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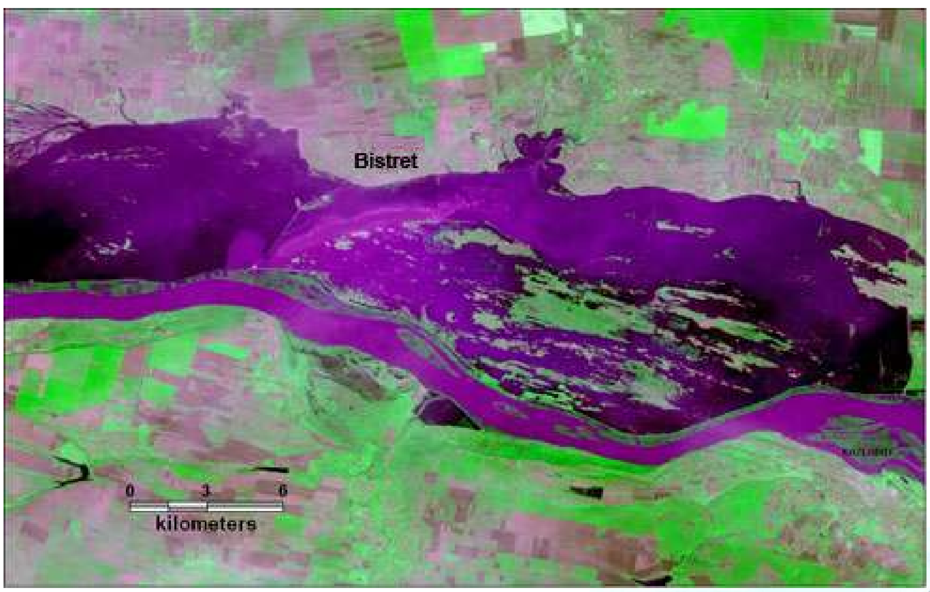
2006 Floods in the Danube River Basin

Flood risk mitigation for people living along the Danube: The potential for floodplain protection and restoration



Working paper

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For further information please contact:

Dr. Christine Bratrich

WWF Danube Carpathian Programme
Mariahilferstrasse 88a/3/9
1070 Vienna, AUSTRIA
Tel.: +43 1 524 54 70
Email: cbratrich@wwfdcp.org

Sergey Moroz

WWF European Policy Office
36, Avenue de Tervuren
1040 Brussels, BELGIUM
Tel.: +32 2 740 09 23
Email: smoroz@wwfepo.org
Website:www.panda.org/epo

Dr. Ulrich Schwarz

FLUVIUS
Gärtnergasse 4/3
A-1030 Vienna
Tel.: +43 1 943 2099
Email: Ulrich.Schwarz@fluvius.com

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The mission of the World Wide Fund for Nature is to stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature, by conserving the world's biological diversity, ensuring that the use of renewable natural resources is sustainable and promoting the reduction of pollution and wasteful consumption.

This document has been produced by:

Ulrich Schwarz, Christine Bratrich,
Orieta Hulea, Sergey Moroz,
Neringa Pumputyte, Georg Rast,
Mari Roald Bern, and Viktoria Siposs.

With friendly contributions from:

Suzanne Ebert, Gerhard Egger,
Laurice Ereifej, Ivan Hristov, Ivan Jarić,
Jelena Knežević, Helmut Mader,
Arno Mohl, Misha Nesterenko,
David Reeder, Julia Reynolds,
Gyongyi Ruzsa, and Erika Schneider.

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Preface:

The aim of this working paper is to review the recent 2006 flood events and their devastating effects along the Danube and its selected tributaries, highlighting the importance of floodplain protection and restoration in order to mitigate flood risks. The paper also provides an overview of the physical restoration potential of four areas along the Lower Danube Green Corridor[1] (LDGC) further referred to in the paper as case studies.

The paper aims to provide background information for political discussions and to shape the political debate towards a more sustainable flood risk management.

Based on the findings of the paper WWF makes a number of recommendations for

1. EU institutions and other international bodies such as the International Commission for the Protection of the Danube River (ICPDR),
2. national governments, in particularly of the new EU Member States and of the EU Candidate Countries (e.g. Romania and Bulgaria) and
3. insurance companies and individuals.

WWF Austria, WWF Danube Carpathian Programme Office, WWF European Policy Office, WWF Germany, and WWF Hungary provided data and helped with background information and research. Ivan Jarić and Jelena Knežević provided additional information from Serbia. Primarily existing data was used, supported by some Internet research and phone interviews with international and local experts.

[1] Lower Danube Green Corridor is an initiative of the governments of Bulgaria, Moldova, Romania and Ukraine, signed in 2000, which aims to establish a corridor of about 7.740 km² of existing protected areas and 3,000 km² of planned protected areas along the nearly 1000 km Danube stretch from the Iron Gate to the Danube Delta.

List of Acronyms

AT	Austria
BA	Bulgaria
CCB	Cahul Business Center
CS	Serbia
CZ	Czech Republic
DCPO	WWF Danube-Carpathian-Programme Office
DRB	Danube River Basin
DPRP	Danube Pollution Reduction Programme
DE	Germany
EC	European Commission
EPO	WWF European Policy Office
EU	European Union
GIS	Geographical Information Systems
HR	Croatia
HU	Hungary
ICPDR	International Commission for Protection of the Danube River
LDGC	Lower Danube Green Corridor
MD	Moldova
NGO	Non Governmental Organization
NL	Netherlands
RO	Romania
SK	Slovak Republic
TEN-T	Trans-European Networks for Transport
UA	Ukraine
WFD	EU Water Framework Directive

Glossary of selected terms

Aggradation	The building up of sediments, which occurs when there is a supply of sediment and changes in water flow.
Annuality	The occurrence or probability of a predefined flood (calculated by long-term hydrological observations and models) once in 10, 30, 100 or more years
Dike	An artificial construction along the river
Discharge	Volume of water flowing through a cross section of a river within a certain time period.
Geomorphology	The study of landforms, their origin and evolution and the processes that shape them
Hydromorphology	Study of hydrological conditions and channel structures such as islands and sand bars of the river bed, its banks and floodplain (flood dynamics, connectivity)
Morphological floodplain	Natural (former) floodplain within natural terraces and without human alterations (the period referred to dates from about 300 years ago)
Recent floodplain	Active floodplain between flood protection dikes or natural terraces as part of the “morphological” floodplain.
Polder	A low-lying tract of land, forming an artificial hydrologic entity, enclosed by dikes

Executive Summary

Recent floods in Central and Eastern Europe have caused dramatic situations along the Danube and its major tributaries. Human suffering and the evident failure of traditional flood protection show the need for integrated sustainable measures to protect local settlements and property. WWF is calling for alternative concepts of flood management, which aim to reduce human losses *and at the same time* improve the ecological health of river ecosystems. This study gives an overview of the restoration potential in several areas, further referred to as case studies, along the lower Danube region.

The **first chapter summarizes the flood events of 2006** and the associated damages along the upper, middle and lower Danube. Throughout April, very high discharges occurred in the middle Danube, the lower Tisza River and parts of the Sava River. The flood along the lower Danube nearly reached the level of a 100-year event. In the entire Danube basin at least 10 people lost their lives and up to 30,000 people were displaced, with overall damages estimated at more than half a billion Euros.

The comparison between former and recent floodplains[2] clearly indicates the dramatic loss of retention areas: the middle and lower Danube have lost about 70% of its former morphological floodplains. Moreover, nearly 90% of the former floodplains along the Tisza River and 70% of the former floodplains along the Sava River have also been lost. For several longer stretches of the lower Tisza and Danube, this figure approaches 90%. The loss of floodplains has a major impact on the hydromorphology of the river system, and can additionally increase flood peaks particularly close to human settlements, where embankments and other infrastructure have further reduced discharge capacities.

The **second chapter** provides a detailed analysis of four case study areas looking at their restoration potential. They were once part of the former floodplain and are currently outside of the flood protection dikes. These sites lie along the lower Danube from the Iron Gate to the Danube Delta, where large areas outside of the flood protection dikes were flooded in 2006 (more than 90,000 ha). The selection of these sites was based on the availability of data, site size and existing regulatory frameworks. It should be possible to apply this method to other parts of the Danube, other tributaries, or even other river systems.

The **case studies along the lower Danube** illustrate impacts of reduced river discharge capacities and retention areas during the severe flood event in spring 2006. As said above, since the 1970s the lower Danube has been almost completely disconnected from its large floodplains and many side channels have been closed, in particular on the Romanian side. This has considerably reduced the discharge capacity of the river system forcing floodwaters to overflow and break the dikes during the spring 2006 flood event. Four areas, mostly agricultural polders in Romania, were heavily impacted: the Baltas of Bistret, Potelu, Calarasi and the island Calarasi-Raul. An overall area of 70,000 ha was flooded and about 10,000 people lost their livelihoods.

Our analysis shows that the four case study areas would have an overall retention capacity of nearly 100,000 ha with a volume of 1,6 billion m³. **If these four areas plus about 500 million m³ had been restored and the discharge capacity had been increased through reconnected side channels and widening of the riverbed, the flood level would have been lowered up to 40 cm during the spring flood 2006**. The study presents estimated restoration costs and estimations of ecologic values for each of the areas in relation to potential restoration costs. The results show that the overall value of these areas might be higher if former floodplains are re-connected with the river system. The calculations highlight the necessity of a paradigm shift in EU flood risk management and other relevant policies in order to create more retention areas along the rivers and to provide an alternative income for the local population who are currently using these areas for agriculture.

In the **third chapter, lessons learned from other rivers and regions** within the Danube Basin and recommendations are given. Lessons learned from other European countries clearly indicate the necessity for a political willingness to enlarge the potential retention areas along rivers.

[2] For an explanation of former and recent floodplains, see glossary.

The **final recommendations** are given **in chapter four** targeted at different levels (EU, ICPDR, national governments, as well as insurance companies and individuals):

- **Sustainable land use** to support the retention of water in the catchment is key to preventing future flood disasters. So far, flood management is dominated by measures focusing on river systems, but does not sufficiently include landscape changes or land use impacts. Successful flood management must include a profound understanding about the genesis of floods on a basin-wide scale, including land use pattern and the temporal characteristics (superimposition or disconnections) of flood waves.

- The **mitigation** of flood damages and the protection **and ecological restoration of floodplains must go hand in hand**. So far, this is not common practice. WWF calls for the preservation and improvement of still existing floodplains in order to benefit from their function as retention areas, and to enhance the hydromorphological situation of the main and side channels in order to increase discharge capacity.

- WWF believes that **simply increasing retention areas, for example by construction of polders, is a not a sufficient solution.** It is essential that establishment of flood retention zones along the Danube and its tributaries is combined with the restoration of wetlands, opening of side arms, and widening of river profiles, which would reduce flood peaks more effectively over prolonged flood periods. The combination of restoration *and* increased retention must be a key component of the EU Flood Risk Management Directive, currently being negotiated between EU institutions.

- Restoring floodplain areas along the middle and lower stretches of the Danube River should **yield multiple benefits,** not only in terms of enhanced flood protection by soaking up floodwaters, but also for local livelihoods, as demonstrated by already restored floodplain areas in the Danube Delta and still existing natural floodplain areas along the middle Danube in Croatia, Serbia, and the Danube National Parks of Hungary and Austria.

- WWF calls for the strong promotion of **further implementation of the LDGC agreement** and an emphasis on the need for improvements of the Hungarian flood mitigation practice.

- WWF calls for the improvement of national legislative requirements and **law enforcement in the field of spatial planning** (prevention from building more houses and infrastructure in flood-prone areas) and increased preparedness and emergency response to flood events.

- WWF calls for **open public participation** in national and international flood risk management. This applies in particular to the current negotiation processes in Romania where new restoration sites are discussed only by the governmental bodies.

- **Insurance companies play a key role in future flood risk management**. Bonus systems might support people who are willing to move out of high and very high flood risk zones. Financial responsibility has to be required when infrastructure and individual property is located in very high and high-risk areas. New settlements in areas prone to flooding should not be protected by large-scale measures paid by the general public (e.g. by enlargement of polder or dike systems) and should only be allowed if individuals can provide sufficient status of individual flood protection (individual dikes around the private property, specific measures for windows, fundaments etc).

1. 2006 Floods in the Danube River Basin

In general the floods in 2006 can be divided into two types:

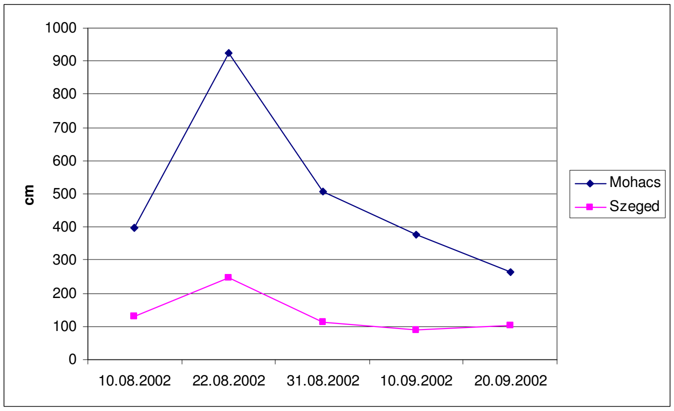
(I) Primary floods in some tributaries (Morava/Dyje, Bodrog) arising in the upper catchments, and

(II) Secondary floods on the large lowland rivers such as the middle and lower Danube, Tisza and Sava Rivers that occur when the most important tributaries have very high discharges at the same time.

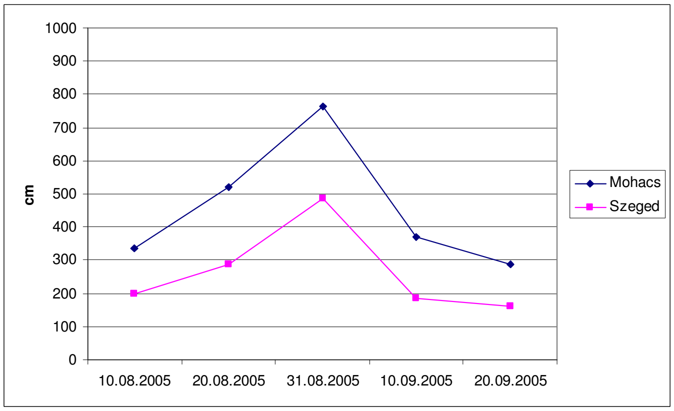
The Danube has a very complex hydrological system. Its flow characteristics change over large reaches, influenced by the main tributaries. This applies especially to the middle course, where Drava, Tisza and Sava join the Danube.

The winter of 2006 was long and snow-rich and was characterized by an extended period of low average temperatures in the Alps and the Western Carpathians. The increase in temperatures led to intensive snowmelt, accompanied by a heavy rainfall at the end of March. These factors caused long-lasting high discharges in the Danube and in its two most important tributaries, the Tisza and the Sava. Due to these high discharges, large floods affected the Danube beginning from Bratislava and especially around Belgrade, and subsequently the whole lower Danube in Romania, Bulgaria, Moldova and Ukraine. Along the lower Danube, the high water levels lasted for over six weeks. In some places the river level reached the highest levels in 100 years.

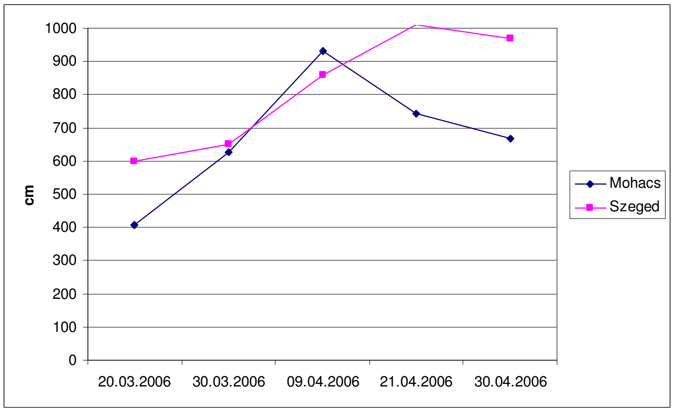
In contrast to the 2005 floods in the Northern Alps, the floods in 2006 were limited to the middle and lower Danube and, mostly driven by snowmelt (Fig. 1-3). Conversely, in 2005, heavy rainfalls particularly affected the upper Alpine catchment, and the main flood wave reached the middle Danube only as a negligible 3-5 years event, failing to reach the lower Danube at all. Nevertheless, (flash) floods in Bulgaria and parts of Romania that year affected Balkan and Carpathian foothill valleys and destroyed many villages. Going further back to August 2002, flooding along the middle Danube in Hungary and Croatia/Upper Serbia reached nearly the same level as that of 2006.



In 2002 the flood peak coming from the upper Danube catchment reached a 100-year flood event in Mohacs with 926 cm. The duration of high to very high discharges was about two weeks. During the same time the Tisza had a low water period (Sava similarly with 150-300 cm in Zupanja (last Croatian station along the Sava)). No dangerous flooding occurred in Belgrade and downstream.



After the catastrophic floods in the northern Alps in 2005 the flood peak in Mohacs reached only 762 cm (low annuality). At the same time the Tisza water level increased only very slightly and the Sava reached 300-500 cm in Zupanja. No flooding at all occurred in Belgrade and downstream.



In 2006 the Danube reached Mohacs with 931 cm - one of the highest values ever measured. Also significant is the duration of the flood wave, with high to very high discharges over four weeks. Nearly parallel though slightly delayed, the Tisza reached the highest values ever measured with 1009 cm. Additionally, the Sava had constantly high values of about 750 cm. Within a very narrow time frame, the floods reached Belgrade and further downstream the lower Danube.

Figure 1-3: The figures illustrate the three different flood events in 2002, 2005 and 2006 by presenting water levels in the lower Danube. Stations: Mohács, Danube before entering the Croatian and Serbian reach, and Szeged, Tisza leaving Hungary.

1.1. Flood 2006 history and overview

The floods in the Danube River Basin (DRB) in 2006 started at the end of March in the upper catchment and lasted until June 2006, when several areas were flooded along the lower Danube in Romania (confirmed by satellite images from middle of June). Nearly 30,000 people lost their livelihoods and many of them will never return to the destroyed houses. Along the lower Danube in Romania several dike breaks were recorded, and several controlled breaks were made in order to take the highest pressure off the other dikes, in order to temporarily lower the water table.

The following table (Tab. 1) shows the flood events in April and May 2006 by summarizing the main indicators available in the media. All damage costs estimations are preliminary.

Table 1: Flood 2006 overview

	Duration	People	Damage [million €]	Cause	Annuality
1. Upper Danube (DE, AT, CZ)	28.3. - 17.4.	5 dead, 4,000 displaced (mostly in CZ)	~ 110	Snowmelt/rain	Lower Morava and Dye about 100 years event
2. Middle Danube (SK, HU)	28.3. - 28.4.	3 dead, 6,000 displaced	~ 30	Snowmelt and rain and locally dike breaks	About 100 years event for the lower reaches of Bodrog and Tisza and the Danube
3. Middle Danube (CS, HR)	4.4. - 28.4.	2 dead, 3,000 displaced	~ 60	Concurrent high discharges of the Danube, Tisza and Sava	At least 100 years event
4. Lower Danube (CS, HR)	7.4. - 15.6.	14,000 displaced	~ 400	Water from middle Danube, Several dike breaks and controlled flooding	About 100 years event

- **Upper Danube (Germany, Austria, Czech Republic)**

The German and Austrian stretches of the Danube did not reach very high discharges (e.g. less than 10 year annuality in Vienna) but extraordinary floods affected several smaller tributaries in Bavaria and particularly the Morava/Dyje river system. Water levels were increasing due to snowmelt, and some heavy rainfall in the middle and lower Morava and Dyje river catchments further increased the water levels. As a consequence, the flood protection dikes broke on several upper reaches of the Morava in Austria, which caused additional damages.

Duration: 28.3. -17.4.2006
People: 5 dead, 4,000 displaced (mostly in Czech Republic)
Damage: app. 110 million, - € (March: Austria 60 million €)
Cause 1: Snowmelt and some rain
Cause 2: Dike breaks (Austria) and locally controlled release (Dye, Czech Republic)
Annuality: Danube near Vienna about 10 years, lower Morava and Dye about 100 years
Flooded area: Lower Morava and Dye near Breclav, > 3,000 ha, March (Austria) dam break: 1,500 ha agricultural land and settlements

Comments:
Czech Republic: the lower Morava and Dye rivers were particularly affected.
Austria: A dike collapsed and the water flooded large parts of Dürnkrut and Stillfried, namely where the recent floodplain is very narrow (a planned dike replacement that would reactivate more retention area had been stopped by local farmers but now is again under discussion).

- **Middle Danube: (Slovak Republic, Hungary)**

The Danube flooded its whole former riverbed and floodplain parallel to the Gabcikovo hydropower plant diversion canal in the Szigetköz along the border of Slovak Republic and Hungary. The Tisza received flood waves from the Bodrog and the Körös rivers. In the lower reaches on Hungarian territory the Danube and Tisza, reached a 100-year flood event level.

Duration: 28.3. -28.4.2006
People: 3 dead, about 6,000 displaced
Damage: 30 million €
Cause 1: Snowmelt and rain
Cause 2: Dike and dam breaks or releases (affecting only small areas)
Annuality: About 100 years, but only in the lower reaches of Bodrog and Tisza
Flooded area: 10,000 ha (mostly along Tisza tributaries), another 15,000 ha affected by groundwater

Comments:
Slovak Republic: Floods in several smaller rivers leaving the Tatra mountains damaged over 120 towns and villages and 2,000 hectares of agricultural land.
Hungary: The Danube reached a record level of 8.61 m in Budapest on April 5 (a 100 years event). Along the Körös confluence into the Tisza a dike was very close to a break.

- **Middle Danube: (Serbia, Croatia)**

Due to the very high discharges in the Danube and the Tisza at the same time, the Serbian Danube was hit by a nearly 100-year flood event. The backwater of the Danube flooded some lower reaches of the Drava and in particular the Sava, which was already effected by a 25-year flood event.
Duration: 4.4. -28.4.2006
People: 2 dead, 3,000 displaced, 1,000 households flooded
Damage: 40 million € for agriculture, at least 20 million € for infrastructure
Cause: Snowmelt, heavy rain (Sava 20-25 years event, lower Drava (Croatia) affected by backwater of the Danube, Osijek 30-40 years event)
Annuality: 100 years event
Flooded area: About 50,000 ha of arable land mostly alongside tributaries such as Begej and Tamis outside the recent floodplain; another 50,000 ha of arable land within the recent floodplain (however, this estimate seems unrealistic, as the recent floodplain, which was completely flooded (about 100,000 ha), is covered mostly by poplar forests and not by crops); another 110,000 ha affected by groundwater flooding

Comment:
Danube level was at 120-year-high in Belgrade, Tisza at 100-year-high and Sava at 25-year-high. Tamis had about 100-year flood on April 20. Waterway transport on the Danube was partially suspended in April and consequently less than one third of the average transport was conveyed. On the country scale, high groundwater levels caused more problems than direct flooding from the risen rivers. The situation was aggravated by complex flood forecasts and

partly insufficient transboundary communication (Hungarian Tisza, Sava polder in Croatia). Problems with siltation and aggradation (fine sediment deposited at the river bottom) of the Iron Gate I reservoir caused an insufficient drawdown of backwater and higher backwater levels further upstream.

- **Lower Danube: (Romania, Bulgaria, Moldova, Ukraine)**

The lower Danube reached a 100-year flood event within the stretch along the Romanian-Bulgarian border, flooding huge areas outside the flood protection dikes and leading to significant damages. In the Danube delta the flood did not reach such magnitudes.

Duration: 7.4. - 15.6. 2006
People: Romania: 14,120 displaced, Bulgaria: 63 displaced
Damage: Romania: 300, - million €: 156 settlements affected in 12 counties, 113 public and industry facilities, 600 km roads were flooded. Bulgaria: 50% of the town of Nikopol was flooded, 1100 buildings flooded, 700 km of roads submerged
Cause 1: Snowmelt from the upper Danube course (secondary by regional rain)
Cause 2: Dike breaks (long flood pressure and partly bad weather conditions endangered dikes) and controlled flooding (dike disruption)
Annuality: About 100 years; maximum discharge at Iron Gate release reached over 15,800 m^3/s on April 17 (highest ever recorded value was 15,900 m^3/s in 1895); Iron Gate dams were built for a maximum of 16,000-22,000 m^3/s (not considering the ongoing silting of the reservoir).
Flooded area: Romania: 95,900 ha of flooded land outside the dikes; including 21,000 ha controlled flooded area. Bulgaria: 5,500 ha of arable land outside the dikes.

Comments:
The Danube in Romania and Bulgaria reached the highest levels since 1895. In total, 13 main dikes broke in Romania. Dikes were artificially opened at Calaras and Fetesti, as well as along the Borcea-Branch and upstream from Tulcea (nevertheless, the local water table dropped only by some centimetres over a limited time). Near Bistret and Gostinu-Greace 250-400 million m^3 of water were released, Calaras polder was flooded with 300 million m^3. As a worst-case scenario (before the flood, the maximum area estimated to be at risk in Romania was 290,000 ha, which included 21,000 households), artificial flooding up to 92,000 ha was discussed. The opening of dikes was carried out according to the local situation, and in some places dikes were also breached in order to release waters from the polders after the flood. No damages major were reported from Ukraine, only leakage problems on the road from Reni to Orlovski (towards Izmail) and some overflowing of sluices to liman lakes.

1.2 Floodplain area comparison

During the last 150 years more than 80% of the former morphological floodplain area in the Danube river basin was lost due to intensive high water regulation works and construction of flood protection dikes (DPRP 1999). The percentage of loss along the Danube and its main tributaries varies between 28% (Danube delta) and over 95% near settlements all over the 2800 km long river course.

Areas were validated by our own GIS calculations, based on recent satellite data illustrating the 2006 floods. Where possible, the values given for the “flooded areas[3]” were compared to

[3] Areas given in hectares (ha) or square kilometres (km^2): 1 km^2 has 100 ha, as comparison the Lake Balaton in Hungary has 600 km^2 or 60,000 ha and the Danube Delta in Romania and Ukraine has 5,000 km^3 or 500,000 ha).

the extent of the recent and morphological floodplains[4]. They mostly indicate the flooding of land outside of the recent floodplain behind the flood protection dikes that was only directly caused by floodwater (dike breaks, dike overflowing) and not rising groundwater, which is particularly the case for the middle and lower Tisza and the Serbian Danube stretch.

The following tables (Tab. 2-6) summarize the extent of recent and morphological floodplains along the Danube in relation to the floods in 2006 and the future restoration potential, which will be discussed in more detail in the chapters 2 and 3. The data are based on investigations of the geomorphologic boundary of the (Holocene) floodplain in the Danube Pollution Reduction Programme (DPRP) study carried out in 1999, as well as other comparable approaches.

The dramatic loss of floodplains leads to a reduced overall river-floodplain cross section and the necessity to deepen and strengthen the main channel, which has adverse effects on the aquatic eco-systems such as the acceleration of flood waves, further bed incision leading to the lowering of the groundwater level, and habitat loss.

Table 2: Floodplain area comparison

	Size of floodplain				Flooded areas 2006		
	Morpho-logical floodplain [km²]	Recent floodplain [km²]	Floodplain loss [%]	Potential restoration area [km²]	Area flooded [km²]	Flooded potential restoration area [km²]	Flooded potential restoration area [%]
Tisza 600 km (HU, CS)	7,200	958	87	900 (1)	947	70	7
Sava 500 km (HR, BA, CS)	5,540	1,555	70	281 (2)	1073	60	21
Middle Danube 500 km (HR, CS)	2,770	1095	60	100 (3)	1110	0	0
Lower Danube 850 km (RO, BG, MD, UA)	9,080	2,310	75	2,250	3,300 (4)	900	40
Danube Delta 100 km (RO, UA)	4,150	2,990	28	1,000	2,010 (5)	95	10

1 Vasarhelyi Plan incl. Szamos confluence, Bodrog mouth, near to Novi Becej, according to DRPR study 1999
2 Mokro Polje, Drina mouth/Bosut, according to DRPR study 1999
3 According to DRPR study 1999 “Gornje Podunavlje”
4 Flooded outside the flood protection dikes
5 The delta was not completely flooded

4 For definition, see glossary

- **Tisza in Hungary and Serbia**

The Tisza River in Hungary and Serbia is a highly meandering lowland river building large floodplains and adjacent depressions behind the morphologically active walls of its banks. The Tisza was straightened over the past 170 years along about 35% of its river length, causing a bed incision of up to 2 m. The overall floodplain loss is estimated at 85%. In 2006, the most important affected tributaries were Bodrog and Körös (see Tab. 3).

Table 3: Floodplain area comparison Tisza

	Hungary [km²]	Serbia [km²]
Size of morphological floodplain [1]	5,450	1,750
Size of recent floodplain	900	58
(loss in %)	(85%)	(97%)
Flooded in 2006	882	65
Artificial polder opening	0	0
Potential restoration area	700 [2] 80 [3]	126 [4]
Flooded potential restoration area	60	10
(% of total potential restoration area flooded)	(8%)	(8%)

[1] Floodplain only, without groundwater influenced areas
[2] Vasarhelyi Plan
[3] Bodrog mouth
[4] Novi Becej, and Bodrog mouth identified in GEF study

- **Sava in Croatia, Bosnia & Herzegovina and Serbia**

The Sava River is the most important tributary of the Danube in relation with discharge. The river is ccharacterized by a long upper stretch, a very short middle stretch around Zagreb and a very long lower stretch down to the confluence in Belgrade. The Sava still has large retention and floodplain areas in the reaches near the Lonjsko Polje, where the ratio of floodplain loss is quite small (Tab. 4). The most important affected tributaries in 2006 were Drina and Bosna.

Table 4: Floodplain area comparison Sava

	Croatia [1] & Bosnia and Herzegovina [km²]	Serbia [km²]
Size of morphological floodplain	4,260	1,280
Size of recent floodplain	1,230	325
(loss in %)	(71%)	(75%)
Total area flooded in 2006	743	330
Artificial polder opening	0	0
Potential restoration area	181 [2]	100 [3]
Flooded potential restoration area	40	20
(% of potential restoration area flooded)	(22 %)	(20%)

[1] Downstream from the city of Zagreb
[2] Mokro Polje, Drina mouth, GEF study
[3] Drina mouth/ Bosut, GEF study

- **Middle course of the Danube in Croatia and Serbia**

The Danube follows the Pleistocene loess terrace in the south, where the recent floodplain is rather limited, and receives the important tributaries Drava, Tisza and Sava. The most important tributaries that were affected in 2006 were the Begej, Sava and Tamis (Tab. 5).

Table 5: Floodplain area comparison Middle Danube

	Danube in Serbia, Croatia (1) [km²]
Size of morphological floodplain	2,770 (1)
Size of recent floodplain	1,095(1)
(loss in %)	(60%)
Flooded in 2006	1,110 (1)
Artificial polder opening	No information
Potential restoration area	100
Flooded potential restoration area	0

[1] Includes the morphological floodplain in Croatia (500 km²) and recently flooded area (300 km²)

- **Lower Danube in Romania, Bulgaria, Moldova and Ukraine (including Danube Delta in Romania and Ukraine)**

Steep banks and terraces line the Danube floodplain along the Romanian-Bulgarian border. The floodplain width in this region is 5-10 km, which is low in comparison to parts of the middle course in Hungary and Serbia or the downstream reaches near Galati (up to 25 km). The Danube Delta is the least impacted floodplain area along the entire Danube, with only 28% of the natural floodplain area lost.

Table 6: Floodplain area comparison lower Danube and Danube Delta

	Lower Danube(1) [km²]	**Danube Delta** [km²]
Size of morphological floodplain	9,080 (2)	4,150 (3)
Size of recent floodplain	2,310	2,990
(loss in %)	(75%)	(28%)
Flooded in 2006	3,300 (4)	2,510 (5)
Artificial polder opening	210	Two small releases
Potential restoration area	2,250	1,000
Flooded potential restoration area	900	95
(% of potential restoration area flooded)	(40 %)	(10%)

[1] From Iron Gate to the beginning of the Chilia/Kilija branch (10 km upstream of Tulcea)
[2] Based on the Atlas 2004 of the WWF Aueninstitut LDGC 1: 200,000
[3] Without lagoon complex in the South
[4] About 990 km² were flooded outside the flood protection dikes
[5] The delta was not completely flooded in April/ May 2006

1.3 Summary and discussion

About 75% of floodplains have been lost in the middle and lower Danube, mostly along the Tisza, and the Sava. Only a few areas still contain large natural floodplain complexes that are capable to mitigate flood risk. These areas include the Drava-Danube confluence (Kopacki Rit), the Lonjsko Polje or Obedska Bara areas along the Sava, the small Braila island along the Danube, and finally the Danube Delta.

An estimation of the restoration potential must take the local situation into account e.g. land availability, floods dynamics and ecological values of such areas (see also Chapter 3.1.2). As most of the floodplains were cut from the river in the 1960s and 1970s (especially in the middle and lower Danube), the potential to restore the floodplains that are still largely intact along with the potential for flood risk mitigation remain high, but these potentials are limited by political agreements and the ownership of land in the restoration areas.

2. Feasible restoration sites on the lower Danube

Based on a first analysis of the largest flooded areas along the lower Danube and availability of data, four case study sites were selected as restoration areas to study their flood mitigation potential (chapter 1.3, see Fig. 4). In the following sections Bistret-Rast (Balta Bistret), Dabuleni (Balta Potelu), Oltenita-Calarasi (Balta Calarasi) and the island of Calarasi-Raul are described in more detail. Other areas outside the flood protection dikes should also be considered as potential restoration sites, although they are not described in the following chapters (e.g. Ialomita confluence with some 5,000 ha, parts of the Borcea branch with some 1,500 ha, and several smaller areas in Bulgaria).

Along with the floodplain restoration potential, side channels must be reactivated in order to improve discharge capacity during floods, particularly around settlements. The restoration of additional sites is recommended for further hydromorphological improvements, e.g. closed side channels at narrow recent floodplain stretches near the town-pairs of Vidin/Calafat, Lom/Rast, Ruse/Giurgiu, Tutrakan/Oltenita and Calarasi/Silistra, but also tributary confluences and long side channels parallel to the main channels within the morphological floodplain.

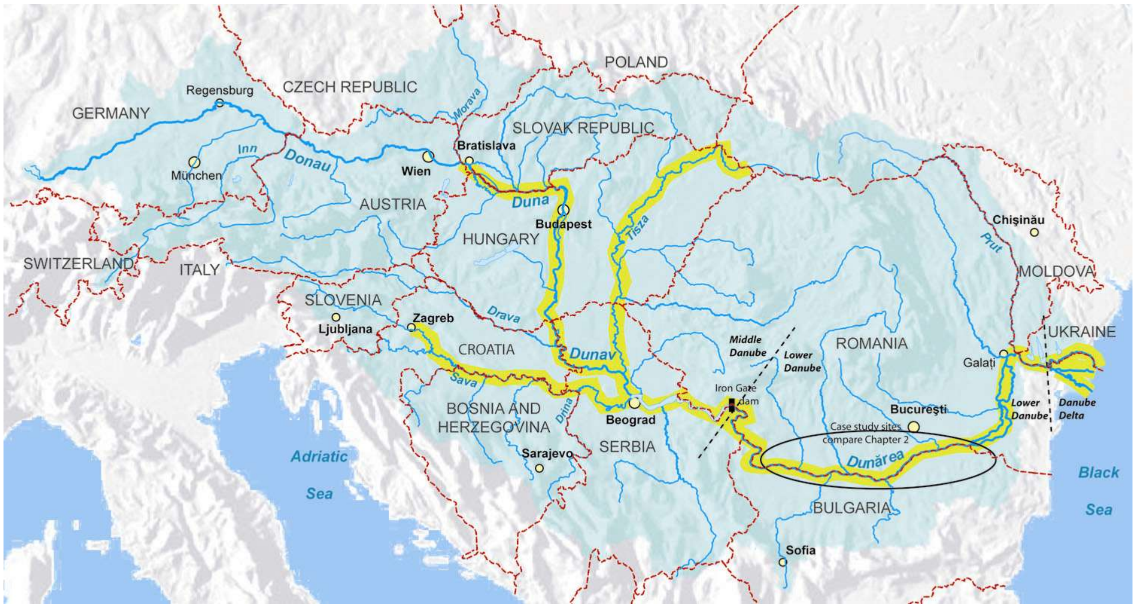


Figure 4: The Danube River Basin. Rivers that have been analyzed in this study are highlighted in yellow. The middle and lower Danube and the Danube Delta are separated with dotted lines. The black ellipse indicates the region of the four case studies described in this chapter.

2.1 Characterization of the four potential retention areas

- **Balta Bistret**

The Balta Bistret is located near the small towns of Bistret and Rast and upstream from the Jiu confluence (about 700 rkm of the Danube, Fig 5). The floods heavily affected it in 2006, with the largest extent of flooded areas outside of the flood protection dike (over 27,000 ha). More than 8,000 people were displaced.

- **Balta Potelu**

The Balta Potelu is located just downstream from the Balta Bistret near the small town of Dabuleni (about 680 rkm of the Danube river). The eastern part of the area was almost entirely flooded by two subsequent dike breaks. Nearly 2.500 people were displaced and at least 6,000 ha of fields were flooded.

- **Balta Calarasi**

The Balta Calarasi is located between the towns of Oltenita and Calarasi (at about the 400 rkm of the Danube). It is the last large floodplain of the Romanian-Bulgarian border stretch before the Danube turns northwards. In this area no villages were flooded, mostly agricultural areas that were hit. About the half of the area was affected by very high groundwater levels.

- **Calarasi-Raul Island**

The Calarasi-Raul Island is located east from Calarasi (at about the 380 rkm of the Danube). It is situated between two Danube branches and therefore is still an actual island ("balta"). The first restoration project in the eastern part of the island was carried out in the last years. On 17 April 2006 the western part of the island was flooded (see Map 3).

Figure 5: Danube near Bistret (on the right side) showing the very narrow river corridor between the Bulgarian bank (on the left side, mostly limited by natural terraces) and the flooded polder area with dike breaks and overtopping turbid Danube water in the fore- and background (for reference see the bottom of the picture)

Figure 6: Danube near Kozloduj and the Jiu confluence (right) showing the completely flooded recent floodplain (flood water below the forest canopy is not visible) between the flood protection dikes and highlighting the importance of intact side channels that increase the discharge capacity.

2.2 Impacts of the spring flood 2006

The following maps for each of the case study sites show:

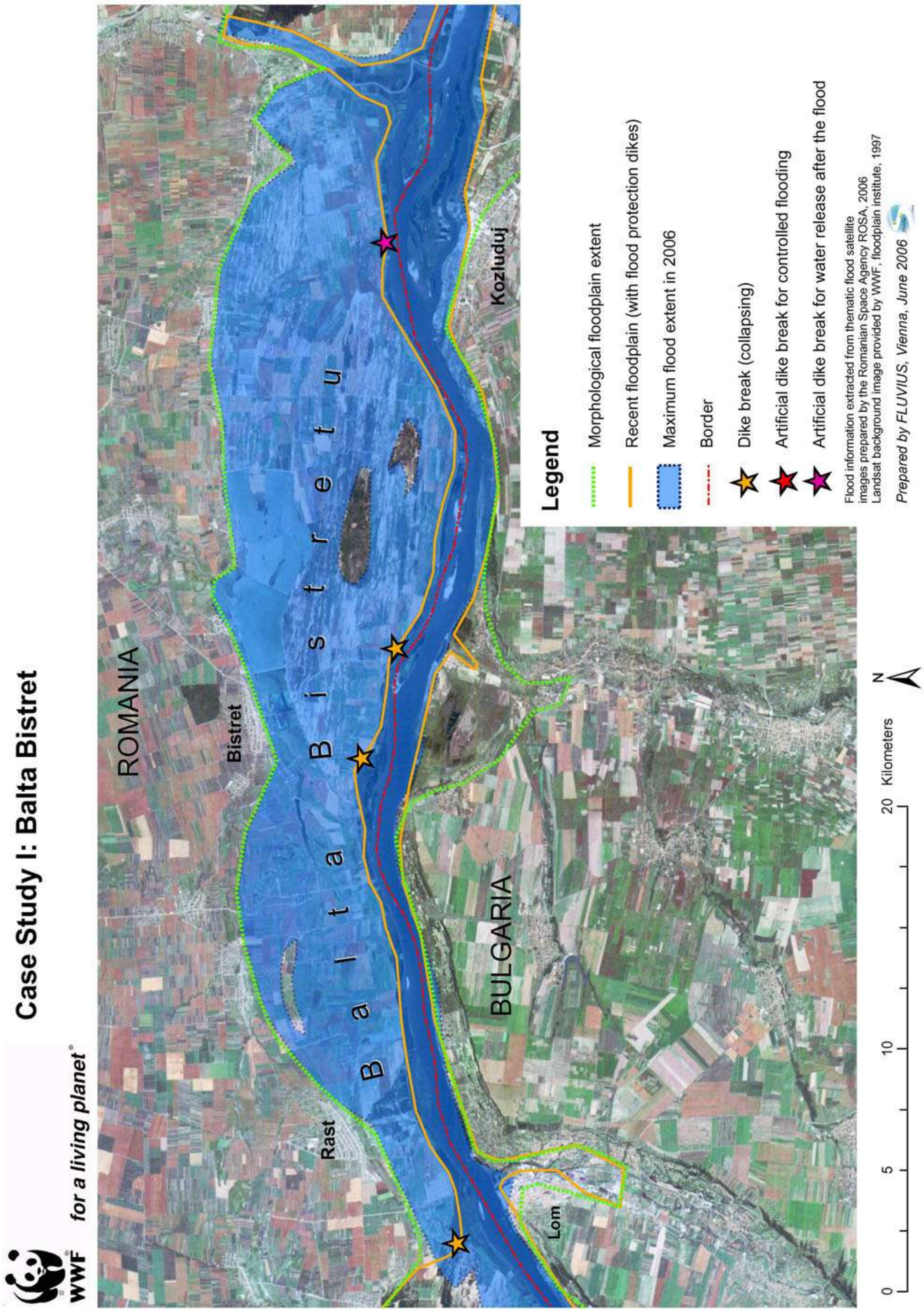
1. The extent of morphological (former) floodplains

2. The recent active floodplains mostly within the flood protection dikes

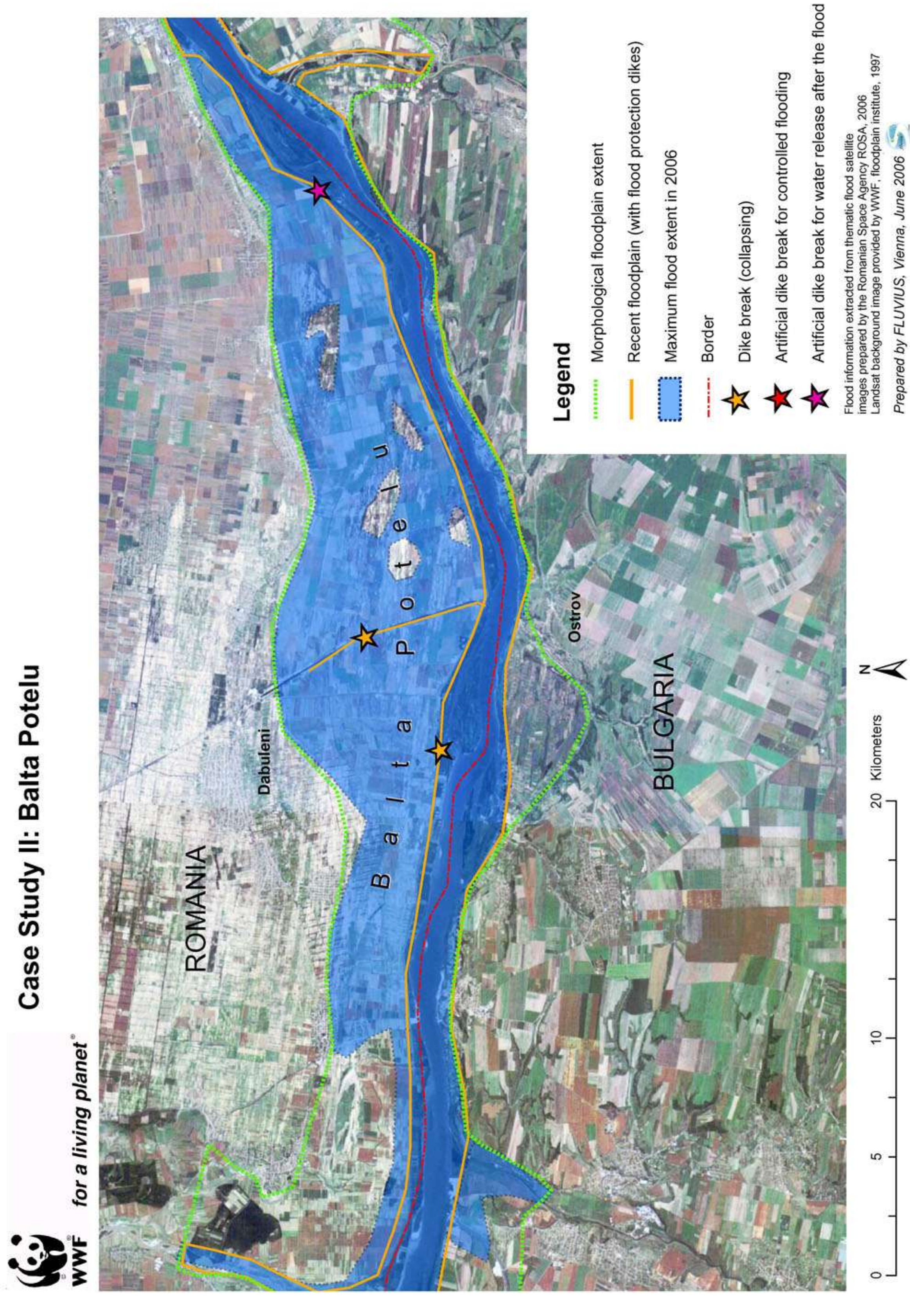
3. The extent of maximum flood in 2006

4. Three types of dike breaks:
    a. collapsed dikes
    b. artificially opened dikes to lower the water table
    c. artificial opened dikes to release the water from the areas after the flood

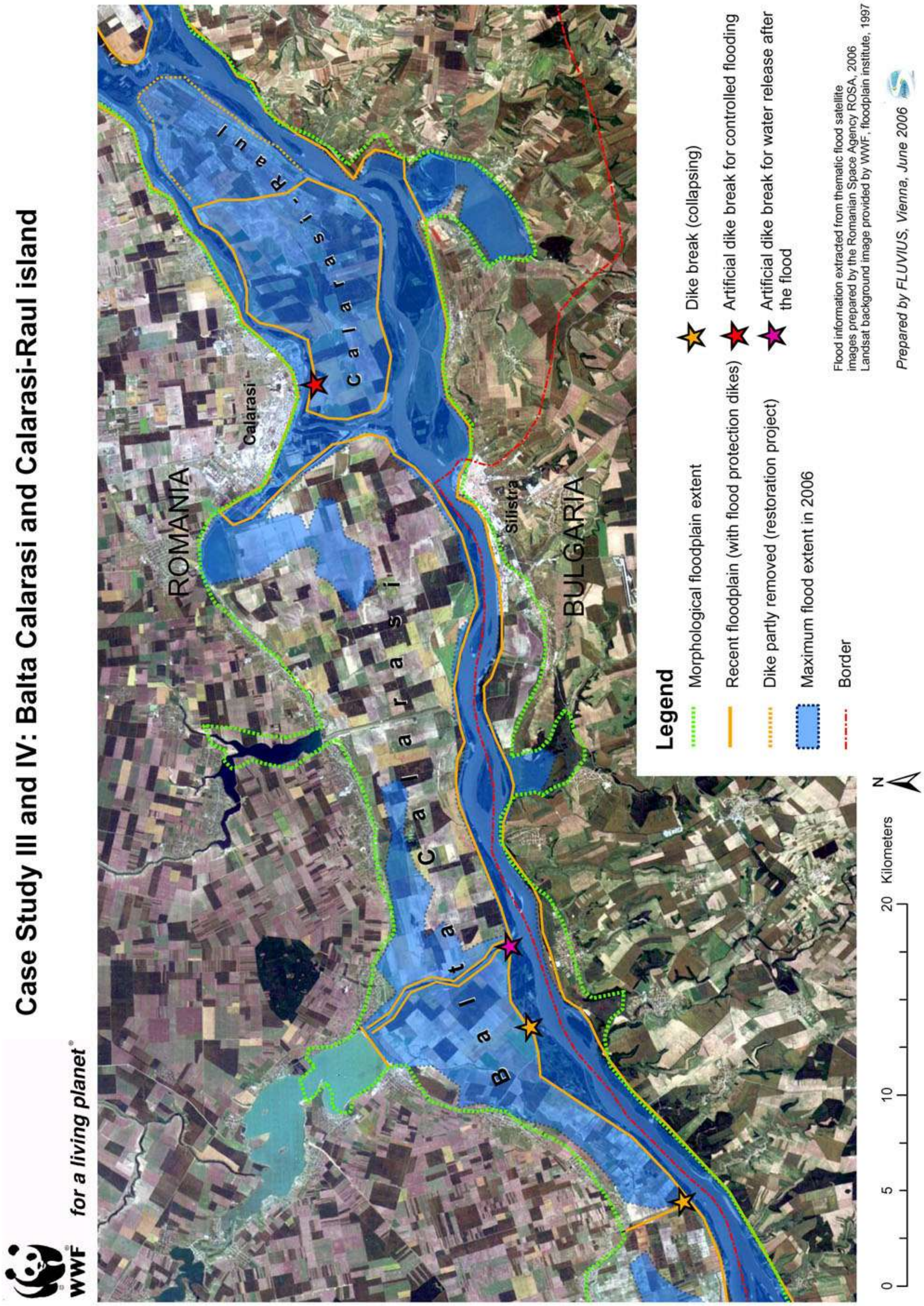
Map 1: Case Study I: Balta Bistret



Map 2: Case Study II: Balta Potelu



Map 3: Case Study III and IV: Balta Calarasi and island Calarasi-Raul



- **Floodplain delineation, floods 2006 and retention volume**

This section focuses on the extent and delineation of the affected areas and calculation of retention volume, based on the overview calculations of the recent and morphological floodplain area in the last chapter (see Tab. 7). The morphological floodplain delineation was derived from the LDGC Atlas of the WWF Floodplain Institute[5].The area size was extracted using GIS, including the best available flood satellite images. The largest visible flood size was mapped for each area. This exercise revealed a significant loss of the floodplain – over 90% was destroyed - due to the construction of flood protection dikes and the melioration during the 1970s.

An area's retention volume depends on many factors. For simplicity it was assumed that the area is mostly flat. Potential water depth is not extractable from the analysed data because an elevation model and a two-dimensional flood model would be necessary to estimate the retention volume in detail. As an initial and rough estimation, the volume was derived by multiplying the size of the area with an average storage height of 1.5 m (2.5 m for the Calarasi-Raul island). This is a quite conservative assumption of storage height for polders but allows more elevated remote areas to be taken into account. The calculated volume values correspond rather well with the officially published data.

Table 7: Floodplain size of case study sites and retention volume

	Morphological floodplain outside the flood protection dikes [ha]	**Recent floodplain** without the Danube channel [ha]	**Flooded area** outside of the flood protection dikes [ha]	**Potential retention volume** [million m^3]
1. Balta Bistret	27,950	2,600	27,600	415
2. Balta Potelu	28,870	2,890	20,050	300
3. Balta Calarasi	31,350	3,110	12,010	180
4. Calarasi-Raul island	10,750	3,750	10,750	270

- **Human and economic loss during the 2006 flood event**

Along the Romanian Danube, a total of 650 houses were totally destroyed. Table 8 shows the human and economic loss incurred in 2006 and clearly indicates the dramatic situation in the Balta Bistret (villages of Bistret and Rast), where over 8,000 people had to be evacuated during the flood.

Table 8: Damage done by floods on productive land and on human well-being

	Evacuation	**Loss of productivity**
1. Balta Bistret	8,322 displaced	11,126 ha arable land flooded
2. Balta Potelu	-	8,200 ha arable land flooded 5.900 ha forest flooded 2.600 ha pastures flooded
3. Balta Calarasi	2,480 displaced	1,222 ha arable land lost 4.686 ha arable land lost
4. Calarasi-Raul island	-	7,450 ha arable land lost [(1)]

[1] Presently not part of the recent restoration project (5 million USD World Bank project on "nutrient reduction and sustainable agriculture practices")

[5] WWF Floodplain Institute (2004): Atlas LDGC 1st edition 2004, 1: 200,000

- **Land use: historical uses and benefits**

The current uses of the former floodplain, mostly characterized by agriculture and forestry, can be taken from the European CORINE land use classification and compared to the historical situation taken from historical maps and aerial images (compare Fig. 7 and Tab. 9). Further assumptions about the land uses and main habitat types should be made from more detailed studies of the surrounding areas, where available. Analysis of the satellite images from the 1960s - before the polders were built - allows to quantify the most important aquatic and semi-aquatic structures of the riverine landscape, as well as the forests.

Figure 7: Former floodplain of the Balta Calarasi in 1962 before the establishment of the agricultural polders and melioration (compare Map 3).

Table 9: Historical and current land of the case study sites
(Calculations based on Baltu Potelu, comparable to all sites, though some are more intensively used)

Historical land use and habitats	Current land use [(1)]
Water bodies and swampy vegetation	Arable land
60%	75%
Pastures	Meadows
30%	23%
Wood	Forests
10%	2%

[1]Mostly public/state ownership

Floodplain ecosystems provide a broad range of services such as the provision of fish, reed, wood, drinking water, nutrient reduction/storage and flood risk mitigation among others. To estimate the floodplain values, several studies relevant for the lower Danube were reviewed. The evaluation scheme of the publication “10 years of restoration in the Danube Delta”[6] for the pilot project *Babina & Cernovca polders* was used to estimate the added value of a restored floodplain. The assessment uses the parameters for economical values (fish, reed, pasture/cattle) and ecological values (water storage, nutrient removal, sediment retention, habitat for birds and fishes, aesthetic value). The benefits of restored floodplains were calculated for fish, reed, cattle and tourism, with an overall value of about 40, - € per ha/year.

[6] WWF Floodplain Institute with Danube Delta Biosphere Reserve Authority and Danube Delta National Institute 2004

For the nutrient reduction (nitrogen, phosphorus) in floodplains the literature still differs highly, ranging from 250 to 800, - €/ha/year (see also Barbier et al 1997).

A large scale calculation of the economic values for the restored lower Danube, Kettunen and ten Brink (2006) estimate the benefits based on Romanian expert estimations for nutrient reduction, provision of fish, reed, crops, vegetables, animals and tourism, at 1,354, - € per ha/year. The difference is mostly based on the nutrient reduction (in this study 870, - €/ ha/year). Another WWF study calculates the value based on provision of fish, forestry, animal feeding, nutrient retention as well as recreation and gives an estimate of about 380, - € per ha/year (WWF 1995).

Based on these highly differing economic values, an average value was calculated to be around 500, - € /ha/year. The average income from agricultural land in Eastern Europe can be estimated at about 450,- €/ha/year (net farm income based on data from Lithuania[7]). This does not include any agricultural subsidies.

- **Implementation costs for floodplain restoration**

The costs of floodplain restoration, which can fluctuate significantly, depend on whether the dike is breached or removed (by one or several small openings or removal of the longer stretches) and whether reinforcement of dikes on other stretches is possible. For the restoration of the eastern part of the Calarasi-Raul island, 800,000, - € was spent for dike replacement (the size of the restoration site is about 3,300 ha). Unfortunately, no values for the change in land use and subsequent compensation are available from this case as yet. Other solutions, such as the Hungarian Vasarhelyi Plan, are much more expensive, about 14,000, - €/ha due to high investment costs into infrastructure (dikes, water inlets and outlets). In the Western European countries the costs for a dike relocation project with structural works is estimated at about 1-2 million €/km^2 plus land use compensation, depending on the local situation and land rights. The latter cost can be much higher than the planning and construction costs. To enhance the hydromorphological situation along straightened river reaches closed side channels need to be reconnected and the riverbed needs to be widened in addition. In Western European countries the removal of such bank protection infrastructure are likely to reach about 150,000 €/km. In countries like Romania the costs can be estimated to be four times lower.

Therefore, only a basic estimation for each area is shown following the methodology presented in Kettunen & ten Brink (2006; see also Tab. 11 on p. 26). The restoration costs are compared with the potential values of restored floodplains. This calculation is based on the land use characteristics of Balta Potelu by using an average value of about 500, - € /ha/year, as described above.

- **Existing political agreements and their implementation**

For the lower Danube, the LDGC agreement signed in 2000 and its stepwise implementation is the most important framework for floodplain protection and restoration. The four case studies belong party to the area that has been designated for further restoration work (current state of implementaion, see Tab. 10). The ICPDR is the most important international body whose mandate is to promote the cooperation of Danube countries and lead the implementation of the EU Water Framework Directive (WFD) in the Danube river basin. The purpose of the WFD is to establish a framework to protect all waters (inland, transitional, coastal and groundwater), with

[7] Segrè A. & H. Petrics (2005)

the aim of achieving 'good status' in all European waters by 2015. It is an innovative legislation, which brings a holistic and modern approach to water management across the EU - Integrated River Basin Management (IRBM) on a river basin scale. This is based on the natural functioning of freshwater ecosystems, including wetlands and groundwater. It follows that management of river basins must include maintenance of ecosystem functions as a paramount goal. Under the provisions of the Directive, the Danube River Basin Management Plan should be prepared by 2009 addressing key water management issues including hydro-morphological alterations, flood risk management and floodplain/wetland restoration among others.

Table 10: Political agreements

	Political agreements	Implementation
1. Balta Bistret	Bistret-Nedeia-Macesu: 1080 ha [(1)]	No
2. Balta Potelu	LDGC: 23.300 ha	No
3. Balta Calarasi	Not part of the LDGC	No
4. Calarasi-Raul island	Ostrovul Calarasi-Raul: 13.050 ha [(2)]	WWF project: 3,300 ha [(3)]

[1] Only a small part was proposed as restoration side in the LDGC
[2] Calculated for the LDGC
[3] Lower Calarasi area

2.3 Summary and discussion

- **Realistic size for restoration of the case study priority sites**

The proposed case study sites for the lower Danube comprise at least 75% of the area flooded during April/May 2006. This area comprises only some (mostly illegal) settlements and not a much infrastructure. Since most of the land is not in private ownership, the area as a whole should be considered for restoration. Exiting settlements, of course, needs improved flood protection and the accessibility for important border facilities along the Danube River should be ensured.

Maximum restoration size:

Bistret-Rast: 27,950 ha
Dabuleni (Balta Potelu): 28,870 ha
Oltenita-Calarasi (Balta Calarasi): 31,350 ha
Calarasi island (Calarasi-Raul): 10,750 ha (3,300 already existing)

Total: 98,920 ha

- **Total volume for flood retention**

The experiences gathered during the flood in 2006 can give valuable indications of the retention volume in the proposed sites. As explained above, the estimated flood retention volumes for the proposed sites can be seen as average to average-low estimations:

Balta Bistret: 420 million m^3
Balta Potelu: 430 million m^3
Balta Calarasi: 470 million m^3
Calarasi island (Calarasi-Raul): 270 million m^3

Total: 1,59 billion m^3

- **Rough estimation of restoration costs**

The estimated costs from existing projects are quite different for Hungary and Romania. In the case of Hungary, expensive facilities are planned in order to set up a new polder system along the Tisza, partly separated from the river by means of building inlets and outlets (structures through which the flood waters enter or leave the reservoir).

In Romania, the costs of restoration depend directly on the costs of removing the dikes, which range between 50-200,000 € per km, depending on the size and material of the dike. For large parts of the restoration area, the compensation for agricultural land is much more expensive then the dismantling/decommissioning costs. Our preliminary calculations show a total restoration cost of €19,784,000 for all four case study areas. Using the average value of € 500 per ha/year as an estimate for the socio-economic and ecological value generated from resorted floodplains, the case studies show a total value of € 49,460,000. Table 11 provides detailed costs and benefits from the respective case studies.

Table 11: Rough estimations: Restoration costs vs. potential value of floodplain

	Restoration costs calculated at 20,000 [€/ km²]	**Values of potentially** restored floodplain area [€/ year] (1)
1. Balta Bistret	5,590,000	13,975,000
2. Balta Potelu	5,774,000	14,435,000
3. Balta Calarasi	6,270,000	15,675,000
4. Calarasi-Raul island	2,150,000	5,375,000

[1] Calculations based on Balta Potelu, average value used: 500 €/ha/year

- **Effect on flood risk mitigation in comparison to the floods in 2006**

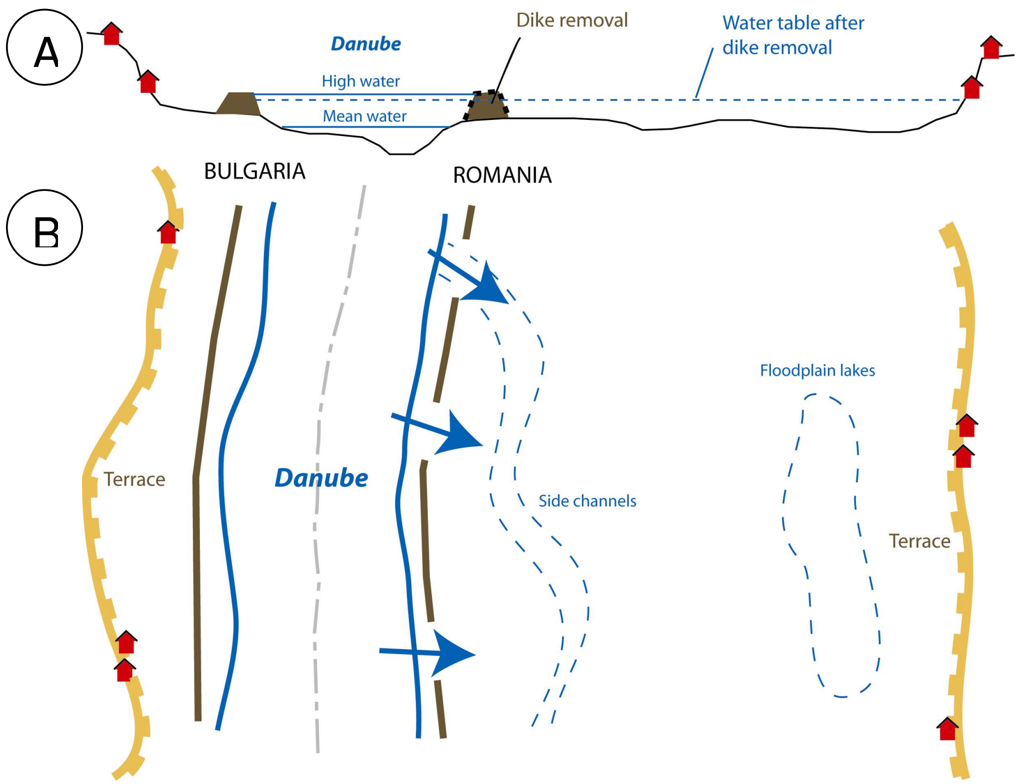
For the Danube an estimated reduction of about 10-40 cm is realistic if about 2 billion m³ along the lower Danube were retorted[8] The higher values (up to 40 cm) are calculated for areas close to restoration sites where the dikes need to be opened (see blue arrows in Scheme 1 on page 27). Lower values (10-20 cm) are estimated for all areas between potential restoration sites without dike removal. In addition, the flood risk can be mitigated by reconnecting side channel systems and widening of the floodplains upstream of settlements. Both, the ecological and socio-economic analysis of the case study sites show clear advantages for restoration over pure technical polder management. Floodplain services, reduced compensation costs after stochastically occurring flood damages and ecological values have to take into account for the development of new flood management plans along the lower Danube.

- **Discussion**

Based on maps and aerial pictures from the 1960s, the former ecological importance of the stretch of the Danube forming the border between Bulgaria and Romania is estimated to be very high. The floodplain was flooded periodically and hosted a wide variety of water bodies (e.g. long side channels, large floodplain lakes) and wetland complexes with floodplain forests, reed and pioneer habitats. Since the Danube serves as the border between the two states, large areas in the “Baltas” are still publicly owned, which should facilitate their restoration and further use for flood mitigation purposes. However, the experience from recent restoration projects (Danube Delta, Bulgarian floodplain) is very different and the implementation should

[8] The calculations are based on a Danube flood event with 15,000 m³/s in the lower Danube over 15 days and a potential average flooding depth in the retention areas of 2 meters. This represents the volume of the four case study sites plus about additional 500 million m³.

not underestimate land compensation or the overall acceptance of measures amongst the local population. The involvement and support of local people will be very important when launching restoration activities. The combination of sustainable land use, river protection and restoration, and flood protection must be considered right from the beginning of future planning processes. This is crucial to generate both economic values and ecological benefits.



Scheme 1: Lowering of the flood water table based on the reconnection of the former floodplain in Romania (A) cross section, (B) overview.

3. Lessons learned from flood risk management projects and initiatives

3.1 Lower Danube Green Corridor (LDGC)

In the LDGC agreement, the signing parties (Bulgaria, Moldova, Romania and Ukraine) pledged to establish a corridor of about 7.740 km² of existing protected areas and 3,000 km² of planned protected areas (Danube Delta: 5800 km² RO/ 460 km² UA and 20 km² MD), along the nearly 1000 km stretch of the Danube from the Iron Gate to the Delta. All in all, a total area of 2.250 km² (an area almost four times larger than Lake Balaton) is proposed for restoration. This restoration is based on comprehensive ecological assessment along the whole corridor, including ecological improvements for the main channels and tributaries.

In the mid-1990s the first large-scale restoration of Delta polders was carried out. The urgency of flood mitigation measures should speed up the ongoing and further restoration projects under this agreement.

The flooded area outside the flood protection dikes in 2006 clearly showed the importance of the restoration of the whole morphological floodplain areas along the Romanian-Bulgarian border stretch of the Danube instead of scattered small areas.

3.2 Tisza flood management plan ("Vasarhelyi Plan")

Hungary is preparing a flood protection scheme (the so-called "Vasarhelyi Plan"), outlining plans for 14 retention reservoirs with a total size of 70,000 ha (700 km²) along the Tisza River. The planned retention capacity of these reservoirs is over 1.7 billion m³, a volume that would lower the flood peak water level by about 1 m. The water level in the reservoirs can reach up to 5-6 m depending on the flooding situation.

These reservoirs will be artificially created and surrounded by dikes with inlets and outlets, including possible natural levees or existing dikes. Farmers owning land in the emergency reservoirs will be encouraged through financial incentives to convert current agricultural land to land uses that can recover from occasional flooding more easily. This implies a change from growing grain to using the areas as meadows for hay, grazing or fish farming. Farmers will also be compensated for losses when the reservoirs are flooded. However, a more effective solution would be to use the natural deep areas surrounded by natural high borders. Scientific models and calculations (by the Budapest Technical University) has proved that even more water can be safely displaced in case of extreme floods without the risk generated by artificial dyke systems.

In total, about 0.5 billion Euros over the next 15 years will be spent on the project. Possible expansion is discussed, such as the reconnection of morphological floodplain structures outside the dike ("Nagy-fok system"). National and regional water management authorities in cooperation with the rural planning authorities carried out the overall planning for the "Vasarhelyi Plan". Additionally, land use and nature protection aspects were highlighted by WWF Hungary. Cigand-Tiszakarad and Tiszaroff are two projects currently being implemented:

Table 12: Current projects on the Tisza in Hungary

Case study site	Average flood situation		In case of big flood event	
	Surface:	Volume:	Surface:	Volume:
1. Cigand-Tiszakarad	24.7 km²	46 million m³	24.7 km²	94 million m³
2. Tiszaroff	14.3 km²	22.8 million m³	22.8 km2	97 million m³

3.3 Sava 2000 Programme

The Sava 2000 programme is based on a flood control scheme for the central Sava basin. It has been developed by the UN in the 1970s and aims to enlarge the existing 110,000 ha to 117,000 ha. This is equal to an increase of retention capacity from about 2 billion m³, to 2,1 billion m³. In comparison with the "Vasarhelyi Plan" for the Tisza and the optimistic proposed LDGC (retention volume 1,5-2 billion m³), the Sava Programme represents already a leading example for ecologically sound large-scale flood mitigation (see Brundic 2001).

3.4 Danube and selected tributaries large floodplain areas with high potential for flood risk mitigation

The following chapter goes beyond the four case studies and deals with a wider scope of flood protection in the entire Danube basin. As presented in the previous chapter, the 2006 floods took place over large parts of the DRB. The overview map (see map 4) indicates the most important retention areas, and in particular highlights the potential restoration sites that could increase the area and volume of future retention areas, thus supporting the flood risk mitigation and ecological river rehabilitation.

Besides the already proposed restoration sites (UNDP/GEF wetland study from 1999). additional areas must be proposed based on realistic estimations concerning the retention volume, the flood dynamics, and the current land use, and taking into account the existing plans for flood mitigation and ecological restoration in those areas. The complexity and size of retention areas in the upper, middle and lower river catchments must be considered as well.

Remaining large floodplains, such as the Kopački Rit (Fig. 8) illustrate the important role that floodplains play in regional flood risk mitigation. 2006 saw the flooding of the entire floodplain of the Kopački Rit, as well as the adjacent areas from the Danube river km 1367 to 1409 (42 km) with a size of 26,500 ha. The retention volume of this area is about 700 million m³. As the area is naturally flooded, the lowering of the flood peak is smaller than with a managed polder, but still exceeds at least 0,5 m in comparison with measurement stations upstream from the Kopački Rit (Mohacs in Hungary). The floodplain retains water and considerably slows the rise of water levels.

Figure 8: View of the flooded Kopački Rit during the 2006 flood at river kilometre 1,388 from the main river with navigation signs (photo by Boris Bolsec, Nature Park Kopački Rit)

The following map and table show large floodplain areas with high potential for flood risk mitigation and restoration for the Danube and selected tributaries.

Map 4: Large floodplain areas with high potential for flood risk mitigation and restoration for the Danube and selected tributaries

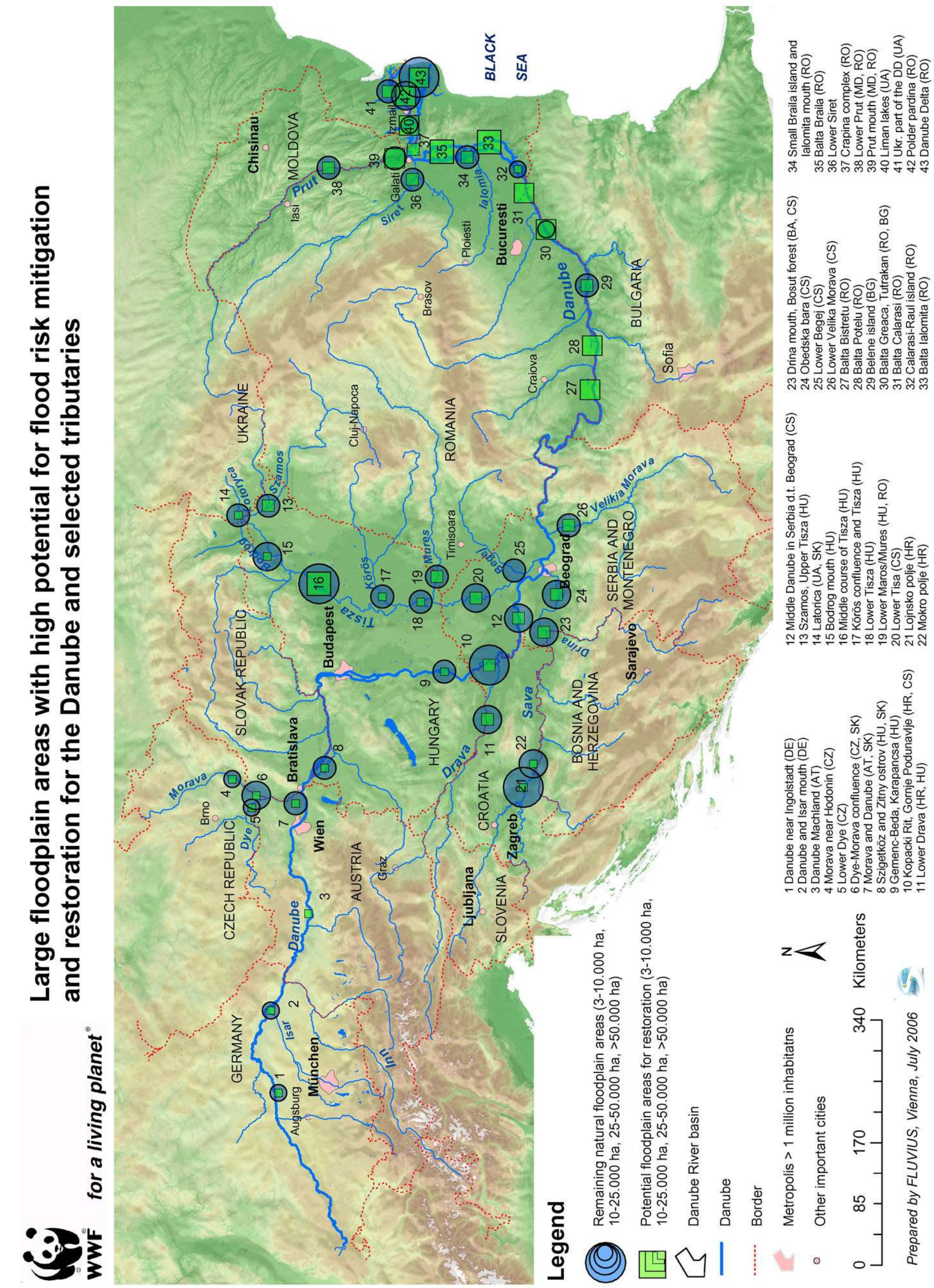


Table 13: Large floodplain areas and preliminary estimation of potential restoration areas

River, Name and Country	**Recent floodplain** without restoration potential [ha]	**Restoration potential** preliminary estimation [ha]
1. Danube near Ingolstadt (DE)	1,500	1,125
2. Isar mouth (Danube; DE)	1,700	1,000
3. Danube, Machland (AT) [1]	4,500	0
4. Morava, Hodonin (CZ) [2]	7,500	2,850
5. Lower Dye (CZ)	8,000	2,000
6. Morava-Dyje confluence (CZ, SK, AT)	30,000	5,000
7. Donau-March Floodplains (AT, SK)	21,500	2,100
8. Szigetköz / Zitny Ostrov (HU, SK)	15,000	5,000
9. Gemenc-Beda Karapancsa (HU)	25,000	5,000
10. Kopacki Rit / Gornje Podunavlje (HR, CS) [3]	50,000	20,000
11. Lower Drava (HR, HU) [4]	30,000	10,000
12. Middle Danube Corridor (CS, HR)	30,000	15,000
13. Szamos, Upper Tisza (HU)	20,000	10,000
14. Latoryca (UA, SK)	15,000	1,000
15. Bodrog mouth and Tisza (HU)	28,000	8,000
16. Middle course of the Tisza (HU)	100,000	50,000
17. Körös confluence and Tisza (HU)	10,000	6,000
18. Lower Tisza (HU)	15,000	12,600
19. Lower Mures/ Maros (HU, RO)	20,000	10,000
20. Lower Tisza (CS)	15,000	6,000
21. Sava, Lonjsko Polje (HR)	50,000	1,000
22. Sava, Mokro Polje (HR)	30,000	7,100
23. Drina mouth with Bosut forest (BA, CS)	45,000	21,000
24. Sava, Obedska Bara (CS)	25,000	10,000
25. Lower Begej (CS)	20,000	0
26. Lower Velika Morava (CS)	20,000	10,000
27. Danube, Balta Bistret (RO)	0	28,000
28. Danube, Balta Potelu (RO)	0	29,000
29. Danube, Belene island (BG) [5]	18,000	10,000
30. Danube, Balta Greaca, Tutrakan (RO, BG) [6]	1,100	43,200
31. Danube Balta Calarasi (RO)	0	31,000
32. Danube, Calarasi-Raul island (RO)	3,300	8,000
33. Danube, Balta Ialomita (RO)	0	70,000
34. Danube, Small Braila island, Ialomita Confluence (RO)	15,000	10,000
35. Danube, Balta Braila (RO)	0	78,000
36. Lower Siret (RO)	15,000	10,000
37. Danube, Crapina complex (RO)	0	10,000
38. Lower Prut	20,000	10,000
39. Prut confluence	20,000	30,000
40. Liman Lakes	8,000	30,000
41. Ukrainian Delta (UA) [7]	12,000	15,000
42. Polder Pardina (RO)	0	29,000
43. Danube Delta (RO)	300,000	40,000

[1] Other areas proposed for Austria: 11,000 ha restoration sites on 23 selected tributaries (WWF AT, 2006)
[2] Proposal for an ecologically sustainable Morava flood management (NGO "UNION for Morava")
[3] Proposed. Large trans-boundary Biosphere Reserve
[4] Proposed. Lower Mura, middle Drava with another 25,000 ha
[5] Only minor effects on the retention, very slow implementation
[6] Very slow implementation, max. 1.500 ha so far
[7] The size of limans is much higher, depending on the delineation of the Danube floodplain

3.5 Regulatory framework and law enforcement

- **Existing law enforcement**

The active floodplains of rivers ("recent" floodplain) are used for many purposes, including water management, monitoring, farming, forestry, and housing. Areas close to rivers are popular spots to settle, especially in cities and in holiday areas. In Budapest, new "housing parks" often advertise themselves as "holiday-like wellness centres" close to the river and water sports. Local governments spend state money to build or enforce dikes in order to protect these luxury real estates, increasingly narrowing the river's space.

The extremity of the recent floods illustrates the need for the revision of the legal framework and the implementation of serious enforcement. For Hungary, a revision of the Governmental Decree involving the function and use of "recent" floodplains was discussed in spring 2005. The new law prohibits new buildings in the recent floodplain and regulates the land use.

Laws and regulations should reflect the function of the river as an ecological phenomenon. Integrated solutions that include the catchment area can solve problems related to floods, water management, land use and socio-economic issues. Building flood protection structures increases the speed of the water down-stream, generating even more serious problems especially in cases of parallel flooding of tributaries. Developing such a solution involves national and international responsibility, and it lies in the widening of the floodplain, providing more space for the river and for floodwater.

- **Water Framework Directive**

Timely and effective implementation of the WFD (for definition see chapter 2.1 under 'Existing political agreements and their implementation') will also help mitigate flood risks. The Integrated River Basin Management (IRBM) approach, enshrined in the WFD as a legal context for water management in Europe, is also the internationally recognised vehicle for delivering flood risk management. IRBM is based on the joint assessment of the needs and expectations of all water stakeholders at a basin-wide level and is oriented towards the proper and long-term functioning of ecosystems and maintenance of the associated socio-economic benefits for people. The IRBM offers authorities of all levels a window of opportunity for making strategic decisions on water management - including flood risk management - that are economically, socially and ecologically sustainable.

The WFD requires managing all waters at a river basin and sub-basin level, provides for international/transboundary cooperation between countries sharing the same river basin, and has a strong emphasis on public participation. It further allows for working with nature rather than against it, through the restoration and conservation of wetlands and floodplains, which are not only central to the delivery of 'good water status' – the overall aim of the directive – but also help reducing the likelihood of catastrophic flood effects.

- **Flood Risk Management Directive**

In response to the severe floods in 2002, the Europen Commission took the initiative to launch concerted action at Community level to help reduce the severity of flood events and the damage caused by these floods.

The European Commission proposed to move forward the European Action Programme on Flood Risk Management through three distinct but closely linked components:

- improving ***information exchange***, sharing of experiences and the co-ordinated development and promotion of best practices, as well as increasing the awareness of flood risks through wider stakeholder participation and more effective communication.

- a targeted approach to the ***best use of EU funding tools*** for the different aspects of flood risk management, for example via the Common Agricultural Policy, the new Cohesion Policy, and the European Union Solidarity Fund.

- the development of a proposal for a ***legal instrument – Flood Risk Management Directive -***, currently negotiated between the EU institutions.

WWF believes that the European Commission proposal for a Flood Risk Management Directive makes the right, but timid, steps towards sustainable flood risk management but fails to clearly spell out the three essential conditions

- Full support for the ecological sustainability conditions embedded in EU's Water Framework Directive which as stated above provides the organisational and planning platform to introduce newer, more creative sustainable forms of water and land management including for mitigation of flood risk. This is the most cost-effective and sustainable way to develop any flood risk management measures and will reduce bureaucracy by avoiding 2 parallel planning and reporting processes.

- Promoting measures that work with nature in managing flood risks, not against it. Traditional flood protection infrastructure often failed to deliver the safety it was supposed to provide. To simply reconstruct dikes and agricultural polders and to close off highly valuable retention areas are an inappropriate use of taxpayer's money and should be avoided. The priority should be given to non-structural flood risk management measures wherever possible.

- Making economics work for the environment: ensure that all measures are subject to sound and transparent economic appraisal, which includes environmental and resource costs and include possibility to recover the costs of flood defence measures. Flood risk management measures are an important service for citizens and businesses. In flood prone areas the development of human activities should therefore bear the costs of flood defence measures. This will then encourage citizens and businesses in flood risk areas to take precautionary measures to reduce damage.

If flood risk is to be managed, all encompassing visions and programmes, giving increased importance to non-structural (nature related) measures are needed, in order to shift away from traditional short term paradigm of building to protect to ecologically sustainable flood risk management.

3.6 Different funding sources for wetland restoration and sustainable flood risk management

The EU regulations for the most relevant EU funding instruments contain many explicit as well as implicit opportunities for financing sustainable flood risk management measures and promoting floodwater retention capacities of wetlands and functioning floodplains for example

- LIFE + (EU Financial Instrument for Environment) can fund pilot/demonstration as well as flood risk management implementation projects

- European Regional Development Fund, European Cohesion Fund and European Agricultural Fund for Rural Development all provide opportunities to fund measures for sustainable flood risk management as well as overall WFD implementation measures which should lead to mitigation of flood effects.

Nevertheless, the inclusion and integration of sustainable flood risk management, as one of the priorities in programming and actual spending is an option, not an obligation for the individual EU Member States. No matter how many opportunities are included in the EU regulations, it will depend largely on decisions made at national and sub-national levels on programming for the use of these funds. These decisions will determine which, if any, of these opportunities are in fact seized. The process of programming for eventual use of these funds has already begun in all of the 27 existing and acceding EU Member States in order to be able to draw on funds from January 1, 2007.

- **The European Union Solidarity Fund**

After floods in summer 2002, the European Union has set up a new financial instrument - European Union Solidarity Fund, in order to come to the aid of any Member State in the event of a major natural disaster. The Fund has an annual budget of one billion Euros.

The Solidarity Fund is focused on giving immediate financial assessment to help people, communities, regions and countries return to normal living conditions as quickly as possible in the event of a major natural, technological or environmental disaster. Its scope is therefore limited to covering the most urgent needs.

The investment aid provided under this Fund for flood affected countries and regions between 2002-2006 went to support short term structural measures, which have already shown their shortcomings, instead of examining the extent to which inadequate land-use and water management policies have contributed to these problems. Thus, so far, investments have been much more focused on emergency repairs for damage to infrastructure, without consideration of long-term strategies for flood control. WWF shares the Member States' general concern that communication links and other vital infrastructure have to be restored, but it also needs to be recognized that in many areas the very same infrastructure has contributed significantly to the catastrophic impact of floods in the first place.

WWF believes that the application of the Solidarity Fund should avoid the repetition of mistakes from the past and deal with the root-causes of flooding rather than with the symptoms. Taking into account the fact that the Fund provides relatively large investments over short periods of time, national governments should consider and select only the most effective (environmentally and economically) flood-protection measures. The mere reconstruction of facilities and infrastructure may be a waste of money and time, and may also constitute an obstacle to implementation of the Water Framework Directive and the ultimate achievement of its objectives - a statutory obligation on Member States. WWF considers that access to the Fund should be conditional on adoption of ecologically sustainable flood-management and risk-reduction strategies. Although it is a short-term tool intended essentially for reconstruction, the relevant State authorities should be more forward-looking and identify more progressive and sustainable ways of using it. The Solidarity Fund has to be regarded by both ‘donors’ and ‘recipients’ as a means of adding value to flood prevention and protection in the future, and not only as a temporary measure to address present problems.

For more information on these opportunities and advice on current programming process and ideas for potential measures and projects to be developed in the next programming cycle 2007-2013, see WWF publication “ EU Funding for Environment - A handbook for the 2007-2013 programming period” available at
http://www.panda.org/about_wwf/where_we_work/europe/what_we_do/epo/initiatives/regional_policy/publications/index.cfm?uNewsID=20070

Other useful resources are:

- General information on EU funding
  http://europa.eu.int/comm/environment/funding/intro_en.htm
- Funding handbook of DG ENV
  http://europa.eu.int/comm/environment/funding/pdf/handbook_funding.pdf
- Rural Development Programmes and WFD implementation:
  http://forum.europa.eu.int/Public/irc/env/wfd/library?l=/framework_directive/thematic_documents/wfd_agriculture&vm=detailed&sb=Title
- Structural and Cohesion Funds and water policy:
  http://europa.eu.int/comm/environment/integration/pdf/final_handbook.pdf
- LIFE
  http://europa.eu.int/comm/environment/life/funding/index.htm
- Research funding for the environment
  http://europa.eu.int/comm/environment/integration/research_fund_en.htm

4. WWF recommendations

General recommendations

- WWF stresses that mitigation of flood damages and the protection and ecological restoration of floodplains must go hand in hand. So far, this is not common practice. This report clearly shows that there are plenty of opportunities to protect and restore former floodplain areas, which will reduce flood risk as a result. Existing floodplains should be used as retention areas, and main and side-channels can provide additionally discharge capacity.

- WWF emphasizes that restoration of floodplains along the Danube and its tributaries will only reduce the risks of future flooding if it is accompanied by wetland restoration and improvements in the disconnected side arm systems. Retention polders will create more space, but will have no significant increase in the discharge capacity of the Danube. For long-lasting and intensive floods, like the spring floods in 2006, polders can delay the flood impacts for only a few days, but in the end they will not have a major effect in mitigating damage. Only the restoration of wetlands and improvement of the natural discharge capacity of disconnected natural side arm systems and widening of river profiles will lead to sustainable and sufficient solutions.

- WWF calls to include sustainable land use practice into the Flood Directive to support the retention of water in the catchment as a key to prevent future flood disasters. So far, flood management is dominated by measures focusing on river systems, but does not sufficiently include landscape changes or land use impacts. Successful flood management must include a profound understanding about the genesis of floods on a basin-wide scale, including land use pattern and the temporal characteristics (superimposition or disconnections) of flood waves. Effects of intensive land use in river basins, such as deforestation, sealing, drainage and compacting of large areas for infrastructure should be considered in the implementation process of the WFD and the Flood Directive. In the future it will be crucial to reduce the speed and runoff of flood waves from the upper catchments that cause dangerous overlaying flood peaks in the main rivers.

Recommendations for EU institutions and other international bodies, such as the International Commission for the Protection of the Danube River (ICPDR)

- Early flood warning systems should be further developed on international and regional levels. WWF supports the approach taken by the EU Flood Directive to implement better technology and communication among countries sharing one river basin.

- International and national political frameworks are essential to promote progressive and environmentally compatible solutions for new concepts of flood protection. An integrated approach combining flood protection, nature conservation, and economic returns of investment is key for successful flood risk management concepts. Therefore, WWF calls for the promotion of further implementation of existing political agreements. This applies in particular to the Lower Danube Green Corridor agreement and to further improvements of the Hungarian flood mitigation plan (Vasarhelyi Plan).

- Laws and regulations should reflect the function of river as an ecological system that provides us with a number of important services. The problems of floods, water management, land use and socio-economic issues can be solved with an integrated solution. Legal instruments for reducing risk of future floods already exist. The ambitious Water Framework Directive promotes working with nature by, for example, restoring and conserving wetlands and floodplains, which are not only central for the delivery of good water status, but which also help protect citizens from catastrophic flood impacts. EU Institutions and Member States should ensure its timely and effective implementation. The proposed Flood Risk Management Directive should be fully integrated with the Water Framework Directive, promote measures that work with nature in managing flood risks, and make economics work for the environment.

- WWF believes that the application of the Solidarity Fund should avoid the repetition of mistakes from the past and deal with the root causes of flooding rather than with the symptoms. Access to the Fund should be conditional on adoption of ecologically sustainable flood management and risk reduction strategies. Although it is a short-term tool intended essentially for reconstruction, the relevant authorities should be more forward-looking and identify more progressive and sustainable ways of using the Fund.

Recommendations for national governments, in particular for the new EU Member States and EU Candidate Countries (e.g. Romania and Bulgaria)

- Restoring floodplain areas along the middle and lower stretches of the Danube River will yield multiple benefits not only in terms of enhanced flood protection through the soaking up of floodwaters, but also by providing local livelihoods based on experiences of already-restored floodplain areas in the Danube Delta, the existing natural floodplain areas along the middle Danube in Croatia and Serbia, and the Danube National parks in Hungary and Austria. There are a number of options for funding such measures from main EU funding instruments. However, the regulations on these funds only offer options, not obligations. EU Member States have the greatest influence on the choosing sustainable flood risk management measures as one of the priorities of the national strategies and programmes.

- WWF calls for the improvement of national legislative requirements and law enforcement in the field of spatial planning. This includes the prevention of the further construction of houses and infrastructures in flood prone areas. Today, local governments often spend state money to build or enforce dikes, which often create a false sense of security influenced by construction investors who wish to protect their luxury real estates, making the river's space narrower. Spatial planning, in contrast, should ensure that the river corridor within high flood risk zones is not utilized for human use and settlements. A clear and frank declaration of unpredictable risk zones could help to raise awareness.

- Governments should also ensure that all flood risk measures are subject to sound and transparent economic appraisal, which includes environmental and resource costs and includes the possibility to recover costs of flood defence measures. Flood risk management measures are an important service for citizens and businesses. Therefore, the development of human activities in flood prone areas should bear the costs of flood defence measures. This will then encourage citizens and businesses in flood risk areas to take precautionary measures to reduce damage.

Recommendations for individuals and insurance companies

- WWF calls for open public participation processes in terms of national and international flood management. This applies in particular to the current negotiation processes in Hungary and Romania, where new restoration sites are discussed only among governmental bodies. The case studies from Hungary clearly demonstrate that an open and transparent process helps to provide a common basis to solve conflicts between traditional land use and sustainable flood risk management.

- Insurance companies play a key role in future flood risk management. The political process of sustainable spatial planning could be triggered by new insurance concepts. Bonus systems might serve as an incentive model to support people who are willing to move out of high flood risk zones. Providing general insurance policies for high or medium risk zones, in contrast, might support traditional concepts of flood protection measures without initiating new spatial planning opportunities.

- Future flood protection concepts in high or very high flood risk zones should ensure that individual infrastructure and property will be protected individually by local measures and be a private financial responsibility. New settlements in areas prone to flooding should not be protected by large-scale measures paid by the general public (e.g. by enlargement of polder or dike systems) and should only be allowed if individuals can provide sufficient status of individual flood protection (individual dikes around the private property, specific measures for windows, fundaments etc). Insurance companies could actively promote such a scheme to support local authorities and decision-making processes.

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