Review of Draft DRBMP Report 2009 (Version 6, 18 May 2009)
by IAD (Jürg Bloesch & Cristina Sandu)

General Comment

To our opinion the DRBMP is a good state-of-the-art document with realistic measures proposed. We acknowledge the great work performed by ICPDR, however, found some parts that still can be improved. We know about the problems of data quality supported by the countries and some constraints given by a conflict of interests and the political agenda, and we are aware that these points cannot be fully treated in this report. However, we appreciate if it is mentioned, in a respective footnote, that specific problems do exist that must be solved later. Such a transparency will increase significantly the quality of the DRBMP. We also recognize and took notice that some important gaps are planned to be filled out in the finalization period until December 2009; we fully support these passages in the draft report and do not specifically comment on them. In addition, some of our recommendations may be included in this revision.

It may not be the place here to reflect critically the **WFD** (e.g., with regard to the paradox of “not allowed to deteriorate waters” vs. “sustainable development of navigation” and other technical impacts and infrastructure projects). However, in the context of hydromorphological alterations it seems to be necessary to elucidate the selection and designation of **HMWBs**, particularly in the Green Corridor and Danube Delta. The question, how realistic it is to achieve the goals of protection and restoration by 2015, is addressed by stating the options for 2021 and 2027. This is a realistic view in our opinion and part of the pragmatic step-by-step procedure.

In a general view, we have the impression that the **following topics need to be improved:** Sediments, groundwater, WWTPs, toxicity of hazardous substances, legal framework of countries, wetlands, neozoans, and climate change impact (see special comments and respective Annexes with text tools to be integrated in the DRBMP). We plea that **not only quantity but also quality** counts. This addresses to some issues of the report, e.g., number of WWTPs, fish passes (both need to be functional to be effective), ring-tests, complete list of FIPs, and SEA & EIA. The DRBMP should clearly state that the goals of the WFD cannot be achieved if the many measures proposed do not meet functional quality.

We acknowledge the application of well accepted principles such as those of polluter/user pay, precaution, cost-recovery and **best available technique (BAT)** - although the latter is not consequently applied (see e.g. WWTP technology, fish pass construction, where the DRBMP should refer to); however, we miss the **principle of solidarity** in the DRB (as relevant for fish/sturgeon migration and pollution load to BS). We are aware that this is a delicate issue in the given political situation in the highly transboundary DRB; however, it would be good for the DRBMP and WFD implementation to see/feel some more commitment of the countries for cooperation, and we think it would be beneficial in the long term as it is the foundation of many important environmental WFD issues such as the two above mentioned points (sturgeons and load), as exemplified successfully in the Rhine Commission (ICPR).

Special Comments

We renounce of mentioning the printing mistakes as we assume that the final editorial check will yet be done when the document is completed. Apart from some obvious mistakes that must be corrected, we mention mostly important gaps in content that we recommend to fill out with the respective information to improve overall quality of the DRBMP.

#1: Acronyms: we recommend to further complete this list by the following acronyms used in the text:

- REACH (p.17, 69, 86) – EC regulation ref. **R**egistration, **E**valuation, **A**uthorisation and Restriction of **Ch**emical substances
- FIP (p.25, 48, 81) – Future Infrastructure Projects
- GFP (p.61) – Good Farming Practice
- BEP (p.69, 70, 81, 86) – Best Environmental Practice
- PI (p.73) – Prioritisation Index

#2: p.2: Table 1, **"important water uses and services"**: we recommend some changes in sequence and phrasing, and to insert "dredging, gravel exploitation" as an important use, and "ecosystem services" as important service: water abstraction (industry, irrigation, household supply); hydropower generation, drinking water supply, dredging and gravel exploitation, navigation, wastewater discharge (domestic and industry), ecosystem services (provisioning such as food supply, regulating such as carbon sequestration and climate regulation, supporting such as nutrient cycling, cultural such as recreation and education, etc.).

#3: p.3 footnote 7: the text is not clear, we suggest to change into: "The scale for measures related to point source pollution is smaller and therefore more detailed."

#4: p.4, Table 2: the total population in the DRB is quoted as 81 mio, while on pp. 2 and 50 it is 83 mio; these figures must be harmonized;

#5: p.5 first two lines: It should be specified here if this task was foreseen for 2015 or can be extended to 2027;

#6: p.11: footnote 31 is redundant as this is explained in the text of the same paragraph just a few lines below the first sentence; we recommend to cancel the footnote;

#7: p.12, 15: the **ban of household detergents** is mentioned (p.15) but to make it clear for the reader, we recommend to add a hint to the planned measures (see p. 60, 62, 65, 85); on p.15 (line 4), it would be good to know which countries have to date introduced the detergent ban; on p.85 (nutrient pollution, item 5) you should explain in a footnote why there is two dates of detergent ban for laundry (2012) and dishwashers (2015) (i.e. different active substances in detergents are required to clean textile materials vs. glass/ceramics, and hence, the time to change technology is longer for the dishwashing products);

#8: p.12, chapter 2.1.2.1, line 3: **"secondary and tertiary treatment for N and P removal":** since WWTP engineering technology varies considerably between countries and according to the aims of purification, it is rather confusing to attribute nitrification/denitrification respectively P removal to a specific treatment step; therefore we recommend to renounce using numbers (i.e., 2nd step, 3rd step) and instead explicitly saying what is meant; the sentence then would read: "It should be mentioned that WWTP engineering technology and proper operation is of particular importance to eliminate/reduce nutrients (nitrates and phosphates)."

this also applies in particular to Figure 3 on p.9 (legends, right side); we recommend:
- collected and N- and P-removal;
- collected and P-removal
- collected and N-removal
- collected, BOD-removal + other more stringent treatment than N- and/or P-removal
- collected and BOD removal
- collected and mechanical treatment
- collected and no treatment
- collected in IAS, treatment not reported
- not collected and no treatment in UWWTP

#9: p.14: we recommend to replace NOx and NHx (or NHy as used in fig.9) by more clear chemical nomenclature, as e.g. NOx is used for "more reactive nitrogen oxides" that occur mainly as gases in the air; we suggest to use: "NO_3+NO_2" and "NH_4"; (see also pp. 63, 64, 66);

#10: p.15, 2nd sub-chapter lines 1-2: we cannot understand, why mineral fertilizers are included in the agglomerations contribution; they are rather part of diffuse sources of agriculture;

#11: p.15, last line: "transportation" may be specified as "traffic, combustion of oil and derivates";

#12: p.15-18, **hazardous substances**: although we recognize that "hazardous substances" is well used in science and in environmental legislation (e.g. WFD) as summarizing many harmful chemicals, we strongly recommend to mention the word **"toxic"** in the text, as many of these substances have an impact on biota at the sub-lethal level ("chronic toxicity") and to mention also the numerous toxicity tests widely used to monitor these chemicals and their effects; we strongly recommend to give a short definition at the beginning of the chapter, as given on the ICPDR website: "... are toxic, persistent and liable to bioaccumulate ... or influencing hormone or immune systems of animals";

#13: p.20, blue box: a definition of the classes 2-5 should also be given, as for class 1 in fig.10;

#14: p.21, lines 1-3: As the figures are rounded and the balance should be 100%, we recommend to write in line 3: "About 19%" or "18-19%" of the existing barriers ...

#15: p.21, fig.12 and text: beside the quantity of **fish passes** it should be said something about their function; if no reliable information is at hand (what we suspect) then at least there should be a sentence with about the following contents: "Besides the quantitative number of fish passes, it is crucial for fish migration that these passes are functional with respect to all species/age classes and according to BAT (referring to extensive literature and expertise). Existing and new fish passes need to be thoroughly monitored (success control), and those with bad function must be technically improved (users pay principle). In the next term of WFD implementation, such information will be gathered from the countries." see also p.71;

#16: p. 21, sub-chapter 2.1.4.2: To stress the ecological importance of wetlands/ floodplains, we suggest to add: "... in functioning of aquatic ecosystems *by providing, e.g., feeding, spawning and nursery habitats for many fish species (among many other ecosystem services),* and have a positive effect ...";

#17: p.22, Table 5: the figures of **reconnection potential** are very low (only 14 rivers from a total of 728); therefore it should be defined what this reconnection potential means; we recommend to give the %-figure in brackets and use one column only (also in Tab.7); we recommend to link the reconnection/restoration potential to the important issue of **flood prevention and the EU Flood Directive**, as reconnecting disconnected floodplains can provide significant flood mitigation by water retention and subsequent lower peak flow; maybe a footnote to Table 5 could explain that these data were given by the countries and the information will be up-dated for the 2nd period of WFD implementation;

#18: p.23, sub-chapter 2.1.4.3, lines 5-6: The figures presented (47% +19% +32% +11% = 109%) are not balanced to 100%; this needs to be corrected;

#19: p.23, Table 6: **Hydropeaking** (artificial water level fluctuation) is normally measured by the ratio of Qmax and Qmin; >1m water level difference is not a precise measure to rate the ecological impact of hydropeaking as the level depends also on the river size and morphological structure at the site; and the speed of changes in water level and flow velocity is of crucial importance to allow escape reaction of benthos and fish (especially in the riparian zone); as in Switzerland we have presently a public debate to integrate hydropeaking into a partly revised water protection law, we recommend to use the following criteria, based on expert knowledge (also from case studies in Austria): "A ratio Qmax:Qmin >5:1 is not acceptable (measures of remediation can be retention basins to break the peak flow); the "ideal" and ecologically acceptable ratio is <3:1; ratios between 3-10:1 may be acceptable under specific conditions but need to be thoroughly investigated. In addition, the speed of water level change must not exceed 15 cm per hour. The change of water temperature induced by hydropeaking must not exceed 5°C. Special emphasis needs to be given to the sediment transport, since hydropeaking fosters colmation of the river bed sediments. Hydropeaking must also respect minimum ecological flow. ";

#20: p.24, water abstraction, end of 1st section: the question here is: how is the **minimum ecological flow** defined? We know that this is a very difficult scientific issue and it cannot be a precise threshold value, but generally should allow biota to survive, for example, fish need a minimum water depth of 20-30 cm to migrate; basically this should be given by harmonized national legislation; we recommend to write in the text or in a footnote: "The definition of minimum ecological flow is subject to scientific research and cannot be quantified easily. Infiltration and exfiltration to groundwater must be taken into account. In general, it is a minimum quantity of discharge that allows survival of migrating fish at any time and any location, for example, a minimum water depth of 20-30 cm. Minimum ecological flow must be defined by national legislation which should be harmonized in the DRB."

#21: p.25, last paragraph: qualitative information is missing; beside the quantity of **FIPs** it should be said something about their quality, i.e., sound good quality SEA/EIA,

impact; with reference to Annex 7 we emphasize that the table is incomplete and that this status should be communicated by a respective footnote (suggestion, for example: „incorrect and/or incomplete information is in the responsibility of the countries"); from our knowledge and perspective, the following projects are missing:
- Kylia branch in Danube Delta, melioration of navigation (as part of the 15 Bystroe projects mentioned, but these need to be specified in the list)
- Drava HR hypower-project in Novo Virje
- Apele Romane plan to channelize St. Gheorghe Branch in the DD to increase sediment transport into the BS to combat coastal erosion
- Vah waterway project (European Waterway E81) with connection to Odra River!
- Sava project to improve navigation;

further the FIPs (in Annex 7) are not harmonized (e.g., Iron Gate sturgeon vs. ISPA 1, 2 and Kylia); in particular with regard to the basin wide dimension dependencies between FIPs should be stressed; apart from completion, a formal title (presently missing) and empty columns to be filled, this Annex needs an appropriate interpretation; after revision of the Annex, the figures given on p. 25 bottom must be corrected accordingly (e.g., if the Danube River incl. Delta is considered and the FIPs of ISPA and Kylia are respected, the now given number of 19 FIPs is far too small);

#22: p.26: chapter 2.1.5. Other issues: according to the importance of sediments and neozoans, we strongly suggest to give them separate chapter numbers and discard "other issues" as subtitle; i.e.: 2.1.5 Sediments, 2.1.6 Neozoans (as climate change is also an important topic, we recommend to insert a new sub-chapter "2.1.7. Climate change", and to transfer your chapter 8 to here); further, it is a bit odd to have Annex 8 with short text, and we suggest to transfer all Annex 8 text into chapter 2.1.5, to make reading easier; the text in Annex 8 is comprehensive, but we miss the items "natural grain size shaping along the rivers course" and "colmation/clogging" of gravel beds by fine particle sedimentation in impoundments"; we also recommend to mention the effect of fine suspended sediments to the biota, such as reduction of light penetration, which diminishes photosynthetis of algae and macrophytes; clogging the filtration systems of filter feeders (zooplankton, benthos), damage to fish-gills (particularly during uncontrolled flushing of reservoirs) or impairment of amphibian and fish eggs; the general effect is a cascading decline of biodiversity along the whole food web;

#23: p.26, **erosion & deposition**: say something about where dredged material is used or deposited, and that dredging/excavation enhance river bed incision and lower the water table (refer to groundwater chapter);

#24: p.27, sediment quality: we recommend to introduce one sentence related to the physical properties and impact on biota, such as: "Special emphasis should be given to sediment grain size (fine suspended sediments) investigation with regard to adsorption capacity and impact on aquatic communities (e.g., by decreasing photosynthesis, impairing fish-gills and filter-feeders, clogging the interstitial that homes amphibian and fish eggs, subsequent reduction of biodiversity, etc.)."

#25: p.27, footnote: despite of some unclear points, at this moment, it is clear that sediments are a crucial component of "good ecological status" as they provide habitat for biota (benthos, fish, macrophytes) and can adsorb/store nutrients and hazardous/toxic substances like heavy metals and POPs; thus, they are an important part of the riverine ecosystem and reflect contamination, erosion, hymo (riparian zone) and affect GW by incision of river bed; therefore, this sentence should be: "Although **sediment issues clearly represent a DRBM SWMI**, the given recommendations may be modified later when they are incorporated into the JPM."; actually, we regret that this cannot be incorporated now in the JPM, and it is also odd with regard to the structure of the Report, to have (preliminary) measures in chapter 2 "Identified Pressures"; so, we finally recommend to move preliminary measures suggested into chapter 7 (JPM);

#26: p.27, chapter 2.1.5.2: According to #22, this should be chapter 2.1.6; we recommend to change slightly the title into **"Invasive alien species (neozoa, neophyta) ..."** as CBD, IUCN, DAISIE, etc officially use IAS, and "neozoa, neophyta" is the commonly used scientific term; according to the international literature, invasive species have proved to be a serious threat to native communities; if they spread extensively they become a nuisance to humans and have negative impact on economy; therefore, they are **certainly "an important pressure"** and not "a possible pressure"; see p.71, grey box upper part, where you state "... is represented with all native species"; this is also documented in the most recent source: the book "Rivers of Europe" edited by Tockner, Robinson and Uehlinger and published by Wiley in spring 2009 (chapter 3: The Danube River Basin, p.75);
although many stakeholders are not aware yet about this threat, worldwide it is considered as the second major cause of biodiversity decline (Millennium Ecosystem Assessment MEA 2005), triggering also important economic loss; therefore we recommend to insert a brief introduction about what invasive species means and what is their impact (text suggested is in *ANNEX 1a* attached); we also supply the table of worst invasive species in the DRB (according to FP6 project DAISIE), which may be attached to the DRBMP (see *ANNEX 1b* attached);

#27: p.28, bottom of Table 8: The four **coastal water bodies** should be designated, may be by a footnote (see also p.42 top, p.44 bottom, p.82);

#28: p.29, **groundwater:** since in all other issues the size of waters is the limit to this Part A Roof Level (which makes sense and is correct), it cannot be understood why for GW only trans-boundary GW areas are considered of basin wide importance; this offends clearly the catchment approach, because also large national GW areas have the same important role in the lateral and vertical connection of surface waters; if this cannot be corrected/included in the DRBMP due to limited time, at least you should give an explanation for this unsuitable selection; it should also be emphasized that GW bodies are more than nutrient (N) sensitive areas as they are mainly used for drinking water supply; therefore, any contamination above the threshold levels for drinking waters with hazardous substances, organic and nitrogen compounds, and bacteria is of crucial importance for humans and must be prevented/mitigated at best;

#29: p.29, chapter 2.3.1: missing or poor **GW protection zones** (an act of national legislation, see e.g. Swiss Federal Law for Water Protection: three different zones with specified and limited land use according to GW protection) could also be another reason for GW pollution; we recommend to mention it here and stipulate it as important measure for protection (precaution principle, p.83);

#30: p.30, chapter 2.3.2: also river bed incision enhanced by **gravel exploitation** and dredging should be mentioned as factors affecting GW quantity; also, the role of floodplains connected to GW should be explicitly mentioned, as they are an important link between surface and GW (water retention capacity);

#31: p.30: we recommend to write a small informative chapter on "GW ecology" about the **phreatic fauna**; although this is not an issue of WFD and hence not explicitly required, this would demonstrate the orientation of DRBMP towards "good ecological status";

#32: p.31-32, Table 9: we recommend to give a definition of „good“ and „poor“ GW status in the footnotes;

#33: p.33, chapter 3: Although it is done according to WFD requirements, this chapter on **„protected areas in the DRB“** seems rather „thin“; it needs some statements about integration to DRBMP; we highly recommend to substantiate this chapter, e.g., by elucidating the legal meaning of protection, the difficulties to implement protection as pressures are strong and usually with large economy behind; again, quality counts as well as quantity;

#34: p.35, chapter 4.1.1, lines 8-9: **quality control (ring-tests)** have been performed and are reported; however, no results of these tests are given: how is the congruence of the output? Were these controls satisfactory or did they reveal major problems? it is not sufficient to mention that the quality control are done; the general result/outcome should be briefly outlined;

#35: p.36, line 4: footnote number should be 55 instead of 57;

#36: p.36, footnote 56: "crayfish" is most likely not the right name in this context, as crayfish are not macro-benthos; should be replaced by "the amphipod Gammarus shrimp" or simply "Gammarus" (often misused term is "common freshwater shrimp"); or you can add to "amphipod Gammarus" "and the isopod Asellus";

#37: p.37-38, Figures 17+18: the term "plausible results" seems to be unclear and not a scientific criterion; should be replaced by "results conform with WFD" or the like;

#38: p.39: As we have discussed in Bratislava, the issue of **HMWBs** is quite complex and difficult to handle, as the WFD is not a priori clear; the crucial questions of how HMWBs are finally designated and how is EP **Ecological Potential** defined? should be addressed and elucidated in more detail to make the intentions of ICPDR clear; we recommend to describe briefly the criteria of definitions (as given by WFD, but may be specifically modified) and also to provide a time frame (e.g., sub-chapter 4.1.4., first item); it should be made clear the reference state is not relevant in this context; the obvious discrepancy between ICPDR and RO judgment and classification of the Green Corridor and DD (see p.34ff, 41, 78) needs to be explained, if RO is not willing to adjust to ICPDR; it cannot be understood that all RO wetlands should be exemptions, and we specifically refer to the ongoing project "Lower Danube" performed by the DDNIRD in Tulcea; we also recommend to specify explicitly how to promote restoration measures to achieve GEP (cost-effective, deadline);

#39: p.44, chapter "Ecological and chemical status of Lakes and Transitional Waters": there is some mistake in these figures (5 lakes ... 3 lakes ... 3 lakes);

#40: p.47, chapter 4.2.3.1: the reported GW quality has remarkably good status; this may need a special explanation, as pressures are quite strong; you may consider, in data interpretation, the depth of sampling as well as the degree of aquifer redox potential.

#41: p. 48, chapter 5 – 5.1.: we suggest to add a short introduction about general **management objectives and ecosystem services**, as they are increasingly gaining importance and recognition (suggestion of text, see *ANNEX 2* attached); the current 5.1. would become 5.2 with possible title "WFD environmental objectives";

#42: p.50: chapter 6, economy: "characteristics of water services" does not mention the **ecosystem services**; although they are not explicitly mentioned in WFD, these should be mentioned as they are of growing importance in the water sector; they include, e.g., "nutrient retention, flood mitigation, seed dissemination, habitats for biota"; further, we highly recommend to mention the issue of value and valuing ecosystem services (vs. the price of goods), and to reflect the fact that costs of engineering constructions plus later restoration costs may be much higher state-expenses as conservation strategies (see also #33: protected areas); e.g., flood protection is good investment; we basically can learn a lot from previous mistakes in that respect!

#43: p.51, line 5: referring to #8, we recommend to change the sentence into: "N and P removal is now also being applied ...", i.e., to delete "Tertiary treatment";

#44: p.55 first line: it is well recognized that the DRBMP seeks for mitigating P and N load in the Danube River to fight BS eutrophication; however, it should be mentioned in a footnote that it is presently **not known/clear whether P or N is limiting** factor for primary production; see also your statement on p.86 (top); to answer this question, algal bioassays are recommended (as done in the 1960s-1970s to prove that P is limiting algal growth in most freshwater systems);

#45: p.55: As discussed in Bratislava, we highly recommend to change the text about the low **efficiency of WWTPs** (75%); we accept if there is some legal EU figure or terminology from 1991 that needs to be mentioned; but we consider it as not in the sense of WFD to state these outdated figures as goal to be reached by 2015 or later, as BAT can achieve technically much better efficiency; our suggestion is, to apply generally the widely recognized BAT strategy (as used for other issues in the DRBMP, e.g., p.57 for IPPC Directive) and to give the WWTP efficiency normally achieved by standard technology, which is 85-90% for BOD-, N- and P-removal since the 1970s (as commonly used BAT); it should be mentioned, in this context, that newest updated BAT can remove BOD by 95%, N by >90% and P by 98%, but this is applied only in specific situations and the cost-benefit ratio may become suboptimum; in the DRBMP the common BAT-efficiencies should be demanded, and you should state in a footnote that these replace the legal demand of EU in 1991; by this, ICPDR is documenting that they are pursuing the best available approach although it may need more time to reach these high goals; if ICPDR relates on outdated EU figures, they will have a big problem of credibility; finally, this issue has also a strong economic component: it would be apparent mismanagement to construct, with millions of Euros, technologically outdated WWTPs (to reach 75% efficiency) that clearly cannot match the EU water quality standards; hence, necessary restoration and improvement would generate a significant technological problem and would not be feasible in a cost effective way when compared to the proposed option;

#46: p.56, last paragraph: It is standard of WWT that **collecting systems and WWTP must be combined**; we recommend to change this statement accordingly and skip "recommended to be";

#47: p.57, figure 29: we recommend to give a hint in the legend "note the different scales of the y-axis", as this is crucial when comparing the two graphs;

#48: p.57, „Implementation of Sewage Sludge Directive“: We recommend to give a short abstract of the directive as this is most likely not common knowledge; in the whole paragraph there is nothing mentioned about **contaminated sludge**; this is an important part of WWTP technology and must be addressed; we recommend to include a paragraph about this issue: that sludge is normally contaminated with (toxic) chemicals and that it cannot be used (anymore) as P fertilizer in agriculture (however, newest BAT shows that P can be recycled of sludge and then be processed into clean P-fertilizer); therefore, it is considered as contaminated solid waste and must be treated accordingly, e.g., drained and burnt in special furnaces with air filters (as done e.g. in CH);

#49: p.57, same paragraph, 4th line: in accordance with #8, replace „(tertiary treatment with removal of nutrients)“ by „(removal of phosphorus)“, see also remark #43;

#50: p.57, „Implementation of the IPPC Directive“: We recommend to give a short abstract of the directive as this is most likely not common knowledge; in particular, it is of interest to exactly know what BAT means in the context of IPPC, and we recommend to express this in detail;

#51: p.58, sub-chapter „Recommendation on BAT at agro-industrial point sources“, line 9: specify „end-of-pipe measures“; we suspect it is „connection to WWTP“;

#52: p.61, section **„implementation of BAP“**, second paragraph: It is understood that acceptance by farmers counts, but nevertheless BAP and GFP must be regulated by national law in the agricultural sector as simple volunteering has never worked properly in the industrial/agricultural sector (it is a political illusion of neo-liberalists); we recommend to mention this point as it is crucial for a better implementation; further, the role and importance of erosion by agriculture should be mentioned;

#53: p.68, sub-chapter „phosphorus pollution“, second paragraph: the three figures 46.3, 15.5 and 23.5 should be correctly written with „point“ instead of „comma“;

#54: p.70, blue box **AEWS**: It is good that AEWS has been established in the DRB; however, it is recommended to shortly explain, may be in a footnote, how this early warning system is organized; an alert system on the top political level (e.g., through ministries of environment) is claimed to be non functional, as the information flux is too complicated and too slow; for example, multiple experience from accidental spills (e.g., the Baia Mare cyanide spill in 2000) shows clearly that an alert must be transfered on the technical level directly to the downstream facilities that can take immediate counter measures to mitigate the impact;

#55: p.70, paragraph below blue box: we are surprised of the very low number (97) of **contaminated sites** in the large DRB; this figure should be commented with regard to data quality and completeness; also, it should be referred to the toxic potential (i.e., „quality“) of these sites, and mentioned that there are numerous contaminated sites at the local level mainly threatening small rivers (that are, however, connected to the Danube); in a footnote, it should be noted that the local level cannot be treated in the scale of DRBMP, but nevertheless is an important issue with regard to contamination, as many small hot spots may negatively impact even the large Danube River;

#56: p.71, bottom sections, **construction of fish passes**: specifically here you should demand more, i.e., define or refer to BAT, functionality, monitoring (success control), technical improvement where necessary, implementation - and if this is not possible by 2015 (what we suspect) then you should give another deadline like 2021 or 2027 (see #15 p.21; p.74);

#57: p.72, Figure 37: you should give a reference, from where this figure has been adopted („from xxxxx, modified“); there are two printing mistakes: (a) on top it is „Flounder“ instead of the German „Flunder“; (b) in legend it is „rhitral“ instead of „rhithral“;

#58: p.73, blue box lower part: although you refer to Annex 17 for details, we recommend to explain more clearly, in a footnote, how PI is being calculated so as to make this figure more understandable;

#59: p.74, bottom: „...some migration barriers will not be restored at all...“: It is important to indicate which barriers fall in this category, and how the decision is made; considering the Iron Gate Case we are convinced that in larger barriers a **feasibility study** must be requested and performed as a sound basis for such decisions of significant consequences;

#60: p.81, blue box, second paragraph: It would be good to mention the role of NGOs in the process of elaboration and realization of the Joint Statement on inland navigation to show the cooperation with different stakeholders;

#61: p.81: although climate change and invasive species were not considered by WFD (issued in 2000, when these impacts were not so obvious), and to align the DRBMP to EC strategies ref. climate change and invasive species, two new sub-chapters should be added under "measures" (7.1.5. Climate change; 7.1.6. Invasive species); also measures to cope with the sediments (contamination, transport) should be shortly addressed, either within "hydromorphological alterations" or in an own sub-chapter; these chapters would refer to chapter 8 (8.2 + Annex 19) or the new chapter 2.1.7, and the sub-chapter in chapter 2 "significant pressures" (see #73 and #22, 26); it should be mentioned that these issues will be further developed by 2015;

#62: p.82: we recommend the introduction of a new sub-chapter **"7.3. Surface waters: wetlands"**, as wetlands role in maintaining good ecosystem health through the ecosystem services they provide is increasingly acknowledged (water purification, nutrient cycling, mitigation of flood/drought, etc); mention: the chapter will be detailed in the future (possibly 2015); text suggested is in *ANNEX 3* attached;

#63: p.83, bottom paragraph: you state that countries have **registers for GW use/ abstraction**, but no data are shown about quantity, i.e. (over-)exploitation; again: it is not sufficient to mention that registers do exist, you should provide information if the GW is sustainably used or not, and to request measures for it;

#64: p. 85-87, Chapter 7.5 "Preliminary key conclusions", last section "Other relevant issues": in line with our recommendations to give more weight to the topics climate change, invasive species, wetlands, ecosystem services and sediments (see #22, 25, 26, 41, 62, 73), we think it is not enough to say "More investigations are needed on the significance of other relevant issues ..."; this section should be substantiated with at least one paragraph per topic;

#65: p.86, "river and habitat continuity interruption", second item: you should indicate here which are the "defined ecological priority river stretches";

#66: p.87, chapter 8.1, last paragraph, bottom: to our understanding and as e.g. generally approved and applied by Water Authorities in Switzerland, the AP sets a wrong **sequence of actions**; we highly recommend to change this sequence of priority into:

1. prevention, 2. (if 1 is not feasible) mitigation (here "reverse"), and 3. (if 1 and 2 are not feasible) compensation;

#67: p.89, chapter 8.2.1., last item: it is not clear what you mean by "no regret measure";

#68: maps 19-22 are overloaded such as you should provide an annex table to present site specific information that is needed if one is to compare different situations;

Some comments to DRBMP Annexes

#69: An. 7: List of FIPs – title missing; a column with current number will help to identify easier the projects; columns 2,3 – need completion with river and project names; projects missing (see list under item #21);

#70: An. 8: we refer to the comment given under item #22 with regard to contents and structure of report;

#71: An. 13: incomplete title;

#72: An.18: we basically agree with the step-by-step approach; at the beginning of this Annex it should be emphasized that these measures are part of the Sturgeon Action Plan that is approved by the Bern Convention, which most of the Danube Countries have ratified (and therefore, is legally binding); it also should be pointed out in a brief abstract that and why sturgeons are near to extinction and threats are not only dams, but other pressures such as overexploitation, caviar trade, poaching, habitat alteration, pollution, etc; further, it must be stressed that, according to the natural life cycle, various measures for sturgeon protection must be linked together and harmonized. For example, the approach to support their migration and open new spawning sites upstream of the Iron Gate dams should be harmonized with the FIPs in the Lower Danube (e.g., the projects to meliorate navigation in the Green Corridor "ISPA 1 and 2 Projects", and Kylia branch Project in the Danube Delta).

We also suggest to add some information about further supporting actions, such as:

- the Romanian 10-year ban of sturgeon catch since 2006; this unilateral measure needs to be extended to the Black Sea Basin and supported by the neighboring countries (Serbia, Bulgaria, Ukraine, Russia, Georgia, Turkey) as well, and implementation should be coordinated (we refer to the principle of solidarity, see general comment);
- the planned and ongoing FIPs must respect the sturgeons life-schedule (see *ANNEX 4* attached) and habitat requirements by establishing sound and scientifically based EIAs;
- cooperation with Black Sea and Danube Commissions are required;
- *sensu* sustainable development, no new dams (to disrupt sturgeon migration) nor any new hydromorphological alterations (to destroy actual and potential spawning sites) can be accepted.

#73: An. 19: besides the completion for part 1, the list of climate change projects should be completed with GLOWA-Danube (www.glowa-danube.de);

as recommended in #61, we suggest to substantiate the contents of Annex 19, chapter 1 by some more specific DRB relevant information that you could extract from our proposed text (see *ANNEX 5* attached); specifically, we think that the last paragraph of chapter 1 (“In summary, ...”) is quite “blue eyed” and not reflecting the real situation; we recommend to say something about how global politics copes with climate change (i.e., the well known greenhouse-gas debate and climate conferences Rio 1991 and follow-up conferences); a paradigm change is still needed to fight the causes instead of the effects, and presently, most solutions proposed are end-of-pipe solutions which cannot solve this global problem.

List of annexes prepared and provided by IAD:

- ANNEX 1a – Invasive alien species (2.1.6)
- ANNEX 1b – Worst IAS in DRB (2.1.6)
- ANNEX 2 – Ecosystem services (5.1)
- ANNEX 3 – Wetlands (7.3)
- ANNEX 4 – Sturgeons life-schedule in Danube River (An. 18)
- ANNEX 5 – Climate change (2.1.7 or your 8.2 + An. 19)

ANNEX 1a

Sub-chapter 2.1.6. Invasive alien species (neophyta, neozoa)

According to CBD (Convention on Biological Diversity) definition, „invasive alien species (IAS) are species whose introduction and/or spread outside their natural past or present distribution threaten biological diversity". (http://www.cbd.int/invasive/WhatAreIAS.shtml).

IAS occur in all taxonomic groups, including animals, plants, fungi and microorganisms, and can affect all types of ecosystems. Common characteristics of IAS include rapid reproduction and growth, high dispersal ability, phenotypic plasticity (ability to adapt physiologically to new conditions), and ability to survive on various food types and in a wide range of environmental conditions.

IAS are a major threat as they can: (http://www.cbd.int/invasive)

- produce substantial environmental and economic damage, their negative effects being exacerbated by climate change, pollution, habitat loss and human-induced disturbance;
- change the community structure and species composition of native ecosystems directly by out-competing indigenous species for resources;
- have important indirect effects through changes in nutrient cycling, ecosystem function and ecological relationships between native species;
- cause cascading effects with other organisms;
- alter the evolutionary pathway of native species by competitive exclusion, niche displacement, hybridization predation, and ultimately extinction. IAS themselves may evolve due to interactions with native species and with their new environment;
- directly affect human health: infectious diseases are often IAS imported by travelers or vectored by exotic species of birds, rodents and insects. IAS also have indirect health effects on humans as a result of the use of pesticides and herbicides, which infiltrate water and soil.

The sum of effects of multiple invasive species can have larger/complex impacts in an ecosystem;

Ecosystems that have been invaded by alien species may not have the natural predators and competitors present in its native environment that would normally control their populations. Native ecosystems that have undergone human-induced disturbance are often more prone to alien invasions because there is less competition from native species.

According to the investigations carried out in the FP6 project DAISIE (Delivering Alien Invasive Species Inventories for Europe) over 11,000 invasive species have already invaded Europe (http://www.europe-aliens.org/). The inventory of the worst 100 species revealed that in the DRB and Black Sea region there are 38 species living in or related to aquatic environment (Annex A), most of the established populations spreading rapidly to other regions.

Besides the decline of biodiversity, the economic consequences are dramatic: only in the European Union, the economic loss triggered by invasive species amounts to EUR 12.7 billion/yr (EC, 2008). Therefore, the conclusions of the European Council during the "Mid-term assessment of implementing the EU Biodiversity Action Plan and Towards an EU Strategy on Invasive Alien Species" of 25 June 2009, pointed out towards the urgent need for an EU strategy on invasive alien species (http://ec.europa.eu/environment/nature/pdf/council_concl_0609.pdf).

References

EC [European Commission], 2008. Towards an EU strategy on invasive species. Impact assessment.

Annex to the Communication from the Commission to the Council, the European Parliament, the European Economic and SocialCommittee and the committee of the regions, 68 pp.

ANNEX 1b

The worst invasive alien species in Danube River Basin and Black Sea region (related to aquatic environment)

(Source: European Project DAISIE, http://www.europe-aliens.org)

	Scientific name	Common name	Brief description	Impact	Distribution
	Aquatic inland species				
1.	*Anguillicola crassus*	Eel swim-bladder nematode	A parasite nematode, with intermediate host in arthropods and final stage in the European eel (Anguilla anguilla) and American eel (A. rostrata). Larval stages usually occur in freshwater, but can also tolerate brackish water.	Adults feed on blood supplied to the swimbladder wall and can induce eel mortality; may contribute to the decline of the North Atlantic eel stock because eels may not reach spawning areas due to damaged swimbladders	From Scandinavian Peninsula to the Southern part of Europe
2.	*Aphanomyces astaci*	Crayfish plague	A pseudofungus, aetiologic agent of crafish plague, an acute disease who created problems only in Europe, not in the native range in North America	Native European crayfish were almost totally destroyed by the very aggressive pathogen	Almost all Europe, except the Southern part
3.	*Corbicula fluminea*	Asian clam	Filter feeding bivalve with a globular shell; in Europe there are two subspecies: *C. fluminea* and *C. fluminalis*, the latter occurring in river mouths with small variations in salinity. Intolerant to low oxygen level and high nutrient loads.	Competes with other filter feeding bivalves (unionids) and with snails feeding on organics in sediments. Capable of reducing flows in drainage and abstraction pipes in low-flow areas and during periods of low peak usage. Shells can clog the narrow pipes of power plants	Western, Central and Eastern Europe
4.	*Crassula helmsii*	New Zealand pigmyweed, Australian stonecrop	Perennial macrophyte that grows rapidly and forms an extensive “carpet” that flows on freshwater or may be submerged; inhabits acidic to alkaline, nutrient rich waterbodies	Shade-out other water plants, leading to oxygen depletion, impacting invertebrates, amphibians and fish	Western, Central and South-Western Europe
5.	*Dikerogammarus villosus*	Killer shrimp	Omnivorous predator, feeding on different macroinvertebrates, exhibiting high ecological plasticity; can occupy every substratum except sand; the species is present in areas with low current velocity.	Negative impact on resident invertebrates; eliminates other gammarids through competition and predation; might consume fish eggs	Central Europe and along Danube River
6.	*Dreissena polymorpha*	Zebra mussel	Sesile bivalve mollusk, forming dense colonies on various hard substrates in fresh and slightly brackish waters; filter feeder on microscopic plankton organisms	Competes for food/space with native mussels; can cause severe habitat alterations; bioaccumulates pollutants; represents a food source for birds and	Almost all Europe except the North and the Southern part of Spain, Italy and

			and organic particles	benthophagous fish. Negative economic impacts: pipes clogging, fouling of cages in aquaculture, navigation (fouling ships and constructions)	Balkan Peninsula
7.	*Elodea canadensis*	Canadian pondweed	Macrophyte which tends to form dense stands on hundreds of acres	Competes for nutrients/space with other aquatic plants; can bioaccumulate nutrients and alter the habitat by reducing water movement. During blooming may impair boating, fishing, swimming and water skiing. Can clog water intake pipes of power plants and other industries	North and Central European countries
8.	*Eriocheir sinensis*	Chinese mitten crab	Omnivorous predator, feeding on plants, invertebrates, fish, detritus; dominant food components: gastropods and bivalves. Tolerant to changes of water temperatures and salinity, low oxygen content and air exposure.	Compete for food/space, especially during mass development; damage fish nets eating the fish caught inside. The burrowing activities of crabs increase erosion of dikes and lake embankments. They can also clog up industrial water intake filters during mass occurrences.	North and Baltic Seas countries, the Atlantic seaboard of Europe and in the Mediterranean and Black Seas.
9.	*Gyrodactylus salaris*	Salmon fluke	Worm parasite which attaches to the outer body and gills of fish from salmon family. Due to its presence, heavy infections can occur on the body and caudal fin.	Significant mortality of young salmon in river catchments	Baltic countries, Northern part of DRB
10.	*Procambarus clarkii*	Red swamp or Louisiana crayfish	Crayfish with body length up to 15 cm; due to its size and adaptations, outcompete the native European species. Adult individuals mainly feed on plants and detritus, while juveniles consume a higher proportion of animal food.	It has contributed to the decline of the native European crayfish (Astacidae fam.) because it outcompetes them and acts as a vector for the transmission of the crayfish fungus plague, *Aphanomyces astaci*; reduces the value of invaded freshwater habitats by consuming invertebrates and macrophytes and by degrading riverbanks due to its burrowing activity. It accumulates heavy metals and toxins produced by Cyanobacteria (e.g. *Microcystis aeruginosa)* and can transfer them to humans; intermediate host of trematodes of the genus *Paragonimus*, which are potential pathogens of humans if undercooked crayfish are consumed.	Southern, Central and Western Europe

11.	*Pseudorasbora parva*	Stone moroko, toupmouth gudgeon	Zooplanktivorous fish, inhabiting shallow lakes, carp ponds, irrigation canals, ditches and slow sections of lowland rivers	It feeds on juvenile stages of native fish species; vector of infectious diseases (including *Spherotecum destruens*), constituting a serious threat to native and farmed fish in Europe. In Southern Europe it has probably contributed to the decline of some autochthonous cyprinids such as *Scardinius erythrophthalmus, Carassius carassius, Rhodeus sericeus, Gobio gobio* and *Leucaspius delineatus*. In ponds, during mass occurrence, it depletes the food supplies of farmed species like carps.	Almost all Europe
12.	*Salvelinus fontinalis*	Brook trout, sea trout	Salmonid predatory fish, feeding on amphibians, zooplankton and other invertebrates	Competes with and predates on native fish, such as other salmonids, for food and space. In oligotrophic mountain lakes, brook trout alter nutrient cycles and stimulate primary production by accessing benthic sources of phosphorus; it hybridizes with the native brown trout, of which some hybrids are fertile.	Almost all Europe, from Spain to Norway
	Marine species				
13.	*Balanus improvisus*	Bay barnacle	Sessile crustacean, occurring in marine and brackish environments	Filter feeder on detritus and phytoplankton; competes with native species for food/space; habitat alteration, fouling blue mussels and oysters. Fouling of pipes and underwater constructions.	Atlantic coast of Europe, Baltic and Black Seas
14.	*Crassostrea gigas*	Pacific giant oyster	Filter-feeding oyster, consuming phytoplankton and detritus in coastal, brackish and marine waters	Competing with native biota for space/food; source of several cryptic diseases, oyster pests and other species. Toxic algal blooms can contaminate oysters, leading to diseases in humans if consumed. In tourist areas wild settlements can lacerate bathers' feet.	Atlantic coast of Europe, Mediterranean and N Black Sea
15.	*Ficopomatus enigmatus*	Tube worm	Small worm, forming concretions with their calcareous tubes; seston feeders, usually occurring in estuaries and lagoons	Can form extensive reefs that may provide refuge for invertebrates including snails and crabs, with impact on native species communities. Their dense tube colonies attach to abstraction pipes, reducing water	N European, Caspian, Mediterranean, Black Seas

				flow and causing blockages. Foul surfaces in aquaculture ponds and ports. Areas with thermal effluents can develop large colonies.	
16.	*Mnemiopsis leidyi*	Sea walnut, comb jelly	A comb jelly feeding on plankton, fish eggs, benthic and fish larvae	Dramatic reductions in zooplankton, ichthyoplankton, and zooplanktivorous fish populations. Cascading effects: collapse of planktivorous fish, decline of dolphins in the Black Sea and seals in the Caspian Sea. Significant economic losses for the Black and Caspian Seas coastal countries due to drastic decline in pelagic fish catch (estimated to hundreds of million dollars in the case of Black Sea).	Azov, Black, Caspian, Baltic, North Sea and N-E parts of Mediterranean Seas.
17.	*Rapana venosa*	Asian rapa whelk	A large marine and brackish water Asian gastropod with voracious predatory behaviour. Individuals caught in Adriatic Sea reached up to 137 mm length and 554 g total weight. In Black Sea it shows tolerance to water pollution and low oxygen conditions	Areas with substantial oyster cultures may be at risk once the gastropod becomes established and occurs in high densities. The ecological impacts in the Black Sea have been severe. *R. venosa* predation was identified as the key reason for the decline of the commercially fished *Mytilus galloprovincialis* population in Bulgarian waters, Kerch Strait and Caucasian shelf	Black Sea, Azov, Marmara, Aegean, Adriatic, Tyrrhenian Seas and Brittany; recently, mentioned in North Sea.
	Terrestrial plants connected with aquatic habitats				
18.	*Acacia dealbata*	Silver wattle, blue wattle	Fast growing tree, up to 30 m height, occurring on coastal dunes and sand habitats, littoral zone of inland surface waterbodies, woodland and forest habitats, etc.; prefers moist soils, especially riparian areas	Can form dense stands that suppress the development of other species; allelopathic properties; fixes atmospheric N and increase N soil content; dense tickets disrupt water flow and increase erosion along stream banks. Increasing invasion after fire or in disturbed areas	France, Portugal, Spain, Italy, N and S coasts of Black Sea
19.	*Ambrosia artemisiifolia*	Common ragweed, Roman wormwood	One of the most allergenic plant species, growing along riverbanks, roadsides, cultivated fields. The plant establishes itself in freshly moved soil and disturbed areas; prefers nutrient rich bare soils with neutral or acid pH; resistant to high summer temperatures, drought and	Poor competitor, colonises plant community at early successional stages; highly allergenic, prime cause of hay fever. During the pollen release period, causes rhino-conjunctivitis, asthma and more rarely contact dermatitis and urticaria. In colonized areas, rapidly	Western, Central and Eastern Europe

			moderate soil salinity	becomes the main allergenic species.	
20.	*Campylopus introflexus*	Heath star moss	The rapidly spreading moss can regenerate vegetatively from fragments of leaves; successful pioneer species, colonizes recently burned or disturbed areas. Inhabits coastal dunes and sandy areas, raised and blanket bogs, waste deposits and other anthropogenic ecosystems. It thrives best in acid conditions with moderately high nutrient levels (e.g. areas which suffer from atmospheric pollution)	It can replace much of the ephemeral cover of native lichens, especially on dunes in exposed places. In north-central Europe, it has become problematic on sandy heaths dominated by *Cladonia* lichens and grey hair grass (*Corynephorus canescens*). Invasions do not slow the rate of succession, and although heather seedlings germinate less well than on bare ground, they grow better once established.	North-western oceanic parts of Europe, including remote islands; very abundant on North Sea and German Baltic coasts
21.	*Echinocystis lobata*	Wild cucumber	Fast growing plant, usually in floodplains and forest fringes.	Its branches are growing very fast, covering large areas and overgrowing native vegetation. Its spatial occupation competes with native species. The plant contains toxic substances (cucurbitacines)	Temperate and continental Europe
22.	*Fallopia japonica*	Japanese knotweed	Herbaceous perennial plant; prefers riparian areas. In Europe there are 3 subspecies: *Fallopia japonica* var. japonica, *F. sachalinensis* and their hybrid, *F. x bohemica*	Damages native riparian communities by reducing light availability, alteration of the soil environment and release of allelochemicals. Decreases soil bulk density and increases organic matter content, water content and nutrient levels. Impacts other trophic levels: the biomass of green frog *Rana clamitans* was found to be negatively related to *F. japonica* cover. Prolific rhizome and shoot growth can damage foundations, walls, pavements, and drainage works, causing also flood hazards by increasing resistance to water flow and damaging flood prevention structures. Represents an excellent food source for honeybees.	Most European countries
23.	*Impatiens glandulifera*	Himalayan balsam	A green vascular annual plant up to 2.5m tall; usually grows in riparian habitats and in other disturbed places with good water and nutrient supply, but inhabits also artificial waterbodies	Reduce the diversity of invaded communities, especially widespread weed or non-native species. When becomes dominant in riparian vegetation, due to its modest root system can promote erosion, especially when compare with native dominants of these communities, such as	Almost all temperate European countries

				Urtica dioica	
24.	*Oxalis pes-caprae*	Sour grass	Perennial herb, forming large clonal colonies, abundant in cultivated areas but also occurring in littoral zone of inland surface waters and artificial waterbodies	Can suppress other ruderal weedy species; the leaves contain toxic oxalates, being dangerous for livestock.	S Europe; in DRB occurs in Czech Rep.
25.	*Paspalum paspaloides*	Knotgrass, mercer grass, water couch	Stoloniferous perennial herb adapted to marshy, brackish conditions and saline soils, which are moist in summer	Dense populations can cover large surfaces in short time, competing successfully with other weeds. Harmful weed in rice fields. Sometimes can block irrigation ditches.	Western and Eastern Europe
26.	*Rhododendron ponticum*	Rhododendron	Evergreen shrub, growing up to 5 m, typical for mixed deciduous forests, temperate heaths, raised and blanket bogs	After its invasion, few native plants survive. In woodlands, only the trees growing above its canopy will persist; toxic potential as it contains “free” phenols and diterpenes	Native in Southern part of Black Sea; naturalized in United Kingdom, Ireland, Belgium, France and Netherlands; present in Austria
27.	*Robinia pseudoacacia*	Black locust, false acacia	This tree can reach up to 30 m. N-fixing species, can colonize acidic or polluted soils; grows next to surface running waters, grasslands, etc.	Rapidly expanding, competing with native species for pollinators. The robinine contained in flowers and seeds are toxic to humans and provoke gastroenteritis. Good fodder for cattle and deer; horses are more sensitive to the toxic substances. It may have considerable economic impact in the future, as it is suitable for planting as a biomass fuel	Almost all Europe
28.	*Rosa rugosa*	Japanese rose	Small sprouting shrub, forming dense tickets mainly in coastal habitats and sandy areas; can colonize acidic and basic soils alike and invade nutrient-poor habitats	Once invaded, dune plant communities are altered to monospecific stands, with greatly reduced light availability and decreased number of native species. It controls erosion on shores and riverbanks	Widespread at the coasts of the North and Baltic Sea and Northwest-European Atlantic coasts. In Central and Eastern Europe, it is rather rare and only locally established
	Terrestrial invertebrates and vertebrates related to aquatic ecosystems				
29.	*Aedes albopictus*	Asian tiger mosquito	Adults are active during daytime; blood-feeders on human, mammals, birds,	Interspecific larval competition results in displacement of native mosquito species	Western and Southern Europe

			amphibians and reptiles. Mostly antropophilic species, able to use any type of water container for breeding; can colonize waste deposits	(*Culex pipiens*) and other invasive mosquito species (*Aedes aegypti*). Biting nuisance (diurnal biter); potential vector for at least 22 arboviruses (including dengue, West Nile virus, Japanese Encephalitis, Eastern equine Encephalitis), avian plasmodia and dog heartworm filariasis (*Dirofilaria* nematodes).	
30.	*Branta canadensis*	Canadian goose	Omnivorous bird, feeding mostly on plant parts, rhizomes, stems, leaves, seeds and fruit; spread in coastal habitats and inland surface waters (avoid rivers and deep oligotrophic lakes)	Hybridizes with 16 *Anatidae* species in captivity; potential for hybridization with other goose species such as *Anser anser* (Greylag Goose). Competition with Greylag Goose. Very aggressive to small waterfowl such as *Gallinula chloropus* and *Fulica atra*, displacing territory and killing young and adults. Some benefit to dabbling ducks, which steal floating vegetation from submergent vegetation dislodged by Canada Geese during feeding. Induce habitat alteration such as trampling and algal blooms from eutrophication caused by released nutrients. It is also a minor feeder on crops	Established in north-central Europe from Belgium east to Russia. Introduced in other seven central and southern Europe countries such as Austria, Italy, Poland, Czech Republic and Switzerland
31.	*Lithobates catesbeianus*	American bullfrog	The largest N-American ranid; in Europe, adults may exceed 195 mm snout-vent length. Feeds on amphibians, fish, small mammals and birds species, molluscs, crustaceans, insects. It occupies any type of habitat that is lentic or with slowly moving water, especially if aquatic and bank vegetation are abundant	Where introduced, it has the ability to occupy a whole range of habitats and to feed on many species. A negative impact on native ranids has been notably stressed. Carrier of an emerging pathogenic fungus, *Batrachochytrium dendrobatidis*, which has been implicated in global amphibian decline.	Introduced in Germany, Italy, United Kingdom, Spain, the Netherlands, Greece, Belgium and France
32.	*Mustela vison*	American mink	Small semi-aquatic carnivore living in freshwater and marine habitats; opportunistic predator with a variable diet that includes aquatic, semi-aquatic and terrestrial prey	Negative impact on ground nesting birds (e.g. Larus *ridibundus*, *Sterna hirundo*) and small mammals (e.g. *Arvicola terrestris*). Compete with the European mink (*Mustela lutreola*) by aggression. Might be vector of Aleutian disease. Can inflict damage to free ranging chickens,	Former Soviet Union, France, UK, Germany, Poland, Slovakia, Spain, Italy etc.

				reared game birds, fisheries (salmon farming) and the eco-tourist industry. Germany estimates the costs of impacts to € 4.2 mio.	
33.	*Myocastor coypus*	Nutria	Large semi-aquatic rodent living along rivers, lakes and marshes. It is herbivorous except for occasional feeding on mussels. High adaptability, inhabiting different freshwaters but also drainage canals	Severe impact on wetlands through feeding on aquatic vegetation. Selective feeding caused massive reduction in reedswamp areas and eliminated plants of *Rumex* spp. and *Nuphar lutea* over large areas. It destroys nests and preys on eggs of several aquatic birds, including some endangered species.	Western, Central and Eastern Europe
34.	*Nyctereutes procyonoides*	Racoon dog	Omnivorous carnivore, the only canid with winter lethargy; inhabits coastal areas, littoral zones of inland surface waters, mires, bogs, fens, grasslands and woodlands, but also anthropogenic ecosystems	Predation on birds and amphibians with decreased nesting success and/or decreased population sizes. There may be competition for food and space with the raccoon (*Procyon lotor*), badger (*Meles meles*) or the red fox (*V. vulpes*). One of the main vectors of rabies in Europe and an important vector of sarcoptic mange, the fox tapeworm (*Echinococcuss multilocularis*) and trichinellosis	Eastern and Central Europe
35.	*Ondrata zibethicus*	Muskrat	Aquatic rodent, eating almost any aquatic vegetation and crops; feeds also on crayfish, mussels, fish, amphibians and reptiles in ponds with scarce vegetation	Strongly affects vegetation dynamics through grazing and threatens endemic species such as the desman (*Desmana moschata*); impacts shellfishes, fishes and ground nesting birds; endangered mussel populations are particularly impacted. They may carry Leptospira, causing Weil's disease in humans. Intermediate host for the cestode, *Echinococcus multilocularis* (infection rates up to 28% in wild populations). Burrowing can weaken riverbanks; extensive damage to crops, irrigation structures, railroads and dams; potential impact on aquaculture industry - in Germany it is estimated at € 12,4 mio/yr	Northern and Central Europe, Ukraine, Russia

36.	*Procyon lotor*	Racoon	Omnivorous carnivore, mostly nocturnal with excellent climbing and swimming ability; inhabits coastal areas, mires, bogs, fens, grasslands and woodlands, but also anthropogenic ecosystems.	Occasionally predate on birds (nests) and amphibians with resulting decreased nesting success and/or decreased population sizes. Due to the raccoon roundworm (*Baylisascaris procyonis*) there is a high potential of zoonosis for humans and its animal vectors. The *cerebral larva migrans* in humans caused by the raccoon roundworm can be lethal.	In Europe: France, Germany, Austria, Switzerland, Netherlands, Belgium, Luxembourg, Poland, Czech Republic, Slovakia, Hungary, Slovenia, Romania and Serbia.
37.	*Rattus norvegicus*	Norway rat, brown rat	Omnivorous and opportunistic terrestrial rodent; inhabits anthropogenic ecosystems, but also coastal areas, inland surface waters, mires, bogs and fens, grasslands and woodlands, etc.	Induce negative impact on small mammals, reptiles, marine and land bird populations; it has contributed to the disappearance of several insular marine bird populations (i.e. *Hydrobates pelagicus*). Serves as a reservoir and vector of *Leptospira interrogans* and as a reservoir of the Hepatitis E virus.	Almost all Europe
38.	*Trachemys scripta*	Common slider	Medium to large turtle, inhabiting inland freshwaters; prefers quiet habitats, with soft bottom and abundant aquatic vegetation. The diet of this opportunistic predator changes from highly carnivorous in juveniles to omnivorous in adults.	Feed on several species of plants and animals, from insects and other invertebrates to all vertebrates, including amphibians and reptiles, small mammals and birds. Compete with indigenous turtles, particularly with the endangered European pond turtle *Emys orbicularis*. May contribute to the spread of diseases and parasites that could affect native turtles and other aquatic wildlife. Considered a potential vector of Salmonella. Large specimens can inflict painful bites.	Occurs in many European countries, but apparently breeds only in Spain, France, Italy

5. ENVIRONMENTAL OBJECTIVES AND ECOSYSTEM SERVICES

5.1. Management objectives for the DRBD and ecosystem services

Nowadays, increasing anthropogenic pressures lead to a strong impact on the environment and, consequently, to a loss of support-services provided by the natural ecosystems. These, in turn, affected human well-being. For instance, due to water overexploitation and increased frequency of droughts, 17 % of the European territory was already confronted with water scarcity, the losses raising up to 100 billion Euro within the last three decades (EEA, 2009). Therefore, a holistic management at basin level should consider all the major threats and try to prevent the degradation of present resources, especially a water crisis in the DRB.

The main driver of changes in the water sector was the demographic evolution and the subsequent economic development triggered by the increasing population. This accelerated the industrial and agricultural development, the land use change (deforestation, wetlands conversion to agricultural fields), the overexploitation of natural resources, the introduction of alien invasive species, the hydromorphological alterations (dams, embankments, channelization, navigation), and recently, due to the increasing amounts of green-house gas (GHG) emissions, the climate change (Fig.1).

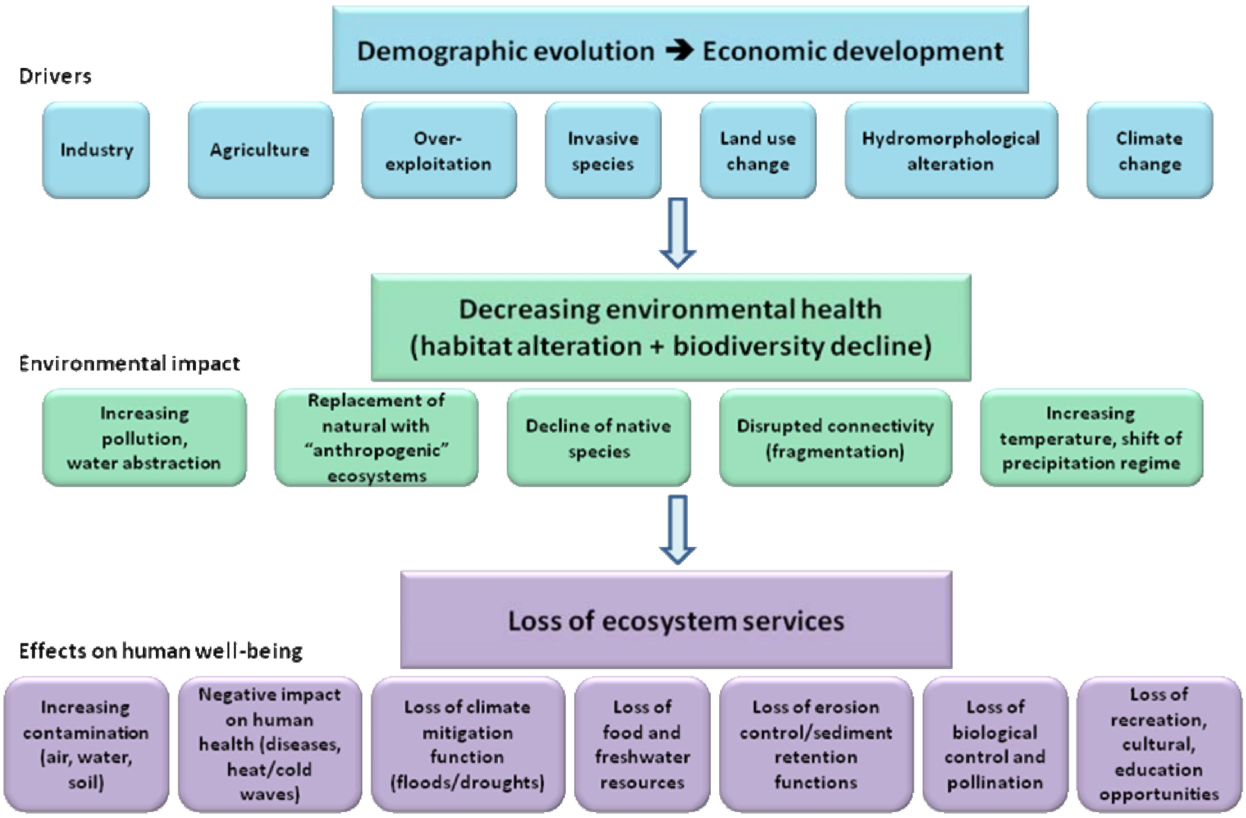

Fig. 1. Impact of ecosystem changes on human well-being
(blue - drivers of environmental changes, green – impact on the environment,
purple – impact on human well-being)
Compilation from De Groot et al.2002, MEA 2005, IPCC 2007b, 2008, EEA 2009

As a consequence of increasing industrial and agricultural emissions, the air, water and soil were polluted with an increasing amount of chemical compounds and negative impact on biological communities. Through land use changes, natural ecosystems were replaced by anthropogenic (man-made) ecosystems such as agricultural fields, urban areas, reservoirs, etc. The fragmentation of natural habitats and disruption of connectivity (lateral, longitudinal, vertical) lead to the loss of migration corridors and shelters, feeding, spawning habitats, affecting the whole food-web. The accidental or intentional introduction of alien invasive species lead to an increased competition for the existing resources (food and habitat) and usually to the decline of native species. A new threat emerged in the last decades: climate change that weakens even more the ecosystems across the globe. Elevated air and water temperatures, melting glaciers, sea level raising, shift of precipitation regime, increasing frequency of extreme weather events (floods/droughts), are only some of the major consequences.

All these synergic actions had a dramatic impact on ecosystems structure and functionality, leading to a marked loss of ecosystem services (i.e. benefits obtained from ecosystems) provided to human society. There are four categories of ecosystems services (MEA 2005): provisioning, regulating, supporting and cultural services. (1) Provisioning services refers to products obtained from ecosystems such as food (plants, vegetables, fish, game), raw materials (wood, oil, fossil fuel, organic matter, natural fertilizers), medicinal and ornamental resources (pharmaceuticals, drugs, ivory, orchids, butterflies, aquarium fish); (2) Regulating services include benefits obtained from the regulation of global processes such as atmospheric composition and climate, essential in e.g. maintaining air quality, a favorable climate or providing uv protection by the ozone layer; water regulation is important for flood/drought mitigation as many ecosystems serve as buffer areas during extreme hydrological events; biological control is important for providing pests and diseases control trough food-web relationships. (3) Supporting services are essential in the production of all the other ecosystem services – they include e.g. biomass production, production of atmospheric oxygen, waste purification, nutrient cycling, soil retention and formation, polination and seed dispersal, provision of habitat for human, natural and commercially harvested species etc. (4) Cultural services include the non-material benefits people obtain from ecosystems such as aesthetic, recreation, cultural, spiritual, historic, scientific, education, cognitive development, eco-tourism, outdoor sports, etc.

The current DRBMP offers the frame to adjust the water policies across the basin by considering the synergic action of the current drivers on water quality and quantity. Although at the moment mainly chemical pollution and hydromorphological alterations are considered, the adoption and implementation of adaptation/mitigation measures based on current trends recorded in the DRB may help to optimize costs of water management. Diminishing human impact on freshwater ecosystems during the sensitive periods, re-evaluating future infrastructure projects in light of the paradigm of the „integrated water resources management" and changing the concepts and management practices towards sustainability, will increase ecosystem health and, hence, human well-being.

5.2. WFD environmental objectives

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ANNEX 3

Sub-chapter **7.3 Surface waters: Wetlands**

According to Ramsar Convention on Wetlands, “wetlands are areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres” (www.ramsar.org).

Considered for centuries as low-use and nuisant areas, wetlands were drained, filled, embanked and converted to agricultural or construction land until their disappearance and the consequent loss of the ecosystem services they have provided (such as fish and game, water supply, climate regulation, flood mitigation, recreation and tourism) triggered highly negative consequences for human well-being.

Their degradation was determined by the increasing anthropogenic pressure: besides hydromorphological alterations (consisting in dams, embankments, channelization, hydropower plants, navigation), wetlands are subject to water withdrawal, pollution (with nutrients or xenobiotics), land use change (deforestation, conversion, increasing agricultural areas), global warming (increased evaporation rate, shift of precipitation regime, droughts), overexploitation, invasive species, etc.

Nowadays, the increasing evidence about the benefits they can provide due to their regulative, habitat, production and information functions, brought them into the attention of policy makers as a potential key to achieve a sustainable management of water resources.

According to the Millennium Ecosystem Assessment report (MEA, 2005) future management strategies should take into consideration that:

- when both the marketed and nonmarketed economic benefits of wetlands are included, the total economic value of unconverted wetlands is often greater than that of converted wetlands; a priority when making decisions that directly or indirectly influence wetlands is to ensure that information about the full range of benefits and values provided by different wetland ecosystem services is considered.
- the degradation and loss of wetlands is more rapid than that of other ecosystems; similarly, the status of both freshwater and coastal wetland species is deteriorating faster than those of other ecosystems.
- global climate change is expected to exacerbate the loss and degradation of many wetlands and the loss or decline of their species and to increase the incidence of vector-borne and waterborne diseases in many regions.
- excessive nutrient loading is expected to become a growing threat to aquatic ecosystems; growing pressures from multiple direct drivers increase the likelihood of potentially abrupt changes in wetland ecosystems, which can be large in magnitude and difficult, expensive, or impossible to reverse.
- the projected continued loss and degradation of wetlands will reduce the capacity of wetlands to mitigate impacts and result in further reduction in human well-being (including an increase in the prevalence of disease); at the same time, demand for many of these services (such as denitrification, flood and storm protection) will increase.
- physical and economic water scarcity and limited or reduced access to water are major challenges facing society and are key factors limiting economic development in many countries; however, many water resource developments undertaken to increase access to water have not given adequate consideration to harmful trade-offs with other services provided by wetlands.
- cross-sectoral and ecosystem-based approaches to wetland management—such as river (or lake or aquifer) basin-scale management, and integrated coastal zone management—that consider the trade-offs between different wetland ecosystem services are more likely to ensure sustainable development than many existing sectoral approaches and are critical in designing actions in support of the Millennium Development Goals.
- many of the responses designed with a primary focus on wetlands and water resources will not be sustainable or sufficient unless other indirect and direct drivers of change are addressed; these include actions to eliminate production subsidies, sustainably intensify agriculture, slow climate change, slow nutrient loading, encourage stakeholder participation, and increase transparency and accountability of government and private-sector decision-making.
- major policy decisions in the next decades will have to address trade-offs among current uses of wetland resources and between current and future uses. Particularly important trade-offs involve those between agricultural production and water quality, land use and biodiversity, water use and aquatic biodiversity, and current water use for irrigation and future agricultural production.
- the adverse effects of climate change, such as changes in hydrology and in the temperature of water bodies, will lead to a reduction in the services provided by wetlands.

- removing the existing pressures on wetlands and improving their resiliency is the most effective method of coping with the adverse effects of climate change. conserving, maintaining, or rehabilitating wetland ecosystems can be a viable element to an overall climate change mitigation strategy.

References:

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ANNEX 4

Migratory sturgeon sp.	Dates	January	February	March	April	May
Huso huso (beluga)	migration		starting t = 4-5 C			
	reproduction				t = 15-17 C	
	return					
Ac. stellatus (starry sturge	migration				max. in May, t = 8-11	
	reproduction				t = 8 - 15 C	
	return					
Ac.guldenstaedti	migration				max in April, t = 8-11 (	
(Danube sturgeon)	reproduction				similar Huso	
	return					

The environmental window: December - January, maximum extension: Nov - Feb.

Banarescu, P., 1964: Pisces - Osteichthyes. Ed. Academiei, 959 p.
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June	July	August	Septembe	October	November	December
				max in oct-nov.		
C						
C			max. migr.occur in autumn			
	similar Huso					

ANNEX 5

(2.1.7 + An.19) Climate change

The resilience of many ecosystems is likely to be exceeded this century by an unprecedented combination of climate change, associated disturbances (e.g., flooding, drought, wildfire, insects, ocean acidification), and other global change drivers (e.g., landuse change, pollution, over-exploitation of resources). Over the course of this century, net carbon uptake by terrestrial ecosystems is likely to peak before mid-century and then weaken or even reverse, thus amplifying climate change; approximately 20-30% of plant and animal species assessed so far are likely to be at increased risk of extinction if increases in global average temperature exceed 1.5-2.5°C (IPCC 2007a).
Climate change affects the function and operation of existing water infrastructure – including hydropower, structural flood defences, drainage and irrigation systems – as well as water management practices.
It can be expected that the paradigm of Integrated Water Resources Management will be increasingly followed around the world (United Nations, 2002; World Bank, 2003; World Water Council, 2006 quoted in IPCC 2007b), which will move water, as a resource and a habitat, into the centre of policy making. This is likely to decrease the vulnerability of freshwater systems to climate change (IPCC 2007, b). Consideration of environmental flow requirements may lead to modified reservoir operations so that the human use of the water resources might be restricted.
The sensitivity of Europe to climate change has a distinct north-south gradient, with many studies indicating that southern Europe will be more severely affected than northern Europe (EEA 2004). The already hot and semi-arid climate of southern Europe is expected to become warmer and drier, and this will threaten its waterways, agricultural production and timber harvests (EEA 2004, 2009). Nevertheless, northern countries are also sensitive to climate change.

A. Impact of climate change on European freshwaters

A.1. Current trends

Climatic drivers
The warming trend throughout Europe is well established (+0.90°C for 1901 to 2005) ; however, the recent period shows a trend considerably higher than the mean trend (+0.41°C/decade for the period 1979 to 2005), with higher trends in central and north-eastern Europe and in mountainous regions, and lower in the Mediterranean region. Temperatures are increasing more in winter than summer. Precipitation trends are more spatially variable, with increased mean winter precipitation in northern Europe, and negative trends in the east Mediteranean area. An increase in mean precipitation per wet day was observed in most parts of the continent, even in some areas which are becoming drier.
Non-climatic drivers
Europe has the highest population density (60 persons/km^2) of any continent; therefore, the anthropogenic pressure on natural ecosystems is very high.
The hydrological characteristics, water use and management are very diverse across Europe; there are many pressures on water quality and availability including those arising from agriculture, industry, urban areas, households and tourism. Freshwater abstraction is stable or declining in northern Europe and growing slowly in southern Europe (Flörke and Alcamo, 2005). Recent floods and droughts have placed additional stresses on water supplies and infrastructure (Estrela et al., 2001) (Tab.1).
Despite policies to protect fish, over-fishing has put many fish stocks in European waters outside sustainable limits (62- 92% of commercial fish stocks in north-eastern Atlantic, 75% in the Baltic Sea, and 65-70% in the Mediterranean) (EEA, 2002). Aquaculture is increasing its share of the European fish market leading to possible adverse environmental impacts in coastal waters (Read and Fernandes, 2003).
Note: the references mentioned in the text are quoted by IPCC 2007b report.

A.2. Expected trends

Climatic parameters
According to IPCC Special Report on Emissions Scenarios (SRES: Nakićenović and Swart, 2000), Europe undergoes a warming in all seasons in both the SRES A2 and B2 emissions scenarios (A2: 2.5 to 5.5°C, B2: 1 to 4°C; the range of change is due to different climate modelling results).
Results using two regional climate models under the PRUDENCE project (Christensen and Christensen, 2007) showed a larger warming in winter than in summer in northern Europe and the reverse in southern and central Europe. A very large increase in summer temperatures occurs in the southwestern parts of Europe, exceeding 6°C in parts of France and the Iberian Peninsula (Christensen and Christensen, 2006; Good et al., 2006).

Generally for all scenarios, mean annual precipitation increases in northern Europe and decreases further south, whilst the change in seasonal precipitation varies substantially from season to season and across regions in response to changes in large-scale circulation and water vapour loading. Räisänen et al. (2004) and Giorgi et al. (2004) identified an increase in winter precipitation in western, northern and central Europe, while in southern and central Europe, the summer precipitation decreased substantially, in some areas up to 70% in A2 scenario (Räisänen et al. 2004).

Extreme events

The yearly maximum temperature is expected to increase much more in southern and central Europe than in northern Europe (Räisänen et al., 2004; Kjellström et al., 2007) and a similar increasing trend is expected for yearly minimum temperature across most of Europe. An increase in the lowest winter temperatures, would primarily mean that current cold extremes would decrease. In contrast, a large increase in the highest summer temperatures would expose Europeans to unprecedented high temperatures.

Christensen and Christensen (2003), Giorgi et al. (2004) and Kjellström (2004) all found a substantial increase in the intensity of daily precipitation events; this holds even for areas with a decrease in mean precipitation, such as central Europe and the Mediterranean.

The combined effects of warmer temperatures and reduced mean summer precipitation would enhance the occurrence of heatwaves and droughts. Beniston et al. (2007) estimated that countries in central Europe would experience the same number of hot days as currently occur in southern Europe and that Mediterranean droughts would start earlier in the year and last longer. The regions most affected could be the southern Iberian Peninsula, the Alps, the eastern Adriatic seaboard, and southern Greece. The Mediterranean and even much of eastern Europe may experience an increase in dry periods by the late 21st century (Polemio and Casarano, 2004).

Non-climatic drivers

The European population is expected to decline by about 8% over the period from 2000 to 2030 (UN, 2004). The relative overall stability of the population of Europe is due to population growth in western Europe alone, mainly from immigration (Sardon, 2004). The low birth rate and increase in duration of life lead to an overall older population, with increased vulnerability to climatic changes.

The SRES scenarios for socioeconomic development have been adapted to European conditions (Holman et al., 2005; Abildtrup et al., 2006). Electricity consumption is projected to continue growing twice as fast as the increase in total energy consumption (EEA, 2006a), primarily due to higher comfort levels and increasing demand for space heating and cooling, which will increase the electricity demand during summer.

Assumptions about future European land use and the environmental impact of human activities depend greatly on the development and adoption of new technologies. Temporally and spatially explicit future scenarios of European land use have been developed for the four core SRES scenarios (Schröter et al., 2005; Rounsevell et al., 2006), showing large declines in agricultural land area. **This decline in agricultural area will mean that land resources will be available for other uses such as biofuel production and nature reserves**.

Note: the references mentioned in the text are quoted by IPCC 2007b report.

A.3. Key future impacts and vulnerabilities

Water resources

Based on various emissions scenarios and General Circulation Models (GCMs), annual average runoff is projected to increase in northern Europe (north of 47°N) by approximately 5 - 15% up to the 2020s and 9 - 22% up to the 2070s, for the SRES A2 and B2 scenarios and climate scenarios from two different climate models (Alcamo et al., 2007). Meanwhile, in southern Europe (south of 47°N), runoff decreases by 0- 23% up to the 2020s and by 6-36% up to the 2070s.

The projected changes in annual river basin discharge by the 2020s are likely to be affected as much by climate variability as by climate change. Groundwater recharge is likely to be reduced in central and eastern Europe (Eitzinger et al., 2003), with a larger reduction in valleys (Krüger et al., 2002) and lowlands (e.g., in the Hungarian steppes) (Somlyódy, 2002).

Changes in the water cycle are likely to increase the risk of floods and droughts. Projections indicate that the risk of floods increases in northern, central and eastern Europe, while the risk of drought increases mainly in southern Europe (Lehner et al., 2006). Increase in intense short-duration precipitation in most of Europe is likely to lead to increased risk of flash floods (EEA, 2004b).

Increasing flood risk from climate change could be magnified by increases in impermeable surface due to urbanisation (de Roo et al., 2003) and modified by changes in vegetation cover (Robinson et al., 2003) in small catchments.

The effects of land use on floods in large catchments are still being debated. The more frequent occurrence of high floods increases the risk to areas currently protected by dykes. The increasing volume of floods and peak discharge would make it more difficult for reservoirs to store high runoff and prevent floods.
For southern and eastern Europe increasing risk from climate change would be amplified by an increase in water withdrawals (Lehner et al., 2006). The regions most prone to an increase in drought risk are the Mediterranean (Portugal, Spain) and some parts of central and eastern Europe, where the highest increase in irrigation water demand is projected (Döll, 2002; Donevska and Dodeva, 2004). The percentage of river basin area in the severe water stress category may increase from 19% today to 34-36% by the 2070s (Lehner et al., 2001).

Mountains regions

The duration of snow cover is expected to decrease by several weeks for each °C of temperature increase in the Alps region at middle elevations (Martin and Etchevers, 2005). Glaciers will experience a substantial retreat during the 21st century (Haeberli and Burn, 2002). Small glaciers will disappear, while larger glaciers will suffer a volume reduction between 30% and 70% by 2050 (Schneeberger et al., 2003; Paul et al., 2004). During the retreat of glaciers, spring and summer discharge will decrease (Hagg and Braun, 2004). Rising temperatures and melting permafrost will destabilise mountain walls and increase the frequency of rock falls, threatening mountain valleys (Gruber et al., 2004).
Change in snow-cover duration and growing season length should have much more pronounced effects than direct effects of temperature changes on metabolism (Grace et al., 2002; Körner, 2003). Overall trends are towards increased growing season, earlier phenology and shifts of species distributions towards higher elevations (Walther, 2004).

Wetlands and aquatic ecosystems

Climate change may significantly impact northern peatlands (Weltzin et al., 2003).
Throughout Europe, in lakes and rivers that freeze in the winter, warmer temperatures may result in earlier ice melt and longer growing seasons. A consequence of these changes could be a higher risk of algal blooms and increased growth of toxic cyanobacteria in lakes (Moss et al., 2003).
Higher precipitation and reduced frost may enhance nutrient loss from cultivated fields (Eisenreich, 2005), increasing the nutrient content and concentration of dissolved organic matter in inland waters and leading to intensified eutrophication of lakes and wetlands (Jeppesen et al., 2003). Streams in catchments with impermeable soils may have increased runoff in winter and deposition of organic matter in summer, which could reduce invertebrate diversity (Pedersen et al., 2004). Inland waters in southern Europe are likely to have lower volume and increased salinisation (Williams, 2001; Zalidis et al., 2002).
Warming will affect the physical properties of inland waters (Livingstone et al., 2005). The thermocline of summer-stratified lakes will descend, while the bottom-water temperature and duration of stratification will increase, leading to higher risk of oxygen depletion below the thermocline (Blenckner, 2005).
Higher temperatures will also reduce dissolved oxygen saturation levels and increase the risk of oxygen depletion (Sand-Jensen and Pedersen, 2005).

Biodiversity

Climate change is affecting the physiology, phenology and distribution of European plant and animal species.
A Europe-wide assessment of the future distribution of 1,350 plant species (nearly 10% of the European flora) under various SRES scenarios indicated that more than half of the modelled species could become vulnerable, endangered, critically endangered or committed to extinction by 2080 if unable to disperse (Thuiller et al., 2005). According to these analyses, the range of plants is very likely to expand northward and contract in southern European mountains and in the Mediterranean Basin.
An assessment of European fauna indicated that the majority of amphibian (45% to 69%) and reptile (61% to 89%) species could expand their range under various SRES scenarios if dispersal was unlimited (Araújo et al., 2006). Another Europe-wide study of 47 species of plants, insects, birds and mammals found that species would generally shift from the south-west to the north-east (Berry et al., 2006; Harrison et al., 2006). Endemic plants and vertebrates in the Mediterranean Basin are also particularly vulnerable to climate change (Malcolm et al., 2006). Habitat fragmentation is also likely to increase because of both climate and land-use changes (del Barrio et al., 2006).
Currently, species richness in inland freshwater systems is highest in central Europe declining towards the south and north because of periodic droughts and salinisation (Declerck et al., 2005). Higher temperatures are likely to lead to increased species richness in freshwater ecosystems in northern Europe and decreases in parts of south-western Europe (Gutiérrez Teira, 2003). Invasive species may increase in the north (McKee et al., 2002); cold-adapted species will be forced further north and upstream and some may eventually disappear from Europe (Eisenreich, 2005).

Sea-level rise is likely to have major impacts on biodiversity by reducing habitat availability in coastal areas, while increasing temperatures might trigger large scale disease-related mortality (Geraci and Lounsbury, 2002). Lowered water tables and increased anthropogenic use and abstraction of water from inland wetlands are likely to cause serious problems for the populations of migratory birds and bats that use these areas while on migration within Europe and between Europe and Africa (Robinson et al., 2005).

Agriculture and fisheries

The effects of climate change and increased atmospheric CO_2 are expected to lead to overall small increases in European crop productivity. However, technological development (e.g., new crop varieties and better cropping practices) might outweigh the effects of climate change (Ewert et al., 2005).

Some crops that currently grow mostly in southern Europe (e.g., maize, sunflower and soybeans) will become viable further north or at higher-altitudes (Audsley et al., 2006), while they will decrease in the south. The predicted increase in extreme weather events is expected to increase yield variability and to reduce average yield, in particular in the Mediterranean region.

An increase in the frequency of severe heat stress is expected to enhance the risk of mortality of pigs and broiler chickens grown in intensive livestock systems; increased frequency of droughts may reduce the productivity of forage crops such that they are no longer sufficient for livestock at current stocking rates without irrigation (Holden et al., 2003). Increasing temperatures may also increase the risk of livestock diseases (increased insects dispersal, enhanced virus survival, etc.)

Climate change is very likely to produce significant impacts on selected marine fish and shellfish (Baker, 2005). Temperature increase has a major effect on fisheries production , causing changes in species distribution, increased recruitment and production in northern waters and a marked decrease at the southern edge of current ranges (Perry et al., 2005); over-fishing is likely to exacerbate the threat to fisheries.

Long-term climate variability is an important determinant of fisheries production at the regional scale, with multiple effects on ecosystems and livelihoods (Roessig et al., 2004). The overall interactions and cumulative impacts on the marine biota of sea-level rise (reduced coastal areas with losses of nursery and spawning habitats), increased storminess, changes in the NAO, changing salinity, acidification of coastal waters, and other stressors such as pollutants, are likely but little known.

Opportunities for new species will arise from expanded geographic distribution and range (Beaugrand and Reid, 2003), but increased temperatures will increase stress and susceptibility to pathogens (Anadón et al., 2005). Ecosystem changes with new invasive or non-native species such as gelatinous zooplankton and medusa, toxic algal blooms, increased fouling and decreased dissolved oxygen events, will increase operation costs. Increased storm-induced damage to equipment and facilities will increase capital costs. Aquaculture has its own local environmental impacts derived from particulate organic wastes and the spread of pathogens to wild populations, which are likely to compound climate-induced ecosystem stress (Boelens et al., 2005).

Energy and tranport

Under future climate change, demand for heating decreases and demand for cooling increases relative to 1961 to 1990 levels (Hanson et al., 2006). Fronzek and Carter (2007) reported a strong increase in cooling requirements for central and southern Europe (reaching 114% for Madrid); this higher demand will increase also the electricity demand up to 50% in Italy and Spain by the 2080s (Livermore, 2005).

The current key renewable energy sources in Europe are hydropower (19.8% of electricity generated) and wind. By the 2070s, hydropower potential for the whole of Europe is expected to decline by 6%, translated into a 20 to 50% decrease around the Mediterranean, a 15 to 30% increase in northern and eastern Europe and a stable hydropower pattern for western and central Europe (Lehner et al., 2005). There will be a small increase in the annual wind energy resource over Atlantic and northern Europe, with more substantial increases during the winter season by 2071 to 2100 (Pryor et al., 2005). By the 22nd century, land area devoted to biofuels may increase by a factor of two to three in all parts of Europe (Metzger et al., 2004). More solar energy will be available in the Mediterranean region (Santos et al., 2002).

Climate change could have a negative impact on thermal power production since the availability of cooling water may be reduced at some locations because of climate-related decreases (Arnell et al., 2005) or seasonal shifts in river runoff (Zierl and Bugmann, 2005). The distribution of energy is also vulnerable to climate change. Higher temperatures can damage rail and road surfaces (Wooller 2003) and affect passenger comfort. There is likely to be an increased use of air conditioning in private vehicles and public transportation. The likely increase in extreme weather events may cause flooding, particularly of underground rail systems and roads with inadequate drainage.

High winds may affect the safety of air, sea and land transport whereas intense rainfall can also impact adversely on road safety although in some areas this may be offset to a degree by fewer snowy days (Keay and Simmonds, 2006). Reduced incidences of frost and snow will also reduce maintenance and treatment costs. Droughts and the associated reduced runoff may affect river navigation on major thoroughfares such as the Rhine (Middelkoop and Kwadijk, 2001) and shrinkage and subsidence may damage infrastructure (Highways Agency, 2005a). Reduced sea ice and thawing ground in the Arctic will increase marine access and navigable periods for the Northern Sea Route; however, thawing of ground permafrost will disrupt access through shorter ice road seasons and cause damage to existing infrastructure (ACIA, 2004).

Tourism and recreation

Tourism is closely linked to climate. Conditions for tourism are expected to improve in northern and western Europe (Hanson et al., 2006), while higher summer temperatures may lead to a gradual decrease in summer tourism in the Mediterranean, with an increase in spring and perhaps autumn (Amelung and Viner, 2006). Occupancy rates associated with a longer tourism season in the Mediterranean will spread demand evenly and thus alleviate the pressure on summer water supply and energy demand (Amelung and Viner, 2006).
The ski industry in central Europe is likely to be disrupted by significant reductions in natural snow cover especially at the beginning and end of the ski season (Elsasser and Burki, 2002).

Human health

Countries in Europe currently experience mortality due to heat and cold, with severe impacts occuring during heatwaves (WHO, 2006), which are very likely to increase during this century.
Climate change is likely to increase the risk of mortality and injury from wind storms, flash floods and coastal flooding (Kirch et al., 2005). The elderly, disabled, children, women, ethnic minorities and those on low incomes are more vulnerable and need special consideration (WHO, 2005).
Future changes in tick-host habitats and human-tick contacts may be more important for disease transmission than changes in climate (Randolph, 2004). Visceral leishmaniasis is present in the Mediterranean region and climate change may expand the range of the disease northwards (Department of Health, 2002). Increases in malaria outside Europe may affect the risk of imported cases. Diseases associated with rodents are known to be sensitive to climate variability, but no assessments on the impacts of climate change have been published for Europe.
Climate change is also likely to affect water quality and quantity in Europe, and hence the risk of contamination of public and private water supplies (Kovats and Tirado, 2006). Higher temperatures have implications for food safety, as transmission of salmonellosis is temperature sensitive. Both extreme rainfall and droughts can increase the total microbial loads in freshwater and have implications for disease outbreaks and water quality monitoring (Knight et al., 2004).
Important climate change effects on air quality are likely in Europe (Stevenson et al., 2006). Climate change may increase summer episodes of photochemical smog due to increased temperatures, and decreased episodes of poor air quality associated with winter stagnation (Kislitsin et al., 2005), but model results are inconsistent.
Stratospheric ozone depletion and warmer summers influence human exposure to ultra-violet radiation and therefore increase the risk of skin cancer (Inter-Agency Commission, 2002).
Pollen phenology is changing in response to observed climate change, especially in central Europe, and at a wide range of elevations, earlier onset and extension of the allergenic pollen seasons being likely to affect some allergenic diseases (Weiland et al., 2004).
Note: the references mentioned in the text are quoted by IPCC 2007b report.

B. Impact of climate change in DRB

B.1. Actual trends

Increasing temperature

In accordance with the global climate trends, an increase of air temperature was noticed in the last century in DRB, from the upper part of the catchment (Tab. 1) to the lower Danube (Fig.1). According to KLIWA project (Long term behaviour of the air temperature) results, in the Bavarian part of Danube catchment the annual mean temperature increased by 0.6 – 1.2 °C, with the main increase in winter season (particularly in December) (Tab.1). In August, the warming occured mostly at lower altitudes (up to about 600 m) (http://www.kliwa.de).

Tab. 3. Areal mean air temperature trends in °C/70 years, time series 1931-2000 in the Bavarian part of Danube River Basin (http://www.kliwa.de)

Gebiet	Höhe m ü. NN	JAN	FEB	MRZ	APR	MAI	JUN	JUL	AUG	SEP	OKT	NOV	DEZ	JAHR
D10	415	1,88	1,76	2,13	-0,12	1,10	0,31	0,72	1,36	-0,14	0,56	0,50	2,09	0,97
D12	432	1,92	2,06	2,36	-0,08	1,24	0,34	0,79	1,31	-0,09	0,66	0,33	2,20	1,10
D7	444	1,92	1,83	2,02	-0,30	1,02	0,23	0,67	1,34	-0,02	0,72	0,30	2,36	1,02
D6	476	1,89	1,76	2,01	-0,11	1,15	0,30	0,90	1,57	0,06	0,70	0,40	2,34	1,09
D8	494	1,64	1,21	1,37	-0,35	0,65	-0,23	0,22	0,92	-0,20	0,35	0,04	1,81	0,61
D4	547	1,90	1,67	1,63	-0,45	0,65	-0,04	0,49	1,04	-0,14	0,88	0,22	2,41	0,86
D15	551	2,12	2,05	2,07	-0,05	1,29	0,41	0,89	1,44	0,01	0,83	0,83	2,04	1,18
D9	569	1,68	1,09	1,23	-0,56	0,70	-0,12	0,33	1,00	-0,26	0,70	0,38	1,78	0,69
D15a	577	2,01	2,01	2,04	-0,13	1,20	0,33	0,74	1,43	0,04	0,87	0,77	1,90	1,12
D14	590	1,87	1,88	1,87	-0,45	0,91	-0,02	0,43	1,08	0,01	1,05	0,44	2,06	0,94
D11	675	2,06	1,87	1,64	-0,43	0,83	-0,05	0,54	1,13	0,01	1,17	0,31	2,26	0,94
D13	785	1,97	1,68	1,32	-0,88	0,64	-0,29	0,32	1,12	0,33	1,76	0,87	2,07	0,89
D5	791	2,31	1,92	1,42	-0,61	0,61	-0,11	0,53	1,23	0,24	1,58	0,32	2,52	0,98
D3	872	1,99	1,67	1,25	-0,83	0,48	-0,20	0,61	1,15	0,14	1,43	0,22	2,32	0,84

In the lower part of the catchment, in Romania, an increase of average annual temperature of 0.3 °C was noticed in the last century. However, in the southern part of the country, the increase was much higher, the average reaching 0.8 °C (Fig.1).

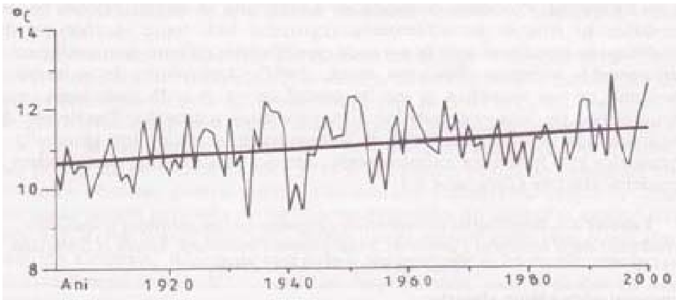

Fig. 1. Trend of average annual air temperature in Bucharest (Busuioc 2002, quoted by Balteanu & Serban 2005)

The increase of air temperature affected also the water temperature; consequently, during the last century the Danube water temperature increased significantly (Fig.2, 3). The GLOWA-Danube project (Impact of Global Change on the Upper Danube) results show an increasing trend of temperature after 1960s and this trend is estimated to increase continuosly by 2050 (Fig.2). The analysis of temperature data sets for River Rhine (1909-2006), River Danube at Vienna (1901-1998) and Lake Saimaa, Finland (1924-2000) show a similar increasing trend (Fig.3).

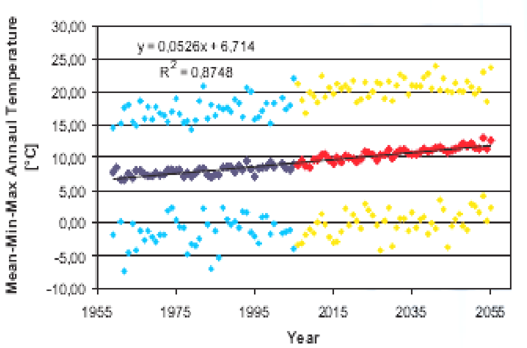

Fig. 2 The temperature increase of the Upper Danube (www.glowa-danube.de)

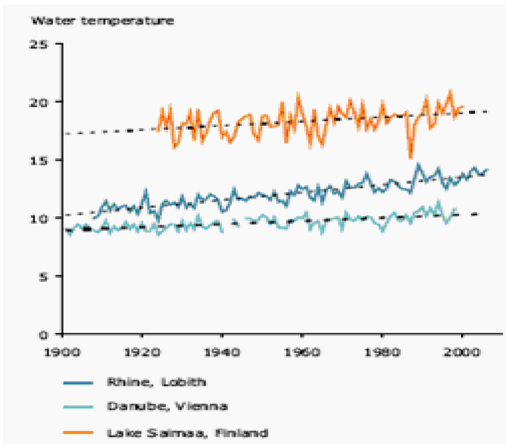

Fig. 3. Increasing trend of water temperature in Rhine, Danube and Saimaa Lake (www.eea.europa.eu)

Similar results were found also on the Croatian stretch of the Danube, where the mean annual water temperature increase since 1950 was of more than 1°C (Fig.4).

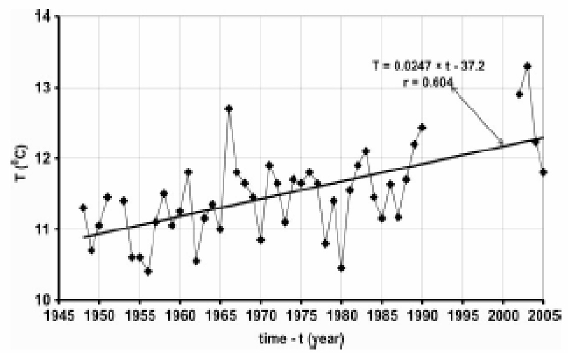

Fig. 4. Mean annual water temperature of Danube River at Vukovar (Bonacci et al., 2008)

Decreasing discharge

The shift of precipitation regime occured at European scale, with 10-40% more in the northern part and up to 20% less in the central and southern parts (DEFRA 2005, IPCC 2007a), had a negative influence on southern rivers discharge. Danube River was also affected: after 1960, a decreasing trend of Danube discharge was recorded (Michaylov, 2004).

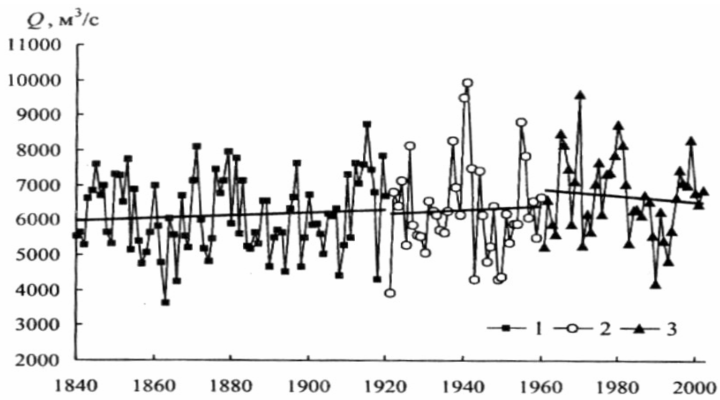

Fig. 5. Danube discharge at Reni (rkm 132), showing the decreasing trend after 1960 (Mikhaylov, 2004).

Increased frequency of extreme hydrological events

In recent decades, the frequency of extreme hydrological events on the Danube River (large spring-summer floods and catastrophic rainfalls) has increased, significant flooding occuring in 1980, 1981, 1988, 1999, 2002, 2005, 2006 (Mikhaylov et al., 2008). Estimates from various sources show that only the floods in August 2002 triggered over 100 deaths and damages of 20 bilion US $.

Trends in the catchment

Similar trends were recorded also in some important Danube sub-catchments. A study carried in Mures catchment (Mures, the main tributary of Tisza River, is located between Romania and Hungary, catchment size 28,310 km^2) revealed considerable changes of climatic parameters in the past decades (Table 4) (Sandu et al., 2009). Annual mean air temperature increased by 0.4 - 0.7 ºC. Annual precipitation increase by 15-33 mm was not significant, but trends were negative in winter, spring and summer and positive in fall. The annual number of days with precipitation was drastically decreased at all three stations while those of snow cover decreased in the lowland (Arad, Deva) and increased in the mountains (Tg. Mures). These results support the hypothesis that heavy rainfall events got more frequent and intense during the last decades and have influenced river discharge towards higher floods (IPCC 2007a). Consequently, flood risk is increased and may trigger hard flood protection impacting the near-natural hydromorphology of the river although retention areas are still available.

Tab.4. Trends of annual climatic parameters at 3 meteorological stations located in Mures catchment

Parameter	Meteo	Trend
Temperature (˚C)	Arad	+ 0.42
	Deva	+ 0.69
	Tg. Mures	+ 0.54
Precipitation (mm)	Arad	+ 33.54
	Deva	+ 29.99
	Tg. Mures	+ 15.14
No of days with precipitation	Arad	- 79.3
> 0.1 mm	Deva	- 77.54
	Tg. Mures	- 66.22
No of days with snow cover	Arad	- 3.75
	Deva	- 10.66
	Tg. Mures	+ 0.50

The trends of climate parameters influenced also the river discharge and water temperature. As for the Danube, a slight decreasing trend was noticed after 1960 (Fig. 6A) while the water temperature increased with more than 1 °C (Fig.6B).

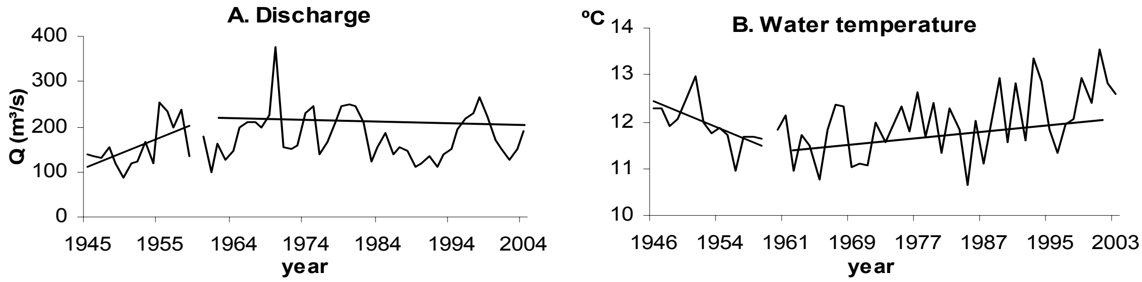

Fig. 6. Discharge (A) and water temperature (B) of Mures River at Mako between 1945-2004 (VITUKI, HU)

Although the river discharge was not strongly affected by the change of climate parameters due to its catchment peculiarities, the mean annual water temperature seems to be more directly influenced (Fig.7). The strong increase since 1969 was supported by both annual temperature maxima (Tmax) and minima (Tmin). In summer, the periods with water temperatures higher than 23°C were more frequent, in winter the freezing periods were reduced as a consequence of the increasing Tmin temperatures above 0 °C (Fig. 7B).

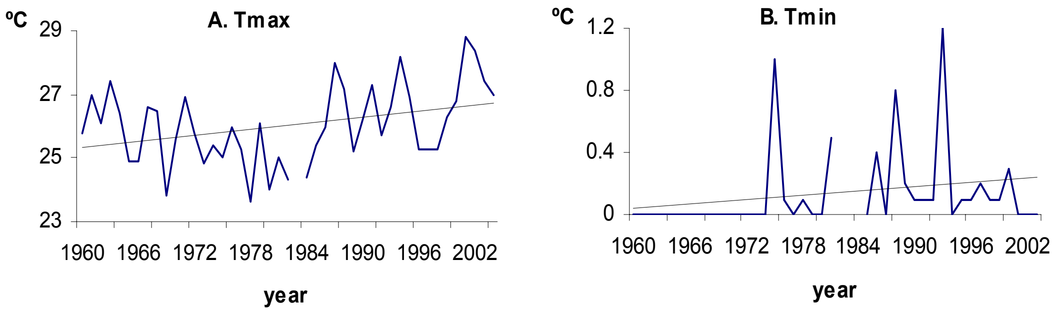

Fig. 7. Trends of water temperature maxima (Tmax, A) and minima (Tmin, B) at Mako between 1960-2003 (VITUKI, HU).

Both, the reduced discharge and the increase of water temperature threatens the aquatic biodiversity.
In summer cold stenotherm fish (brown trout *Salmo trutta fario,* grayling *Thymallus thymallus*) may not survive longer periods with temperatures over 25 ºC. In winter, the reduced duration of freezing may induce earlier emergence of aquatic insects and loss of species needing a resting phase in their life-cycle; mild winters will increase the survival rate of bird species, enhancing the pressure on aquatic communities (Sandu et al, 2009).
The oxygen solubility decreases with the increasing temperature, lowering the self-purification capacity of water bodies and increasing the risk of oxygen depletion.
On long-term, a general shift towards species tolerant of high temperatures may occur (EEA, 2004), together with upstream migration in colder regions; habitat fragmentation may raise a serious problem for the species unable to adapt to the new environmental conditions, leading to their extinction.

B. 2. Expected trends in DRB

Global climate change will increasingly have regional impacts on the water resources: more frequent floods, low flows and droughts, the retreat of glaciers and of snow cover in the Alps as well as changes of the natural and agrarian vegetation particularly in the Upper Danube watershed will be the likely consequences, with strong influence on the future development of the region (e.g. water use, energy management, farming, tourism, industry, etc.) (www.glowa-danube.de).

The preliminary modelling results of CLAVIER (*Climate change and variability: Impact on Central and Eastern Europe)* and CECILIA (*Central and Eastern Europe Climate Change Impact and Vulnerability Assessment)* projects have shown that for the period 2021 – 2050 the warming in the South-Eastern Europe will continue during all seasons (less than +1°C). The highest temperature increase is estimated for the winter (+2.8°C), together with an increased amount of precipitation (~ 20%). In summer, most likely a decrease of precipitation will occur, leading to severe droughts in the southern and south-eastern regions (negative deviations of at least 20%), accompanied by an increased frequency of heavy rains (Balteanu et al., 2009; Boroneant, 2009). – Biowetman wks Bucharest (http://www.ibiol.ro/man/wkp1_2009.htm)

For the upper part of Danube catchment, DANUBIA decision support system was successfully set-up during the first two stages of GLOWA-Danube project (2001 – 2006); this system includes for the first time model components of the natural sciences as well as socio-economic processes and their interaction. The results will be available since 2010 for decision makers, helping them to develop and evaluate regional adaptation strategies (www.glowa-danube.de).
Scenario runs with DANUBIA are based on the findings of the IPCC and use results of regional climate models as well as statistical ensemble approaches for the estimation of the future regional climate change in the Upper Danube watershed. The analyses show that the average air temperature at the Upper Danube has already increased by approx. 1.5 °C in the last 30 years. The IPCC-A1B scenario expects a further intense global warming in the next 50 years. First results of scenario ensembles with DANUBIA already show that droughts in summer will broaden and that the low flow discharge of the Upper Danube will decrease strongly in the future years (Fig.8). Further scenario runs will include changes of glaciers, snow cover, and winter tourism, use of water reservoirs, consequences for water supply and water use as well as impacts on farming, tourism, households and industry (www.glowa-danube.de).

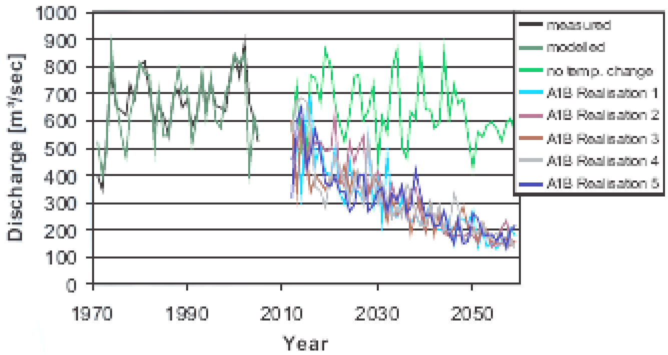

Fig. 8. Scenarios for the development of low flow at the gauge Achleiten,
Upper Danube (www.glowa-danube.de)

Periods of low water flow and droughts can have severe consequences for several economic sectors, particularly agriculture, navigation, energy production and drinking water provision. Activities that depend on high water abstraction and use, such as irrigated agriculture, hydropower generation and the use of cooling water, will be affected by changed flow regimes and reduced water availability. Moreover, wetlands and aquatic ecosystems will be threatened which will affect the sectors that depend on the goods and services they provide (www.eea.europa.eu).

Climate change-related temperature changes are projected to result in less ice formation. For example, studies have shown that ice break-up in rivers now occurs 15–20 days earlier than in the 1950s, and a shift towards a longer annual ice-free period and earlier ice break-up have been observed in many northern lakes and rivers in recent decades (Korhonen 2005; Magnusson et al., 2000 quoted by http://www.eea.europa.eu/themes/water). The timing of lake ice break-up is of ecological importance because the disappearance of ice cover affects the production and the composition of the phytoplankton community and the occurrence of winter fish kills (Weyhenmeyer, 2006); many rivers could become ice-free or develop only intermittent or partial ice coverage (http://www.eea.europa.eu/themes/water)

C. RESPONDING TO CLIMATE CHANGE (IPCC 2007 b,c)

Societies can respond to climate change by adapting to its impacts and by reducing GHG emissions (mitigation), thereby reducing the rate and magnitude of change (IPCC 2007c). The capacity to adapt and mitigate is dependent on socio-economic and environmental circumstances and the availability of information and technology.

C.1. Adaptation and mitigation

Adaptation can reduce vulnerability, both in the short and the long term. Besides the traditional ability of mankind to adapt to extreme events like floods, droughts and storms, additional adaptation measures will be required at regional and local levels to reduce the adverse impacts of projected climate change; however, adaptation alone is not expected to cope with all the projected effects of climate change, especially not over the long term as most impacts increase in magnitude.

Adaptive capacity is intimately connected to social and economic development, but it is not evenly distributed across and within societies. Financial, technological, cognitive, behavioural, political, social, institutional and cultural constraints limit both the implementation and effectiveness of adaptation measures. Even societies with high adaptive capacity remain vulnerable to climate change, variability and extremes, as shown for example by the heat wave in 2003, who caused high levels of mortality in European cities (especially among the elderly).

The substantial economic potential for the mitigation of global GHG emissions over the coming decades could reduce emissions below current levels. The economic mitigation potential, can only be achieved when adequate policies are in place and implementation barriers removed. No single technology can provide all of the mitigation potential in any sector. Future energy infrastructure investment decisions and the widespread diffusion of low-carbon technologies are essential steps to reduce the actual GHG emissions.

Health co-benefits from reduced air pollution, as a result of actions to reduce GHG emissions, can be substantial and may offset a substantial fraction of mitigation costs. Energy efficiency and utilisation of renewable energy offer synergies with sustainable development. In least developed countries, energy substitution can lower mortality and morbidity by reducing indoor air pollution, reduce the workload for women and children and decrease the unsustainable use of fuelwood and related deforestation.

Changes in lifestyle and behaviour patterns can contribute to climate change mitigation across all sectors. Management practices can also have a positive role. Changes in consumption patterns, education and training, changes in building occupant behaviour, transport demand management and management tools in industry may have a positive impact.

A wide variety of national policies and instruments are available to governments to create the incentives for mitigation action. Four main criteria are used to evaluate policies and instruments: environmental effectiveness, cost effectiveness, distributional effects including equity, and institutional feasibility. General findings about policies efficiency:

- ***Integrating climate policies in broader development policies*** makes implementation and overcoming barriers easier.
- ***Regulations and standards*** generally provide some certainty about emission levels. They may be preferable to other instruments, but they may not induce innovations and more advanced technologies.
- ***Taxes and charges*** can set a price for carbon, but cannot guarantee a particular level of emissions. Literature identifies taxes as an efficient way of internalising costs of GHG emissions.

- ***Tradable permits*** will establish a carbon price. The volume of allowed emissions determines their environmental effectiveness, while the allocation of permits has distributional consequences.
- ***Financial incentives*** (subsidies and tax credits) are frequently used by governments to stimulate the development and diffusion of new technologies. While economic costs are generally higher than for the instruments listed above, they are often critical to overcome barriers.
- ***Voluntary agreements*** between industry and governments are politically attractive and raise awareness among stakeholders; in a few countries, they have accelerated the application of best available technology and led to measurable emission reductions.
- ***Information instruments*** (e.g. awareness campaigns) may positively affect environmental quality by promoting informed choices and possibly contributing to behavioural change, however, their impact on emissions has not been measured yet.
- ***Research, development and demonstration (RD&D)*** can stimulate technological advances, reduce costs and enable progress toward stabilisation. Some corporations, local and regional authorities, NGOs and civil groups are adopting a wide variety of voluntary actions who may limit GHG emissions, stimulate innovative policies and encourage the deployment of new technologies.

There is growing understanding of the possibilities to choose and implement climate response options in several sectors to realise synergies and avoid conflicts with other dimensions of sustainable development. Climate change policies related to energy efficiency and renewable energy are often economically beneficial, improve energy security and reduce local pollutant emissions. Reducing both loss of natural habitat and deforestation can have significant biodiversity, soil and water conservation benefits, and can be implemented in a socially and economically sustainable manner. Forestation and bioenergy plantations can restore degraded land, manage water runoff, retain soil carbon and bring benefit to rural economies, but could compete with food production and may be negative for biodiversity, if not properly designed. There is growing evidence that decisions about macro-economic and agricultural policy, electricity market reform, energy security and forest conservation, for example, which are often treated as being apart from climate policy, can significantly reduce emissions. Similarly, non-climate policies can affect adaptive capacity and vulnerability.

C.2. Key vulnerabilities, impacts and risks – long-term perspectives

Vulnerability to climate change is a function of exposure, sensitivity and adaptive capacity. Adaptation can reduce sensitivity to climate change while mitigation can reduce the exposure to climate change, including its rate and extent.

Risks to unique and threatened systems. There is new and stronger evidence of observed impacts of climate change on unique and vulnerable systems (such as polar and high mountain communities and ecosystems, coral reef), with increasing levels of adverse impacts as temperatures increase further.

Risks of extreme weather events. Responses to some recent extreme climate events reveal high levels of vulnerability in both developing and developed countries; the projected increase of extreme events frequency increases their adverse impacts such as increased water stress and wild fire frequency, adverse effects on food production, adverse health effects, increased flood risk and extreme high sea level, and damage to infrastructure.

Distribution of impacts and vulnerabilities. There are sharp differences across regions, those in the weakest economic position being often the most vulnerable to climate change and frequently, the most susceptible to climate-related damages. Low-latitude and less developed areas generally face greater risk.

Aggregate impacts. Besides global temperature increase , synergic impacts should be also considered: for example, climate change over the next century is *likely* to adversely affect hundreds of millions of people through increased coastal flooding, reductions in water supplies, increased malnutrition and increased health impacts.

Risks of large-scale singularities. During the current century, a large-scale abrupt change in the meridional overturning circulation is *very unlikely*. The global warming would lead over many centuries to a sea level rise contribution from thermal expansion alone that is projected to be much larger than observed over the 20th century, with loss of coastal area and associated impacts. Complete deglaciation of the Greenland ice sheet would raise sea level by 7m and could be irreversible.

Both adaptation and mitigation can complement each other and together can significantly reduce the risks of climate change to nature and society. One way of increasing adaptive capacity is by introducing the consideration of climate change impacts in development planning, for example, by:
• including adaptation measures in land-use planning and infrastructure design
• including measures to reduce vulnerability in existing disaster risk reduction strategies

C.3. Environmental and sustainability issues

Sustainable development can reduce vulnerability to climate change, and climate change could impede nations' abilities to achieve sustainable development pathways.

Climate change can slow the pace of progress toward sustainable development either directly through increased exposure to adverse impacts or indirectly through erosion of the capacity to adapt. Over the next half-century, climate change could impede achievement of the Millennium Development Goals as it will interact with other trends in global environmental and natural resource concerns, including water, soil and air pollution, health hazards, disaster risk, and deforestation. Their combined impacts may be compounded in future in the absence of integrated mitigation and adaptation measures.

Making development more sustainable can enhance mitigative and adaptive capacities, reduce emissions, and reduce vulnerability. Both adaptive and mitigative capacities can be enhanced through sustainable development . At present, however, few plans for promoting sustainability have explicitly included either adapting to climate change impacts, or promoting adaptive capacity. Similarly, changing development paths can make a major contribution to mitigation but may require resources to overcome multiple barriers.

Future vulnerability depends not only on climate change but also on development pathway. Synergies exist between adaptive capacity and sustainable development, and societies which are pursuing a path of sustainable development are likely to be more resilient to the impacts of climate change.

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