DRB. Issues of ethnic and cultural identity, threatened and reaffirmed identities in fluid political contexts add to the challenge that cross-boundary co-operation faces. Inequalities generate a big issue and comprise gender, ethnicity, income, access to education and environmental amenities. The basin's long-term and recent history of conflict and nationalism has to be taken into account when developing policies as the Danube, like most rivers in the world is neither a cultural nor a natural space but a complex hybrid, socio-natural site, where the interplay of humans with the environment has taken place over long periods. Communities have had and still have to deal with cultural and natural legacies of past interventions. A plethora of environmental problems threatens a sustainable, prosperous future. Environmental legacies abound, and current conflicts of use are particularly intense in its riverine landscapes.

Sustainable development of riverine landscapes is particularly challenging, because rivers are fragile ecosystems. Hydrological and morphological dynamics are inherent and ecologically important features, and have important bearing on society-river interactions (Fig. 3). The challenges the latter posed and pose to societies led to systematic anthropogenic alterations to stabilize moving aquatic and terrestrial zones. Further, river basins and rivers are closely connected systems. Surface discharge links areas up- and downstream even if they are thousands of kilometres apart. Sustainable flood protection does not seek to discharge water downstream as fast as possible, but aims at lowering flood peaks e.g. with retention areas and unsealed soils as

³ A *Humanities World Report* is currently in the making, see: <http://humanitiesworldreport.net/who.html> ; Environmental Humanities. A Transatlantic Research Network; see also the ALLEA humanities for Horizon 2020 page

storage and filter. Deforestation and intensive agriculture in the upper catchment often increase soil erosion, sediment input and have an influence on bed-load transport not only in the immediate area, but also far downstream until the river reaches the sea, the final sediment trap. This has been convincingly shown in a long-term perspective some years ago for central Europe and Germany (Bork et al. 1998) and recently for the DRB by Giosan et al. (2012). Land use change altered hydrological regimes, flood levels and flood peaks just as much as the erection of systematic flood protection since the 19th century.



Figure 1: The Danube River and its basin (small box on the top; hatched line shows extend of maps in Fig. 8 and 14) cross and cover large areas of Europe. The Rhine-Main-Danube Canal connects the Danube to the North Sea. The mean annual discharge of the Danube amounts to roughly 6 000 m³/sec at the mouth; the approximately 120 tributaries have a total length of about 10 000 km (sources: Wirtschaftsmuseum, English version by B. Domany; overview of DRB on top: ICPDR).

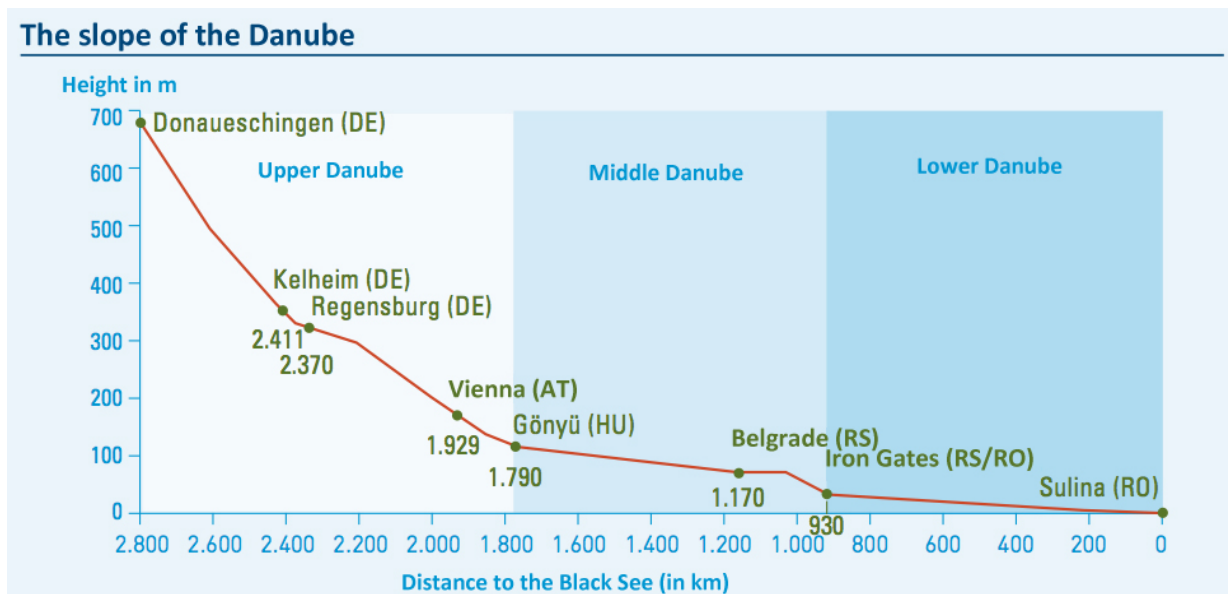


Figure 2: The slope of the Danube creates an important natural gradient. (Source: Wirtschaftsmuseum, English version by B. Domany).

Recent legislation, such as the EU-Water Framework Directive or the EU-Floods directive, take this dynamic and inter-connectedness into account and emphasize the basin-wide cooperation required for the formulation of and the agreement on joint future management activities.

The Danube plays an important role in developing a climate-friendly trans-European transportation network and is a major part of the envisaged Rhine-Danube Corridor.⁴ To date only a small part, i.e. 15 % of the transport potential has been realized (Hasenbichler et al. 2011). Enhancing the transportation capacity has to respect ecological requirements. Hydropower production will remain a major function of the Danube and its tributaries and is an important part of renewable energy regimes, but side effects such as altered hydrology, temperature, habitats and biota have to be taken into account (e.g. Bloesch et al 2012). Natural systems and the ecosystem services they provide encompass also flood protection, and their protection should be part of integrated river basin management. Pollution is a problem that becomes progressively more problematic as it accumulates on the Lower Danube. Connectivity within the basin is not only longitudinal, but also a lateral and a vertical issue - e.g. polluted soils can leach into aquifers, and diffuse input from agriculture threatens surface water bodies throughout the basin.

⁴ Infrastructure - TEN-T - Connecting Europe. Rhine-Danube Core Network Corridor



Figure 3: Mobile flooding protection structures such as those in Grein (Wachau) on the Austrian Danube can increase flood peaks and inundation risk downstream (source: Robert Zinterhof)

Sustainable development needs a long-term perspective

Both societal and natural legacies limit the possibilities for future development. An integrated, interdisciplinary approach is necessary to deal with legacies of cultural and natural hybrid heritage. The current situation of the DRB cannot be understood, and hence a sustainable future cannot be planned, unless the common past of nature and humans is known and accounted for.

The need for a historical long-term perspective is meanwhile widely acknowledged in academia and in environmental policy: In view of the intensity and scale of human impacts on nature, the term “Anthropocene” was coined. It emphasizes that humankind has influenced the lithosphere irreversibly especially since the onset of industrialization. Recently the Anthropocene community shed light on the role of water, with a direct bearing on the DRB (Rockström et al. 2014).

Two recent reports of the European Environment Agency reveal the slow response of society to risks e.g. of toxic or hazardous substances (EEA 2001, 2013). The uncritical use of asbestos or radiation are two cases in point. For the latter, first warnings have been raised more than 100 years ago. But due to the uncertainty in the quantification of the risk, an uncritical application of radiation as medical treatment or examination tool prevailed until few decades ago. Identifying the legacies, i.e. the health and environmental risks from previous use of toxic and hazardous substances and their uncontrolled release is therefore as important as finding ways to deal with scientific uncertainty.

The DRB faces long- and short-term cultural legacies arising from the political divide into ‘East’ and ‘West’, from nationalism and recent wars in South-East Europe. In the last decades, the Balkan conflict connected to the breaking up of Yugoslavia has left traumatic cultural legacies that are only slowly overcome (Gruber 2014).

Political ideals and ways of constructing identities employed by the various nationalist independence movements have influenced the history of the region since the 19th century. In recent decades, hope has been put on nation states as means to raise the standard of living, to enable self-determination and therefore a better economic development and to increase the security of the region (for this and the following argument see Winiwarter V., in print).

While the troubled history of the region needs to be accounted for in any sustainability policy, it is important to work against the misconception that 'The Balkans' were and are a distinct case. Their history is in fact typical for the social processes of the modern transformation to nationally organized entities. In contrast to western European nation states, which were constituted earlier than others, the relative instability of the Balkan nations has been considered in the literature as a transitory phase, as a catching-up in a delayed modernization. The myth of Europe has been a catalyst in the process of border-drawing in the Balkans but also in the transcendence of borders. In bridging national divides, the integrative potential of Europe can and should be used, knowing that the process of integration will also create new differentiations.

Sustainability as common quest for the DRB countries might be the way to create a new, joint identity, as has been the case also in the Baltic strategy⁵.

Taking this background into account it becomes clear that only long-term studies of the DRB can address the co-evolution of nature and society necessary to achieve sustainability. This implies an interdisciplinary cooperation of the natural sciences with social sciences and humanities and new common approaches and methods.

Analysis of the Framework for Research for Sustainable Development in the DRB

THE POLITICAL FRAMEWORK

EUSDR - EU Strategy for the Danube Region

Due to its long- and short-term political, economic and cultural development, the Danube catchment is a truly European macro-region with specific challenges and opportunities. In 2009, the European Council formally asked the European Commission to prepare an EU Strategy for the Danube Region. Commissioner Danuta Hübner on the open day in October 2008 highlighted the importance of this macro-regional strategy abundantly clear: *"The importance of the Danube Basin for the EU cannot be underestimated. Our policies and the investments we are making in the Basin through the EU's cohesion policy in particular have an impact on the livelihoods of 20 million citizens. The Danube needs a specific strategy comparable to the strategy we are developing for the Baltic Sea Region. A one-size-fits all approach doesn't work in an EU of 27 Member States and 271 regions. We need a targeted policy for the Danube that meets its*

⁵ EUSBSR - EU Strategy for the Baltic Sea Region

ecological, transport and socio-economic needs.”⁶

The European Commission adopted the EU Strategy for the Danube Region (EUSDR) in December 2010, the European Council endorsed it in 2011. It identifies both challenges and opportunities on which future sustainable development can be built on (European Commission 2010).

EUSDR Priority Areas

The EUSDR is built on four pillars, encompassing 11 Priority Areas (Fig. 4), focusing on sustainable development with a priority on economic growth and on balancing the socio-economic differences between the countries of the Danube Region. Danube:Future is part of PA7, but has close links to PA3, PA6 and PA9, offering knowledge tools to connect cultural and natural (environmental) concerns.

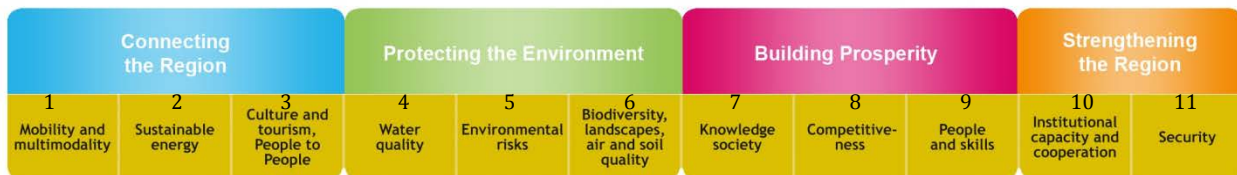


Figure 4: Pillars and priority areas of the European Strategy for the Danube Region

Cooperation and exchange between the Priority Areas of the EUSDR is indispensable, since many topics and subsequent actions are strongly intertwined both in a positive and in a negative way. For example, navigation has an impact on the environment just like hydropower production, as both require maintaining a regulated channel with reduced habitat variability. Bio-economy can reduce input of nutrients as well as organic and hazardous substances and thus also reduce pollution.

Horizon 2020 - European Research and Innovation Program for (sustainable) growth

The priorities and aims formulated in the EUSDR take into account the basin-specific challenges and opportunities, but they have also been harmonized with the objectives and topics of Horizon 2020, Europe's Main Research and Innovation Program. The 'Societal Challenges'-instrument reflects the policy priorities of the Europe 2020 strategy. Such a challenge-based approach necessarily needs to link resources and knowledge across different fields, technologies and disciplines, including social sciences and the humanities.⁷

⁶ European Commission 2008 - Press Release IP/08/1461

⁷ Horizon 2020: http://ec.europa.eu/research/horizon2020/index_en.cfm?pg=better-society
EUROPE 2020: http://ec.europa.eu/europe2020/index_en.htm

The seven challenges identified deal with the following topics:

- Health, demographic change and wellbeing;
- Food security, sustainable agriculture and forestry, marine and maritime and inland water research, and the Bio-economy;
- Secure, clean and efficient energy;
- Smart, green and integrated transport;
- Climate action, environment, resource efficiency and raw materials;
- Europe in a changing world - inclusive, innovative and reflective societies;
- Secure societies - protecting freedom and security of Europe and its citizens.

As has been pointed out, the DRB faces many specific challenges for its societies: Not only is it the most international river basin, with many national languages. The region faces also a divided past on both sides of the “Iron Curtain” and the social and natural legacies of recent military conflicts. With multiple minorities and a long history of migration, it is also one of the most diverse regions regarding its cultural and natural heritage. As stated above, the Danube River Basin can therefore be a ‘laboratory’ for Europe. The societal challenges are depicted in their relation to the sustainable development of the region in Figure 5. Figure 6 shows the connection of H2020 societal challenges and the EU-SDR Priority Areas.



Figure 5: The H 2020 societal challenges and sustainable macro-regional development. (Source: diagram by coordinating lead authors)

	Connecting the region			Protecting the environment			Building prosperity			Strengthening the region	
	Mobility and multimodality	Sustainable energy	Culture and tourism, people to people	Water quality	Environmental risks	Biodiversity, landscape, air and soil quality	Knowledge society	Competitiveness	People and skills	Institutional capacity building and cooperation	Security
Horizon 2020 Societal Challenges	Health, demographic change and wellbeing			•	•	•			•		
	Food security, sustainable agriculture and forestry, marine and maritime and inland water research, and the Bio-economy							•			
	Secure, clean and efficient energy		•					•			
	Smart, green and integrated transport	•						•			
	Climate action, environment, resource efficiency and raw materials				•	•	•				
	Europe in a changing world - inclusive, innovative and reflective societies			•				•	•	•	
	Secure societies - protecting freedom and security of Europe and its citizens									•	•

Figure 6: Main links between the H 2020 societal challenges and the Priority Areas of the EU-Strategy for the Danube Region.

THE RESEARCH FRAMEWORK

In the past, the Danube and its tributaries were boundaries, protective zones and communication routes; they could be commons or imperial property. Cultural, ethnic, political, economic and ecological factors of their history are evident in institutional arrangements and governance characteristics. In conflicting visions, the Danube and its environs are viewed as 'infrastructure to be developed', as 'ecosystem to be protected' or as 'heritage to be preserved'. Any approach to the basin's sustainable development has to consider this potential for a conflict of aims and thus, of measures.

An interdisciplinary research framework on sustainable development of the DRB can build on the rich and often entangled natural and cultural heritage. Both often occur in the same place, and while they can interact synergetically, there can also be trade-offs. A large part of the River Basin consists of ecosystems modified by humans. Both these and protected natural areas suffer from natural hazards. Degradation and susceptibility to environmental stresses are also common for natural and cultural heritage. Intangible cultural heritage is to a large extent about dealing with the natural heritage by means of traditions, such as traditional viticulture, fisheries and aquaculture, or traditional land management including past choices of safe settlement areas. Traditional ecological knowledge as a bridge between cultural and natural heritage offers the potential for a common regional identity due to similarities of regions.

Regional marketing could benefit from taking an active role in the preservation of both via emphasizing traditional ecological knowledge. This translates into a formidable challenge:

Different countries have widely different policies of protecting natural and cultural heritage; in poorer countries, the means to protect the cultural heritage are often lacking, leading to poor preservation. Insufficient implementation of existing legal frameworks and protection measures is another problem.

Given this situation, the Danube River Basin as Europe's main E-W corridor and its rich and varied traditions can become a laboratory for piloting the sustainable transformation processes of Europe. We consider sustainability as a balance between the ecological, the economic and the social system, emphasizing that the latter two are embedded in the boundaries of the first: Economy and society have to remain within the boundaries of the ecological system (Strachan 2009).

The Danube River Basin: Regional characteristics, challenges and assets

The DRB's aquatic systems - a threatened natural heritage

The hydromorphological dynamic (see Fig. 7), together with the longitudinal, vertical and lateral connectivity of the rivers and the links to the terrestrial zones of the catchment form complex systems. Rivers are performing sink and source functions for nutrients, pollutants and sediments. Managing aquatic resources sustainably therefore is inextricably linked with good practices of land and soil-management and land use practices. The rich natural heritage, the environmental assets and the exceptional fauna and flora, which developed millennia ago due to the function especially of the Lower Danube as a refuge during the Pleistocene are important opportunities for future sustainable development, and can be valorised especially for tourism. These natural assets are threatened by hydromorphological change and discharge of untreated sewage and fertilizers and soil run-off, which cause severe pollution.

Soils are important filters and reactors, in particular in wetland buffer zones along the riverbanks. They are themselves an endangered resource, as the EEA, among many other institutions, has pointed out clearly: "Soil degradation is accelerating in many parts of Europe, exacerbated by human activities such as the inappropriate management of arable land, grassland and forest land."⁸.

Future risks from flooding and droughts including long-term changes and the effects of climate change⁹ as well as industrial pollution can be addressed only on a basin wide scale with adequate management plans and resources to implement them. As required by the EU-Water Framework Directive (EU-WFD), the International Commission for the Protection of the Danube River (ICPDR) has issued a "River Basin Management Plan (RBMP)" in 2009 (ICPDR 2009).

⁸ <http://www.eea.europa.eu/soer/europe/soil>

⁹ See for instance the ERC-grant project "Deciphering River Flood Change": <http://floodchange.hydro.tuwien.ac.at/deciphering-river-flood-change/>



Figure 7: Bank erosion is part of the hydromorphological dynamics of rivers. Sustainable land use should take this into account in land management and administration (Source: Stefan Dorondel).

This analysis of environmental problems and the joint program of measures to solve or at least to mitigate them on a basin-wide scale upon consultation of the Danube countries is a novelty. The document identifies organic and nutrient pollution as well as hazardous substances as main water management issues. Pollution is a threat for human well-being and natural heritage mainly in the middle and lower river section. Hydromorphological alteration due to channelization, floodplain isolation and hydro-power use characterize the Upper Danube problem spectrum.

The first RBMP focussed on hydromorphology and pollution The second RBMP takes the effects of alien invasive species and climate change into consideration. Wastewater treatment and better land management in order to reduce the input of pollutants as well as ecosystem restoration are considered as important future tasks to counteract the ongoing negative trends. Important research gaps have been identified for many of these aspects. As the effect of invasive species is largely unknown, ICPDR calls specifically for research in this field (ICPDR 2014; see also ICPDR 2008 and 2015). Sediment quality and quantity also needs to be better studied; the DREAM (Danube River Research and Management) project, a flagship project of EUSDR PA 7, focusses on these issues.¹⁰ Several recently published strategic documents by ICPDR emphasize the need to integrate different sector policies, especially inland navigation, hydropower and agriculture. ICPDR recognizes the need to tackle interlinked challenges with inter- and transdisciplinary approaches.

¹⁰ <http://seddon.boku.ac.at/index.php/en/news/construction-progress-research-channel.html>

The European Innovation Partnership (EIP) on Water likewise identified cross-cutting issues such as governance of water use, monitoring, decision support, and specifically the management of extremes such as flood and drought risk or the Water/Energy nexus.¹¹ The provision of food, raw materials or genetic resources just as the regulation of climate and waste decomposition requires unhampered functioning of basic ecological processes such as nutrient cycling or primary production.

The Danube's ecosystem services offer the potential e.g. of carbon storage, water resource provision and cultural values that underpin tourism (Tucker et al. 2010). The authors recommend a precautionary approach to the conservation of ecosystem services, and emphasize that the role of ecosystem services in decision-making is often still weak because of knowledge gaps not only in research but also in public perception. Consequently, many of the services are being degraded or at risk, often as a result of unsustainable practices. Knowledge about the complex relations between ecosystem processes and functions and their values as well as their sustainment is indispensable, and lacking. Inter- and transdisciplinary cooperation will help society to benefit from the ecosystems of the Danube and will contribute to IPBES (Intergovernmental Platform on Biodiversity & Ecosystem Services).

The current environmental status of the DRB

The Danube and the DRB are not exempt from the profound social and ecological transformations sometimes called the 'great acceleration'. Social and economic legacies have led to many heavily fragmented landscapes and other kinds of fragmentation including societal ones. As already pointed out, the environment of the DRB is particularly threatened by pollution, longitudinal, lateral and in-stream hydromorphological alterations, land use changes, overexploitation, climate change and invasive species.

The monitoring performed by ICPDR has emphasized that only about one third of the Danube exhibits Class 2 according to the 5-tiered classification scheme of the EU-WFD and fulfils the ecological requirements of the WFD ("good ecological status"; ICPDR 2009, see also ICPDR 2015). These sections are situated mainly in the lower part of the river, showing the existing ecological potential, while especially the Upper Danube is severely affected by hydromorphological changes.

Many larger settlements do not collect or process wastewater and a considerable number of industrial facilities emit effluents directly into the Danube and its tributaries or indirectly via urban sewers. Approximately 650 risk spots for hazardous substances were reported in the river basin in 2009. A hazardous equivalent of 6.6 million tons has been identified as potential danger. Non-point sources of pollution such as fertilizer and pesticide runoff add to the overall problem. As Figure 8 shows, the number of potential risk spots is especially high in the Middle Danube and its main eastern tributary, Tisza.

¹¹ <http://ec.europa.eu/environment/water/innovationpartnership/>

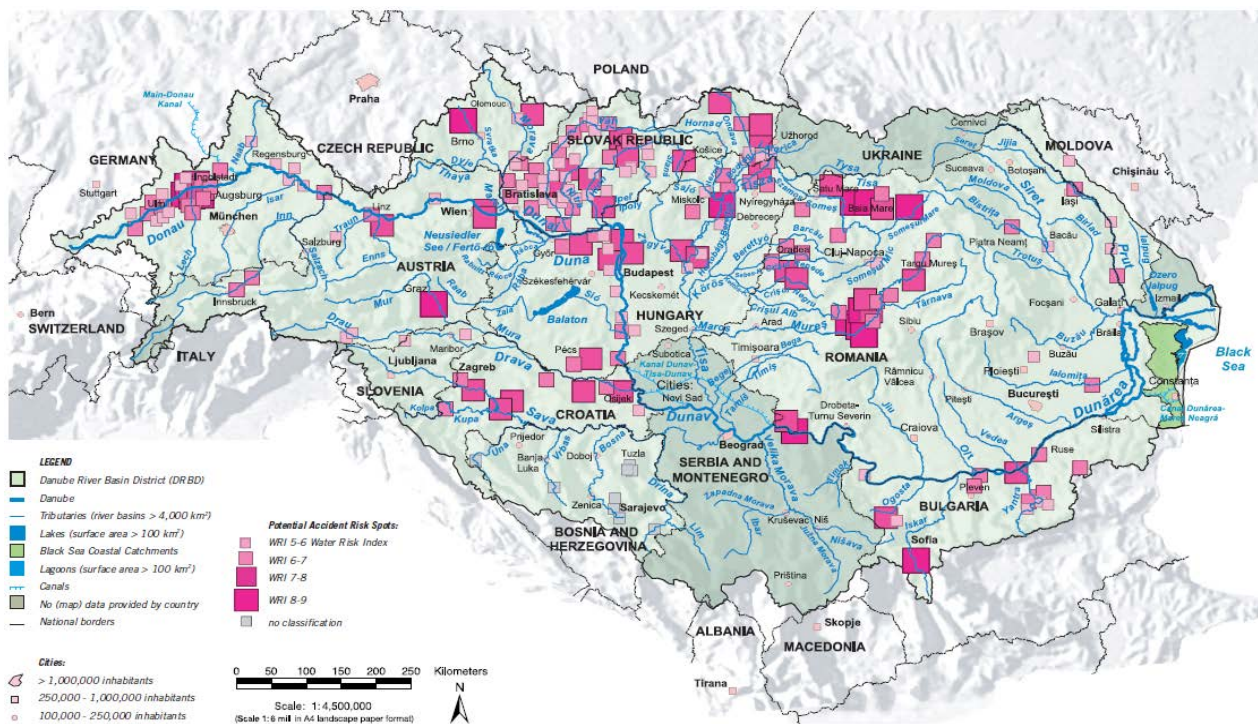


Figure 8: Potential accident risk spots in the DRB. The map shows the Water Risk Index. The darker the colour and the larger the size of the squares, the higher the risk index (Source: ICPDR 2009; Note: the separation of Serbia and Montenegro was not yet considered in this map).

The water cycles of the DRB are frequently altered by interruption of river and habitat continuity, by the disconnection of adjacent floodplains as well as by water abstraction, impoundments or hydropeaking. Hydropower dams are one of the major pressures. Only some are passable for migrating aquatic species, but even they have severe ecological consequences and impact the sediment regime of the river. Three major dams are located downstream of Vienna, Gabčíkovo and the two Iron Gate dams. Especially the latter two barriers are a problem for migrating species. If longitudinal river connectivity were restored with suitable passages, long distance migratory species could re-migrate to the Upper Danube.

Tributaries are no less affected by hydropower dams. Apart from river-specific threats, aquatic ecosystems are impacted by land use or by the effects of climate change. They suffer from overexploitation and from the consequences of urbanization such as sealing and urban sprawl. Locally, forestry activities, salinization, land subsidence and many other problems can dominate the situation. Hence, all sustainability research has to be anchored in localized case-studies and must include a comprehensive view on aquatic and terrestrial ecosystems, taking into account their intrinsic connectivity.

Altered biodiversity and resulting ecological and societal challenges

Biodiversity is negatively influenced by habitat change, species exploitation, by the intentional or unintentional introduction of alien and invasive species, and by disease emergence as well as by climate change. All factors have an impact on habitat characteristics and species' life-cycles.

River systems are characterized by their connectivity. Connecting different European river systems via shipping canals favoured the spread of invasive species, widely recognized as the second major cause of biodiversity decline, after habitat alteration. When the Rhine-Main-Danube Canal was completed in 1992, it opened an invasion corridor between the Black Sea and the North Sea. Further waterway development will lead to even more of a potentially dangerous exchange of biota. The impact of invasive non-native species in the Danube is not yet fully evaluated (ICPDR 2013).

The sturgeon, a flagship species of the DRB once providing livelihood for many communities along the Danube River, faces extinction nowadays due to overexploitation and habitat loss (disruption of migration routes, pollution, hydromorphological changes). Restoring the sturgeon fishery in the Middle and Lower Danube is an important ecological as well as an economic goal. But this cannot be achieved without proper consideration of the socio-economic needs of the fishermen communities, such as provision of economic alternatives to ensure their income until the recovery of stocks. The empowerment of fishermen communities and an open dialogue on the local needs and problems that they are facing would assure good collaboration and ensure their access rights to fishery resources and fishing grounds.

A precautionary approach has to take into account new threats generated by human activities, such as new and emerging pollutants. Endocrine disruptors, persistent organic pollutants, recently launched pharmaceuticals and nano-materials pose yet unknown health hazards. Although their concentration in the aquatic environment could be below detection limits, they can reach alarming levels in biota and human food through bioaccumulation and bio-magnification processes. Hence, their impact should be carefully investigated. Persistent organic pollutants (POPs) accumulate and can reach dangerous levels over time. Time lags and unexpectedly delayed effects on the offspring generations need to be especially considered. In this and in many other issues of environmental hazards, the DRB countries face serious data gaps and inadequate monitoring policies. Disparate data acquired through research studies remains poorly disseminated and underutilised. More data on the occurrence and effects of such pollutants are needed to enable efficient environmental risk assessment.

The Danube Delta is an important migration hotspot for birds and, as a consequence, a major gate for the emergence of infectious diseases. The two recent outbreaks of West Nile Virus and Avian Influenza in the region are conclusive examples. The Danube Delta should be an important surveillance point, with research targeted on epidemiological pathways in domestic animals and

wildlife reservoirs based on the 'One Health approach'.¹² The role of the Danube in pathogen and chemical pollution spreading and its impact on keystone species of the Black Sea (e.g. endangered cetaceans), is still unknown. However, no data is available on the microbial and toxic hazards threatening this charismatic species in the Black Sea.

Industrial legacies and sediment pollution

Legacies of past practices determine river management options today and have to be accounted for when talking about sustainable development. Legacy contamination is embedded in the sediment with a high risk of re-entry into the water cycle with every flood and dredging operation. This problem was studied as a side-effect of the Baia Mare, Romania Cyanide spill of January, 30th, 2000, when a tailings pond burst at a facility reprocessing old mining tailings and re-depositing the waste sludge into a new tailings pond. The incident killed thousands of fish, poisoned waterfowl and affected thousands of people living on the riverbanks. Few months later, catastrophic floods moved more contaminated waters downstream to the Tisza and the Danube. The Baia Mare spill demonstrated that people living next to these dams suffer directly while those yielding the huge profits are not affected (Harper 2005; Dorondel in prep.).

A study conducted thereafter measuring the heavy metal load in sediments and river water yielded an unexpected result. Concentration in the sediment exceeded that in the water (Macklin et al. 2003). Macklin et al. (2003: 256) sum up their findings: *"While not downplaying the short term ecological effects of the spills, they should be seen more as compounding much longer term problems associated with many decades of poorly regulated, and largely untreated, industrial, mining and urban discharges into local rivers."* Mining activity in the area ceased in 2007 and there are signs of ecological recovery. But the long-lasting heavy metal load in sediments, inappropriate conservation work in mining areas and the Roşia Montană mining project currently raise national and international concern.

Pollution from industrial facilities (mines, plants, factories) abandoned after their closure in the 1990s is also a serious problem in adjacent river basins of South-East Europe.

Political and socio-economic situation of the DRB

The DRB encompasses a high political diversity, as EU-member states cooperate with accession countries and neighbouring countries. The different national legislations and political contexts impede a harmonized basin-wide approach, especially with regard to economic cooperation, mobility or research, unless specific frameworks address the DRB in its entirety.

Socio-economic disparities, characteristic for the DRB, are a huge challenge. The annual median disposable income differs between countries of the Upper and the Lower Danube by 15 000 € (see Fig. 9). Financial and institutional cooperation between prosperous areas in the upper catchment and less developed ones in the middle and especially in the lower basin is lacking. Brain drain affects countries such as Bulgaria or Romania and hampers economic growth, just as does

¹² <http://www.onehealthinitiative.com/>

trafficking in human beings and smuggling of goods and corruption. Weak governments, especially when not complemented by civil society institutions, create many environmental problems. When combined with problematic media and a general lack of economic means they exacerbate unsustainable economic exploitation and lead to undesirable environmental and social conditions; they are among the main reasons for the growing inequality in terms of access to environmental benefits in the DRB. The DRB is an area of environmental injustice.

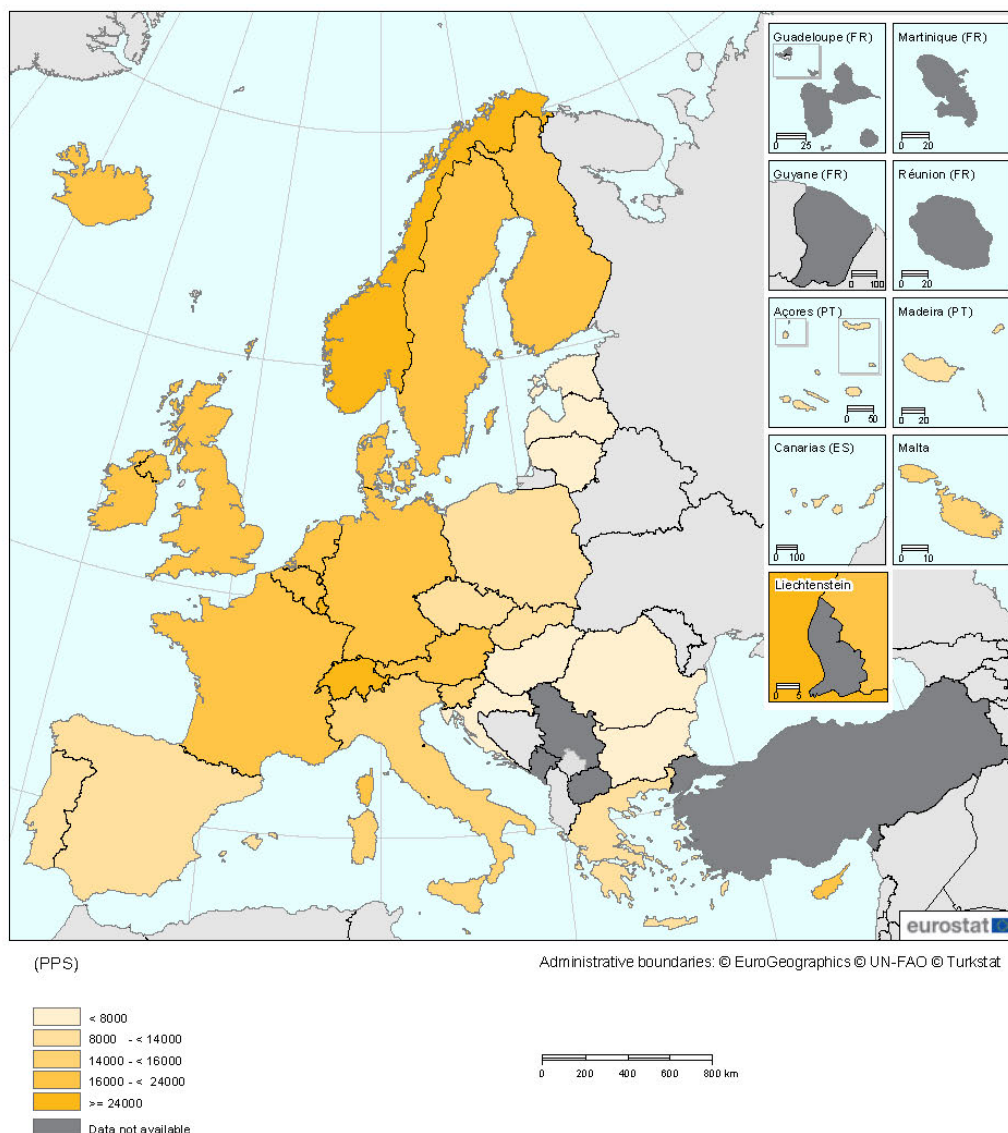


Figure 9: Median yearly income class of the EU-27 countries (source: EUROSTAT 2014)

The DRB offers many opportunities to counteract this situation, not least because of its rich and diverse cultural past and the unique environmental conditions. The Danube itself is a gateway towards the east and connects Europe to the Black Sea and Central Asia. The large potential for renewable energy can only be developed for long-term sustainability if ecological requirements are taken into account to avoid or at least minimize negative impacts on biodiversity and aquatic habitats. The establishment of a sustainable bio-economy can benefit from the fertile soils in the middle and lower basin, which are still in fairly good condition and not degraded by excessive fertilizer use and intensive agriculture (Haidvogel, 2014).

The DRB has a high potential of cooperation in education, as most countries have well established education systems with many higher education facilities connected in international associations. The Danube Rectors' Conference (DRC) was established in 1983. Today, the DRC unites about 70 universities from 15 countries, which discuss and define national, regional and international common targets and strategies of research and education. Together with the Alps-Adriatic Rectors' Conference, which also covers countries of the DRB, more than 90 universities are represented in this largest pool of institutionalized knowledge in the DRB. The International Association for Danube Research (IAD) was established in 1956 by the Academies of Sciences of Austria, Romania and Bulgaria. It includes research institutions and is a well-established platform, where scientists from the Danube countries cooperate and exchange.

The Danube Strategy seeks to create synergies and coordination between existing policies and initiatives of the Danube Region. The Danube Region Strategy serves the goal of increasing prosperity, security and peace for the peoples living there, especially through enhancing cross-border, trans-regional and trans-national cooperation and coordination (European Commission 2010). Participatory processes can play a large role in this endeavour, as they involve local communities and individuals and make their knowledge available for research, planning and management. Danube:Future contributes to the vision of the Danube Strategy by fostering and enabling transnational sustainability research and education.

Recently, European researchers have turned to the public for crowd-based data gathering, monitoring and research. This Citizen Science-Approach is also a great way to empower people in an increasingly science-based world. Sustainability research can benefit from Citizen Science projects which also are great way of lifelong learning and education. The use of modern ICT technologies and geo-information systems can aid this process. Developing "Spatial Citizenship" programs could become an important means for local involvement and lasting transdisciplinary cooperation, strengthening civil society and the research community alike.¹³

Assets of a multi-faceted Cultural Heritage

The history of the DRB has led to a striking cultural, political and ethnic diversity. Many monuments, sites and traditions, including traditional ecological knowledge, have been designated as UNESCO world cultural heritage or are in the process of being assessed. Among the designated

¹³ <http://www.spatialcitizenship.org/>

material heritage one finds the Roman Limes, the cultural landscapes of Wachau in Austria, the banks of the Danube and Buda castle in Budapest, the historic town of Banská Štiavnica, the Mehmed Paša Sokolović Bridge in Višegrad (see Fig. 10) or the painted churches of Moldavia. Acknowledged intangible heritage comprises traditions such as the Hungarian folk dance Táncház or traditional forms of Romanian folk music (Doina). Cultural heritage has the potential to support sustainable tourism and economic growth in the tertiary sector by connected professional activities which include Information and Communication Technologies (ICT), for reconstruction, cataloguing and preservation. Tangible and intangible cultural heritage can help to strengthen social cohesion, regional identities and well-being, empower local stakeholders to participate actively in the process, while at the same time embedding localized cultural heritages into a European context.



Figure 10: The Mehmed Paša Sokolović Bridge in Višegrad across the Drina River in the east of Bosnia and Herzegovina was built at the end of the 16th century (source: Andrić Branislav).

Preservation and valuation of tangible and intangible cultural heritage in the DRB is a multifaceted, interdisciplinary task for several reasons. It was and is threatened by ethnic conflicts and by being the target of ethnic cleansing. Symbolic markers of ethnical groups have been eradicated in recent times in former Yugoslavia (Vos 2015).

Cultural heritage is affected by the disappearance or severe depopulation of rural communities especially of villages in mountainous areas (e.g. Apuseni or Poiana Ruscă mountains in Romania). Historic settlements on river islands have vanished because of river engineering works. Ada Kaleh

Island upstream of the Iron Gate is a case in point (see Fig. 11). Heritage is also affected by material decay (e.g. due to weathering, sunlight and temperature variation, moisture, pollution) and its preservation requires to take natural hazards in the DRB such as floods or landslides or the risk of accidental release of hazardous substances into account.

Addressing these circumstances, the European Commission and the Council of Europe have introduced the Regional Programme on Cultural and Natural Heritage in southeast Europe. It *“... seeks to change local perceptions on heritage and instigate debates about uses of the past. The premise is that only by learning from past conflicts will the region be able to continue its path to EU integration.”* (Vos 2015: 2).

Figure 11: The island Ada Kaleh with its fortress from the late 17th century disappeared when the Iron Gate dam I was constructed in 1971 (source: Library of Congress, Photochrome Prints Collection LC-DIG-Fppmsc-09518)



Preserving tangible and intangible cultural heritage and simultaneously realizing its economic value is evidently an integrative task. Not all economic development will be supportive of the local cultural heritage, even if it integrates it into theme-park-like structures. It will be important to create local and regional value chains rather than enlarging the reach of globalized entertainment industries. Just like natural heritage, cultural heritage requires inter- and transdisciplinary cooperation to fully realize and valorise its societal and economic potential.

Conflict as a sustainability problem

The historiography of the DRB is characterized by a gradient just like the river. While the Upper Basin's history is part of the main narrative of Europe, and rests on a large base of sources, in the Lower Basin, historiography remains scattered, and poorly known to the main narrative of

European curricula. A lack of sources aggravates the uneven development of historiography. This situation can lead to simplified, reductionist black-and-white stories, which have to be overcome, if a post-socialist and post-nationalist sustainability agenda is to be supported. This includes also to counteract perceptions of “The Balkan” as a case distinct from other areas, which would hinder European integration.

Just like in many other international co-operation projects, prejudices, ethnocentricity and a general attitude of ‘othering’ national problems have to be actively tackled. It remains unclear how they can best be addressed. An interdisciplinary approach seems most promising. Sometimes, building cultural bridges can be a question of building them materially. Transportation infrastructure such as bridges, highways or railway networks mirror the fragmented history and hamper the development of cultures of co-operation, because of long and tedious communication paths.

The contrasting impacts of peace or war make for important differences for prospects of sustainable development (see Fig. 12). People in the Danube region fought for centuries and have left all kinds of legacies, but the sustainability problems created by the most recent conflicts are the most dangerous (UNEP and UNCHS 1999).

Among the legacies of the recent war in the Balkans are a bombed oil storage facility in Bor, a destroyed oil tank at Novi Sad and the infamous industrial area of Pančevo, best known for 250 tonnes of liquid ammonia spilled into the Danube during the war. Site managers had released the toxic fluid in an attempt to limit danger from a potential air strike on stored ammonia of the fertiliser plant. This release was probably responsible for fish kills in the Danube, up to 30 km downstream. UNEP assessed that the waters of the Danube were polluted heavily during the Balkan war. UNEP concluded with regard to the overall situation: *“Social, economic and administrative disruption are likely to cause an increase of pressure on natural resources, both within and outside protected areas (e.g. increased use of wood for cooking and heating, due to loss of electricity supplies). [...] Experience from reconstruction activities in other Balkan countries shows that future reconstruction in Yugoslavia will place heavy demands on raw materials (e.g. gravel, rock, wood products, water).”* (UNEP and UNCHS 1999: 68).

Confronting the past—including war and the havoc it wreaks—can turn into a unique learning opportunity. In an ecologically degraded world, long-term economic development is impossible and social unrest will increase. The EUSDR as well as Horizon 2020’s Societal Challenges address these issues, even if the importance of social and environmental legacies has not yet been explicitly stated and formulated as a challenge.



Figure 12: Bombardment of Novi Sad 1999 destroyed infrastructure and oil tanks leading to long-lasting environmental hazards (source: Darko Dozet).

Principles of long-term oriented sustainability research and capacity building for the DRB

The sustainable development of the region is a pre-condition of human wellbeing. It is inextricably linked to material aspects (income, assets, food), health (feeling well, capacity to work, healthy environment), social connections (social cohesion), security (personal safety, tranquillity) and freedom of choice and action (dependent also on education) (MEA 2005, quoted in Sandu 2010). As an integral part of the ecosystems, the Danube citizens are also connected to the quality of the Danube environment. The living generation bears responsibility for the natural legacy they provide to future generations.

The Danube River Basin with its unique natural and cultural heritage, but also with its challenging cultural and natural legacies and political and economic environment can become a model macro region for the Europe-wide transformation to sustainable development.

The integration of cultural and natural heritages and legacy challenges by means of inter- and transdisciplinary approaches has been identified as the most promising specific avenue towards sustainable development of the Danube River Basin macro region. Long-term socio-ecological research is necessary to successfully deal with the legacies and valorise the heritage for sustainable development integrating multiple pressures and long-term effects. This section gives an overview of the programmatic principles for research and capacity building necessary to deal with the entangled cultural and natural legacies and heritage in a long-term perspective.

Systems' behaviour and the consequences for sustainability research

One of the main challenges of sustainability research is the non-linearity of complex systems. In many cases, changes in ecosystems involve non-linear processes. Lag phases, acclimation, resource limitation, homeostasis, hysteresis effects and threshold responses to impacts such as climate change and to human interventions are frequently found in nature (Gerzabek and Winiwarter 2012).

To give but one example, Zhou et al. (2008) modelled ecosystem responses to global climate change. Their results show that response patterns were non-linear, showing parabolic, asymptotic, and threshold-like behaviors. Ecosystem responses to combined anomalies of several factors differed considerably from responses to individual factors with regard to patterns and/or critical points of nonlinearity. To cast it in the terminology of resilience theory, when faced with disturbance, complex systems can move from one stability domain to another, crossing tipping points from where a return to a previous state becomes highly unlikely.

Long-term processes are important drivers for system behaviour. Short-term observations of natural systems cannot reveal realistic trends of such processes of change. Long-term observations are necessary to measure and understand complex ecological processes; this is even truer if one is dealing with coupled human-environment systems. Social sciences and humanities are needed to understand the long-term evolution of such systems.

Coupled, hybrid human-environment systems exhibit emergent properties. This means that despite the best efforts of numerical and statistical modelling, the future remains fundamentally unpredictable, beyond the uncertainty of single data points. Risk management becomes a critically important issue. Interdisciplinary communication including lessons learned from traditional knowledge is a key to success in this vital endeavour.

The above-presented characteristics of the complex systems mandate a long-term and precautionary approach for sustainability research. Such an approach pays particular attention to legacies. It is by necessity transdisciplinary and aims to foster social, transformative learning. This section of the White Paper can build on recently published national White Papers.

A Long-term approach is necessary

With increasing knowledge especially about global and climate change the need for a long-term perspective is acknowledged in research and policy documents as stressed e.g. by Riahi et al. (2007), Singh et al. (2013) or in the Natural Environment White Paper of the UK-Department for Environment, Food and Rural Affairs (2011). In a recent White Paper on Long-Term Research, the Austrian research community has spelled out the necessity for a long-term approach. This White Paper emphasizes the role of global change for all sustainability issues. *“Since global change has long-term impacts, short-term research projects can only deliver inadequate answers. Monodisciplinary approaches are equally unsatisfactory. Human-environment systems can only be recorded and understood using a multidisciplinary approach. This involves capturing the complex interaction of physical-chemical, biological and sociocultural (or social and cultural) processes, in which context humans are both the responsible and the affected parties and yet may also be the creators [...]”* (Mirtl et al. 2015: 40).

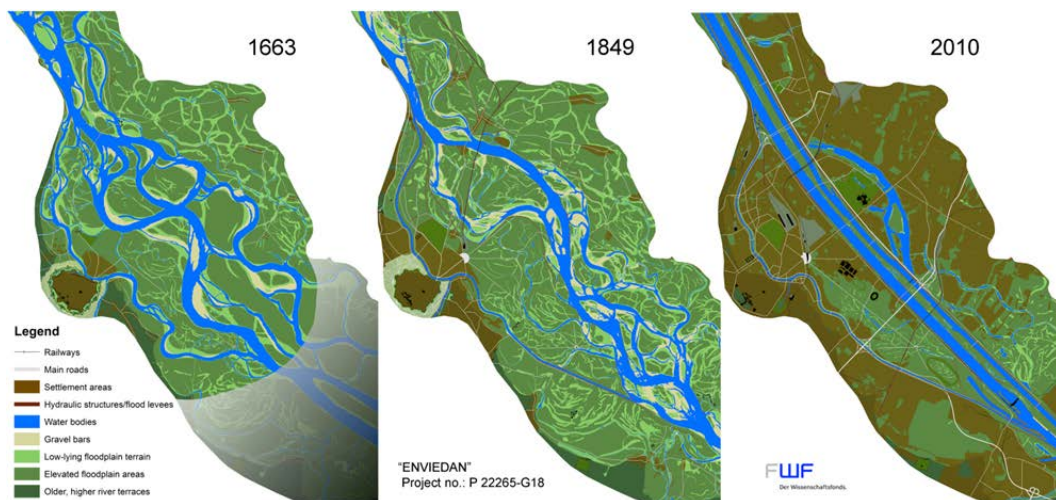


Figure 13: The Viennese Danube and its morphological development from 1663 to 2010 (Source: Severin Hohensinner).

Long-Term approaches are important wherever a bias in the evaluation of ecosystemic properties arises from short-term information. River channelization and its infrastructures affected the Danube since centuries. Such systematic measures implemented e.g. in the Upper Danube since the late 19th century cause long-lasting legacies.

Based on his investigation of the decline of marine animal resources, in particular fishes, marine biologist Daniel Pauly introduced the notion of “shifting baselines” into ecological research and management (Pauly 1995). Pauly stresses that each period has its own perception of baselines, e.g. fish stocks, ignoring long-term changes. Rosenberg et al. (2005) demonstrated this for the early cod stocks of the Canadian Scotian Shelf, which have been underestimated for a long time because fishery statistics from the 1970s were taken as reference for the evaluation of the decline up to the 1990s. Policies targeted towards long-lived ecosystems in the DRB might also suffer from such bias.

Nature and Culture are entangled

Long-Term studies have to account for the presence of humans not just as disturbers of ‘nature’ – but as inhabitants of natural and social environments. Not only are humans an evolutionary species, human societies are also embedded in natural processes. Any transition towards sustainability and necessary adaptation strategies need a comprehensive approach. As Mirtl et al. (2015) state this requires taking into account “... *the interrelations between society and the biotic and abiotic components of the Earth System and of its development to date and into the future*”. Environmental problems are similarly societal ones and according knowledge can support society, politics and economic development for the long-term. “*Sustainability is seen as a policy objective to avoid placing the ecological basis of life at risk, avoiding social conflicts and to create economic stability. [...] Among others, this includes ensuring that the capability of the ecosystem to provide the services required by society (“ecosystem services”) is continually maintained.*” (Mirtl et al. 2015: 40).

As concerns heritage preservation, the interdependence of biodiversity and cultural diversity has been addressed recently by the UNESCO-SCBD programme, a joint initiative of the UNESCO and the Secretariat of the Convention on Biological Diversity (SCBD) on the links between biological and cultural diversity (UNESCO & SCBD 2010¹⁴). In April 2014, the Florence Declaration on the “Links between Biological and Cultural Diversity” was adopted, referring to biocultural diversity as concept (UNESCO & SCBD 2014; Šmid Hribar M. and Urbanc M. 2015).

Sustainability and the Precautionary Principle

Protecting ecosystem services and biodiversity in a sustainable way is a core task of society as a whole and requires among others considering global change in decision-making. This is due to the fact that the “benefits” provided by the ecosystems are the basis of human well-being. Decisions

¹⁴ <http://www.unesco.org/new/en/natural-sciences/special-themes/biodiversity-initiative/biodiversity-culture/unesco-cbd-joint-programme/>

about proximate causes of human well-being are difficult. Decision making under conditions of uncertainty has always been and remains a major challenge for all societies. The difficulty of decision-making has increased with the complexity of the infrastructures and other socio-natural hybrids humans have created. As the technologically mediated abilities rise, so rises the potential risk of interventions. The European Environmental Agency has published two reports calling for precaution as political principle. They show that society has hitherto been late to learn from early warnings and call for a change of the principles of decision-making (EEA 2001, 2011).

As stated above, system behaviour is often non-linear, therefore a long-term approach is mandatory. In many cases, problems of precaution arise from feedbacks across temporal and spatial scales, from risk spirals (Sieferle and Müller-Herold 1996) and from long-term effects with lag phases, thresholds and synergies.

Transdisciplinary, participatory approaches are necessary

Sustainable development is considered a wicked problem (Rittel and Webber 1973) whose realisation ultimately depends on the capacity of different actors and groups to communicate, negotiate and reach collective decisions as actors can have widely different conceptions of what constitutes a positive development of the livelihood and well-being or a move towards a more sustainable situation (Pahl-Wostl 2002, Schusler et al. 2003, Woodhill 2004, quoted after Muro and Jeffrey 2008: 329). Within transdisciplinary research on sustainability issues, messy problems of the outside world require a (re-)solution. Researchers take their disciplinary and even interdisciplinary tools and try to find innovative solutions without standardized research models (Bergmann et al. 2012). In this toolkit, results and methods of basic research are as important as communication skills and the ability to bridge gaps between disciplines and their different ways of researching, arguing and presenting. But ultimately, for robust-implementable knowledge, the participation of stakeholders is a must. Stakeholders contribute their unique perspective, necessary for problem definition, for seeking pathways and for successful application. Mutual learning is necessary to find the path(s) towards a more sustainable future. Stakeholder learning, however, has to be embedded in smart institutional frameworks of multi-level governance structures (Biermann 2007).

Participatory approaches have to be considered in education whereas education for sustainable development has to take into account a participation inequality rather similar to that formulated by Jacob Nielsen (2006) for social media and online communities: 90 % of people are users or 'lurkers', they read or observe but they do not contribute actively to change. 9 % of people contribute from time to time and only 1 % participate intensively and provide most contributions. Education can help to overcome this limited engagement of a majority of people in their daily live and local conditions.

Learning for Sustainable Development: Transformative, Social Learning

Individual learning will not be sufficient to produce the kind of orientational, embedded, democratized expert knowledge that so many authors have called for in the context of environmental problems such as e.g. flood protection or ecosystem restoration. Social learning will have to take place. Sustainability learning has to bear the characteristics of social learning. Open communication, diverse participation, unrestrained thinking, constructive conflict, and democratic structure, multiple sources of knowledge, extended engagement, and facilitation foster social learning (Pfeffer et al. 2003). Social learning for sustainability calls for an interdisciplinary research agenda involving social psychology, education studies, organisation and management studies as well as environmental and natural resource management (Muro and Jeffrey 2008: 326). To sum it up, the sustainability transition calls for robust knowledge as basis for adaptive co-management of resources. (Pfeffer, 2003: 309). This is by no means an abstract goal. On the contrary, integrated river basin management and flood risk policies are built on social learning rather than on structural measures alone (Jha et al. 2012).

In flood- and drought-prone Australia, community scale resilience has been framed as an issue connecting healthy communities and their waterways. This approach could be applicable in many towns along the DRB's rivers (Gooch and Rigano 2010). A recent guidebook for integrated urban flood risk management emphasizes as one of 12 principles that a balance should be sought between structural and non-structural flood protection measures and the effect of both should be monitored to aid decision-making. The guidebook urges cities to see their flood risk programs as processes and not as projects that, once, installed, will work. Continuous communication, learning and reinforcing of preparedness, which builds on continued efforts to raise awareness of the risks are an important component of successful flood protection (Jha et al. 2012, Winiwarter in print, a).

Sterling (2011) distinguishes between different types of change corresponding to different types of learning. First order change seeks effectiveness or efficiency, is conformative and can be summarized as 'Doing things better'. Second order learning seeks to examine and change assumptions. It is reformative and can be described as 'Doing better things'. The third type of learning, transformative or epistemic learning, leads to a paradigm shift and is transformative. It can be summarized as 'Seeing things differently'. This tripartite distinction of learning is the basis of different types of scholarship (called Mode 1, 2 or 3) a reflexive society needs. Mode-3-science aims at producing highly contextualized knowledge on the system level, taking potential fundamental changes of goals and aims into account, and producing transformative knowledge. For Mode-3-science, civil society is an important actor of knowledge production and needs to be institutionalized in the organization of scholarship. The so-created transformative knowledge is heterodox, coming from real-laboratories and from actual processes of transformation (Schneidewind and Singer-Brodowski 2014: 123).

Responsible Research

In 2013, the European Science Foundation launched a report on Science in Society. The Working group reminds both the scientific community and policy makers that neither 'science' nor 'society' are homogenous entities. Science-society issues should move from a logic of clear-cut choices that suggest the idea of a linear problem-solving to a logic of care, which allows for an adaptive process of dealing with these issues in the face of diversity and rapid change already present well before 'the crisis' becomes manifest. The report makes five recommendations. (1) Excellence should be linked to relevance and responsibility. (2) Social science and 'science-society activities' should not be reduced to "dissemination" or be used as an add-on, but become an integral part of research. (3) European research should explicitly acknowledge European diversity. This entails to include addressing science-society issues in ways adapted to the local context, giving space to a variety of understandings of progress and futures, and broadening the notion of innovation to the social sciences, humanities and arts. (4) Such program calls for new spaces for science-society interactions, fostering more trust in bottom-up initiatives and more explorative, processual approaches. (5) Finally, the creation of more time and space for reflexive work within research is suggested, while the necessary incentive structures are still lacking as well. All sustainability research should be based on these principles and foster a research ethic based on the understanding that wicked problems can be resolved if all engaged parties act in mutual respect and with an understanding of the long-term consequences of their work (Felt et al. 2013). It will likely include new approaches to *Citizen Science*, i.e. the active involvement of all interested people in research. Responsible scientists alone are not enough, there needs to be a kind of 'Corporate Social Responsibility' of the academic system as a whole, a research ethics that goes beyond individual decisions but encompasses the designation of priorities.

Corporate social responsibility has been already included in many of the Higher Education Curriculums e.g. considering fields of business and economy studies. But a more strategic approach is needed to build capacity in Higher Education and to facilitate the evolution of social consciousness and culture. DRC and AARC, as institutionalized networks can have an important pioneer role in such a development.

Funding Opportunities

In accordance with the principles of the EUSDR, the Danube River Basin Sustainability Research Initiative (Danube:Future) will rely on existing funding schemes such as HORIZON-2020, COST or Structural Funds. Combining national and international funds was identified as a major challenge.

Participants of the international Workshop held in April 2015 at AAU in Klagenfurt have shared their wide-ranging expertise in different national academic and educational systems. They have formulated general challenges and opportunities of the DRB and specific options for future research and capacity building.

Differences in present and past integration of EU-, Non-EU-, accession- and neighbouring-countries (currently Ukraine, Republic of Moldova) into the European community have led and still lead to different policies and also to different ways of embedding into EUSDR with important bearing for transnational research.

Research cooperation in the economically stronger countries of the Upper DRB is still oriented towards 'Western' Europe. The EU clearly fosters cooperation between Danube countries via different funding instruments, which can all play a role in the Danube:Future context. **Twinning projects**, for instance, aim at knowledge transfer and training from 'better' to 'less advanced' countries with regard to a particular field or skill. **COST** enables creating networks and analysing as well as harmonizing existing knowledge. **Structural Fund programs** such as the intended **Danube Transnational Program** focus on the region in its entirety. In addition, the Central European Initiative covers Danube countries. The **Joint Research Centre of the European Union** has established a **Scientific Support Program** for the Danube Region, which will clearly benefit from the availability of large-scale data. **Existing funds for bilateral and multilateral co-operation** in research and teaching should also be integrated into funding portfolios

While many of the funding programs focus either on research or on capacity building we emphasize that the format and design of research has to enable capacity building. This includes fair treatment of young researchers and might best be supported by a new inclusive format of "learning regions". Curricula based on regional strengths can support economic development and societal integration. These regional approaches can be based on recent analyses of the strengths and weaknesses of the regions (see e.g. ZEW 2014).

Interdisciplinary co-operation can possibly be funded by H2020. Given the potential to use the existing and developing capacities of the knowledge society actors in the DRB for addressing the H2020 challenges, in particular the Challenges five and six dealing with climate change and environment and inclusive and reflective societies in an interdisciplinary way, the Directorate General of the European Union might wish to consider an approach whereby the DRB can contribute as 'laboratory' for the sustainable development of the European Union.

Using the assets of a university-based network

To ensure the long-term transition to sustainable development, tertiary education is a prime mover. Common curricula which consider sustainability are a means to stabilize research output transmission. There is a wide consensus that education can be utilized to transmit values that are essential for higher accomplishment, welfare and well-being. According to the UNESCO - Aichi-Nagoya Declaration on Education for Sustainable Development (2014), there can be no sustainable development without education; achieving sustainable development requires a change in the way people think and act, and formal education is one of the most important ways to gain that goal. Transmission of important values, in order to build a sustainable mind set in a purpose to building young people skills for sustainability is in the frame of societal challenges identified in HORIZON 2020 - **The young generation in an innovative, inclusive and sustainable Europe**. Building

common curricula demands a more strategic approach to sustainable development at the university level in the whole. The DRC and AARC have a crucial role in building capacity of common core curricula for sustainability on the level of Higher Education institutions in the whole region.

Examples for research opportunities already identified

Protected areas emerged as promising laboratories and observatories for sustainable development. Current conservation strategies increasingly follow an integrative approach (e.g. UNESCO Biosphere Reserves, Joint Program UNESCO-SCBD) explicitly including sustainable development into their agendas. Thus, numerous synergies are to be expected if protected areas get involved. As the research side of protected areas is very often underdeveloped, a huge potential to increase their intrinsic value for society by turning them into major actors of the knowledge production systems exists. Their use can be an efficient and integrative, international way of designing pilot sustainability flagship projects. They are well distributed over the river basin (see Fig. 14).

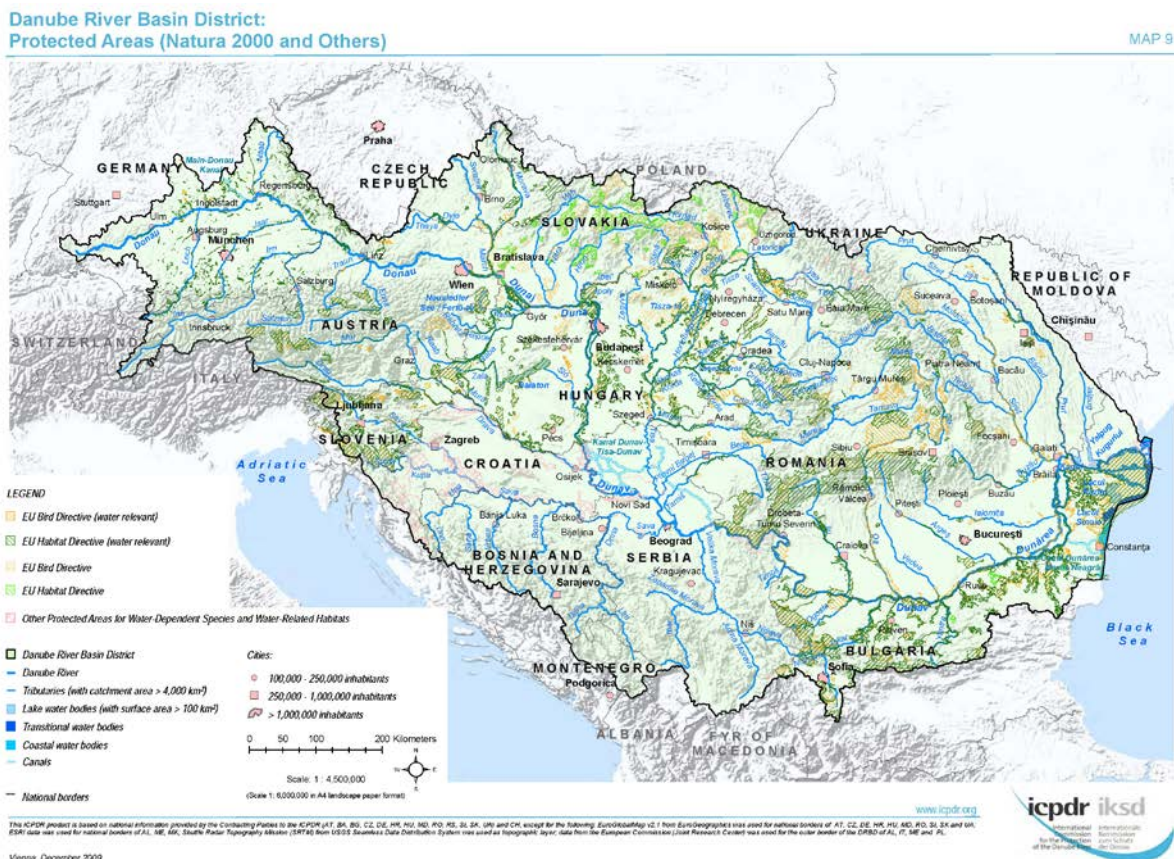


Figure 14: Protected Areas of the DRB (source: ICPDR)

The European Union defined its main sustainability-related challenges in 2000 as (EUROSTAT 2011):

- Climate change and clean energy
- Sustainable transport
- Sustainable consumption & production
- Conservation and management of natural resources
- Public Health
- Social inclusion, demography and migration
- Global poverty and sustainable development challenges

In the DRB, these challenges persist, some with particular urgency or magnitude. In the EUSDR documents, the EU has identified challenges for the DRB countries in the fields of mobility, energy and the environment in terms of pollution, flood and drought risks. It lists challenges in the field of socio-economy in terms of the wide economic disparity and finally, the challenge of security and organized crime (EUSDR 2010). Sustainable development is the way to address these challenges over the long-term. The EU update report on SD from 2011 makes clear that the challenges for the Danube River Basin countries are representative, but in some areas, exacerbated in comparison with the EU-27 levels (Eurostat 2011). A sustainability-focused overview of challenges and opportunities is presented in Figure 15.

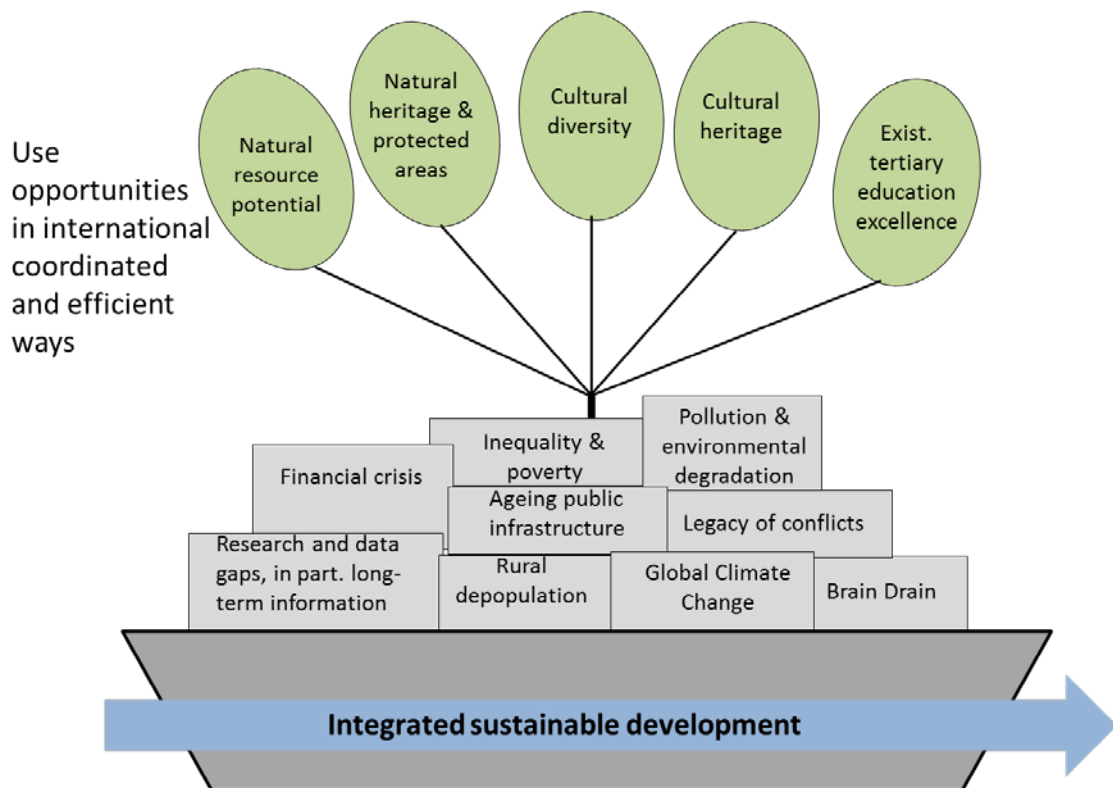


Figure 15: Overview of challenges and opportunities in the DRB (source Winiwarter & Haidvogel 2015 after Fischer-Kowalski et al. 1995)

The rich and diverse cultural and natural heritage of the EUSDR countries stands out as an asset for sustainable development. Focussing on the long-term development of these combined heritages and at the same time, addressing the clearly problematic natural and cultural legacies is a uniquely promising approach to foster European Union Sustainability goals using the DRB as a living laboratory and pilot implementation area for the entire Union.

Many of the legacy challenges only become apparent if the frame of reference is chosen long enough. Long-term data are of crucial importance, but difficult to get in a comparable format. The JRC's support project for EUSDR will be critically important for the success of any pilot project addressing the sustainability challenges.

The way forward: steps to be taken

"Turning the briefing into action"

The White Paper will be presented to the Danube Rectors' Conference and the Alps Adriatic Rectors' Conference, kindly asking their support further disseminate it within the respective networks of universities (making it available on the university homepage, disseminating the link to the DF website, etc.)

In July 2015, the document will be distributed to PAC 7 and PAC 8 and the Steering Group of the PA 7, aiming to connect with currently running initiatives that could be connected with the Danube:Future project, such as the economic study performed by PA 8 and the feasibility study for DRRIF of PA 7, comprising a chapter on research and EU funding absorption. Upon their feedback, the document will be distributed to connected areas PA 3, PA 6 and PA 9, and also to National Contact Points, to increase dissemination at national level.

It is planned to present the document in October 2015 during the largest annual event of the EUSDR, the 4th Annual Forum that will be held in Ulm, Germany.

Collection of important documents and links

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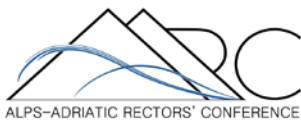
An impression from the 1st Danube:Future Workshop



Workshop Organizers:



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