Temporary flood water storage in agricultural areas in the Middle Tisza river basin - Hungary [1]

Image not found or type unknown
Image from Climate Adapt about this case study [2]

Autor: Â© EPI-WATER Project

The increasing exposure to floods is a consequence of the river regulation and land reclamation works that shaped the landscape in the Tisza River floodplain. During the last 150 years an extensive flood defence and water management infrastructure has been constructed. Climate and land use change in the basin are increasing the frequency and magnitude of floods. The Hungarian Government has been pursuing a new flood defence strategy for the Tisza based on temporary reservoirs where peak flood-water can be released. A plan to build six reservoirs was adopted, with the option to build an additional five. This case study is based on the analysis of operational scenarios of the reservoir schemes, while some of the detailed assessment took place specifically in one of the polders, the Hanyi-Tiszasülyi reservoir.

Case Study Description

Challenges:

Near the geographical centre of Europe, the Tisza drains an area of 157,218 km2; the Tisza River Basin (TRB) has a population of 14.4 million. On its route from the Ukrainian Carpathian Mountains to the confluence with the Danube in Serbia, the Tisza flows mainly through Hungary’s Great Pannonia plain. The topography of the TRB is characterized by high, narrow chains of mountains surrounding expansive, flat lowlands. With a length of 966 km and an average discharge of 794 m^3/s the Tisza is the Danube’s longest and second largest tributary. Most discharge is generated directly from rainfall but there is a contribution from both snowmelt and subsurface soil water. Serious floods can originate from the mountains when rainwater flows quickly down the slopes and accumulates in lowland areas. This problem has become more and more serious over time as deforestation and soil sealing had progressed and precipitation patterns changed.

The river and its tributaries were regulated in the second half of the 19th century. The main purpose of this regulation was to increase the extent of agricultural land, in place of wetlands, marshes and areas at risk of regular flooding (Borsos et al., 2010). The length of the river was reduced by over 400 km as the meandering sections were cut through, while the size of the floodplain area decreased by over 90% as dikes were raised to protect against floods. As a consequence, peak flood water levels increased. As a result of the impacts of additional factors, especially deforestation in the river basin, related increased sedimentation in slow flowing river sections and changing climate, as well as the fall back of agricultural activity in floodplains, peak water levels measured during floods continue to rise. Taking into account a few historical recorded flood events, peak water level was 753 cm in 1876, 909 cm in 1970 and 1040 cm in 2000 (Sendzimir and Magnuszewski, 2009).

Flood defence is based on the runoff capacity of the flood-water riverbed (the permeable capacity of the cross section between the dikes). This capacity has been increased step-by-step since the river regulation works of the 19th century to cope with the increasing peak levels of floods. Today, the length of the flood defence dikes along the Tisza and its tributaries in Hungary is 2850 km. The size of the protected territory is 16,000 km2, out of the total catchment area of the Tisza in Hungary of 47,000 km2. As the peak level of floods continued to increase during the last century and a half, so did the height of the dikes. A further rise of peak flood levels is projected for the 21st century as a consequence of climate change, and it is clear that the current level of flood embankments will not be sufficient to provide adequate protection. Flood defence exclusively as a result of enlarging and strengthening of embankments is estimated to be excessively expensive. In 1999 a World Bank financed research project estimated the cost of the remaining upgrade works to be HUF 175 billion, equivalent to EUR 700 million at a 1999 exchange rate (Szlávik, 2001).

In the period 1998-2001 four serious flood events took place on the river Tisza with peak water levels exceeding all historical values. One of the events (2001) included the rupture of a dike, flooding areas that were supposed to be protected, thereby pointing out that neither the height of the dikes, nor their strength are adequate. Afterwards, a 4-year-long project was launched to investigate the validity of the flood risk projections used at the time (VITUKI, 2006). Besides applying novel methods of time series simulation processes and a revised historical hydrological database, the project considered the impact of changes (in forest cover, reservoirs, and flood embankments) within the different sections of the rivers passing through Hungary, including also climate change (Haase et al., 2006). The key conclusion of the project was that compared to previous projections there is increased uncertainty and higher expected water levels during floods. The land use change in the basin caused an increased surface runoff, while the modifications of the river banks caused an increase of the water speed in some parts of the river; these factors impacted on the height of the water level during extreme events. During an extreme precipitation event, a 100 years return period (an engineering measurement of probability to have an event of similar magnitude in a time period; in this case it indicates a probability of occurrence of one in a century) streamflow provoked an increase of the water level of around 70 cm, in comparison to earlier values of between 900 and 1000 cm. These values are expected to further increase as consequence of climate change. Koncsos (2006) also points to the role of mud accumulation in the river bed which considerably raises the level of water in a long time horizon measured in decades (average value of 0.77 cm/year) (Schweitzer, 2001).

Objectives:

Adopt cost-effective measures aimed at ensuring an adequate flood protection level able to cope with the changing conditions of the river basin and the consequences of increasing peak flows. The implemented strategy was designed to respond to the changes in local climatic variability and specific characteristics of the hydrological system.

Solutions:

As a first reaction to the 1998-2000 floods the government decided to speed up the on-going process of strengthening the dikes: first plan focused on the reinforcement over a ten year period of 740 km of dikes in ten years. In the second stage, the governmental strategy intended to intensify the process further by strengthening an additional 550 km of dikes, but in a shorter period of 5 years. The works started, but suddenly the programme was stopped.

A new Act was designed in 2004 with the following objectives: to increase flood safety (partly) by the reactivation of former floodplain territories, the management of the water surpluses, the development of the regions with most disadvantageous status and the improvement of living conditions in these regions.

For the first period of the plan - from 2007 – the act called for the enhancement of the run-off capacity of the flood channel, the completion of 6 flood defence temporary reservoirs. It was designed focusing on strengthening the existing weak points of the dike system, the restoration of the run off capacity of the flood channel (the cross-section between the dikes) and proposed flood reservoirs, but only to reduce the peak of the biggest flood waves with a total capacity of 1-1.5 km3. The intention is to give room to the river using agricultural areas as temporary storage reservoir for containing peak flow during extreme events. The area is utilised for agricultural purposes in normal period, but could be eventually flooded and utilised for temporary retention of flood waters in case of emergency. This allows buffering during extreme precipitation events and reducing flood wave propagation, with consistent beneficial implications in terms of flood risk mitigation. The first reservoir was inaugurated in 2009, it was financed using national sources. All the other five planned temporary reservoirs were completed in the following years with financial support both from national and EU funds. One of the reservoirs was used in a 2010 flood event. From an engineering perspective the strategy proved to be successful, but some loose ends remain with respect to flood induced agricultural damages within the reservoirs.

Importance and relevance of the adaptation:
PARTFUND_AS_CCA;

Additional Details
Stakeholder engagement:
The designed flood protection strategies were planned so as to be integrated into a wider process of regional development that projected large scale landscape and social rehabilitation efforts in combination with the restoration of the natural ecosystem of the region characterised by a complex system of wetlands. These initial goals were to include a wide, multi-disciplinary and multi-sectoral participation in the strategy planning process. This has not been fully accomplished in the implementation phase. The flood mitigation project was designed with an approach aimed at minimizing the amount of agricultural land surface to be involved. In this way, policy makers tried to minimize the scale of potential conflicts with farmers and landowners that could represent an obstacle for the development of the project. The central government designed and implemented the plan including the flood-water storage reservoirs with the selected sites for the first six reservoirs chosen centrally. This decision was based on the adequacy of sites to be transformed into temporary reservoirs. Farmers and landowners had the possibility to accept the decision of the government or be subject to the expropriation of their land for public use. In this case, attending to the landowners interviewed during the research project, the sum paid out by the government was considered consistent with the market value. The government also adopted the rules for operating the reservoirs, including those associated with the compensation to be provided to land owners and users.

This case was analysed in the context of the EU FP7 funded project EPI-Water, Evaluating Economic Policy Instruments for Sustainable Water Management in Europe. The aim of this specific case study analysis was focused on designing a compensation scheme able to satisfy the requests of the agricultural sector and the needs of central government. The flood risk mitigation system based on the temporary flood water storage in agricultural areas is extremely effective for the purposes of disaster risk reduction, but might have negative impacts on the agricultural production of the affected areas. Flooding agricultural areas during crop production season could very likely result in the loss of the production in the affected areas for the year.

For the EPI-Water project, the participation of the stakeholders has been considered crucial. Landowners and farmers operating in the floodable areas and representative from the regional water directorate were involved in the development of a compensation scheme is able to more fairly compensate for the losses to the agricultural sector. There are multiple problems with the present scheme, making use of the reservoirs expensive for the government and, at the same time, leaves farmers and landowners dissatisfied. Among the others:

- Compensation is not adequate in comparison to the real amount of damages. It compensates the yield losses, but it does not take into consideration soil rehabilitation and the financial consequences due to the disruption of the seasonal production cycle. These extra costs are particularly significant for high value cultivations.
- Long time, up to one year in some cases, for the compensation process to be completed.
- High unpredictability of the compensation scheme cost over time, with potential high impacts on the national financial budget.

An increasing frequency of future floods, projected by the hydrologic models, is expected to increase the amount of damages to the agricultural sector. This could exacerbate the already delicate debate between local farmers and central government and increase the opposition to the construction of new retention areas.

Active stakeholder involvement is fundamental to the process of developing a payment scheme that is more satisfactory for both parties than the currently existing process of compensation of the losses suffered by the agricultural sector. Through their involvement, the process and scheme gain additional credibility and acceptance of the effect of climate change on the future frequency of reservoir use.

Success and limiting factors:
The project has shown to be extremely effective in terms of flood risk mitigation. The retention of flood waters in the identified temporary reservoirs in the agricultural areas is crucial for the reduction of flood frequency and magnitude in the downstream areas, with considerable benefits for the cities located along the river. In normal conditions the retention areas are used for agricultural production. In case of emergency these areas are flooded and the farmers compensated for the losses. Unfortunately, as frequently happens in these cases, not all the stakeholders are enthusiastic about the solution adopted. Farmers claim inadequate consideration of their views and perspectives in the process that brought the government to use their land for temporary flood-water storage. Landowners are called to use their property for providing an important service, but they have not been involved in the design of the flood management strategy and the associated operating rules. In general, they are not enthusiastic about the reservoir concept.

The analysis conducted with the EPI-Water Project proposed to the parties (farmers and government) an Economic Policy Instrument based on a flat fee paid to the farmers plus compensation in case of flood. This scheme would have several benefits:

1. Improved farmers' financial compensation with a scheme that could be perceived as more transparent and fair, increasing the public acceptance of the flood management strategy;
2. Incentive for the farmers to reduce the amount of value exposed to flood events. This could be realised by a different use of the floodable areas, lowering the value of the crop at risk within the reservoir, making the whole scheme cheaper in the long run;
3. The proposed compensation scheme increases the management costs in the short run, but is expected to be cost-efficient in the long run;
4. The new management scheme could inform the planning process for new reservoirs. Public participation and farmer willingness to accept the operating rules could be a viable solution to reduce the implementation of new storage infrastructures.

Stakeholder consultations revealed that representatives of the government are in favour of modifications aimed at improving the scheme, while farmers have mixed opinions driven by their specific conditions. However, although for different reasons both parties expressed scepticism about the viability and enforceability of long term agreements.

Budget, funding and additional benefits:
Several analyses have been conducted in order to assess costs and benefits of the chosen flood mitigation strategy. The solution of establishing temporary flood-water retention areas has been compared with other technically feasible solutions. The solution adopted resulted in an overall cost of around 260 million Euro, the strategy has been implemented with the contribution from the European Regional Development Fund and the Cohesion Fund. The results of a comprehensive ex-post cost-benefit analysis (Koncsos 2006) have been summarised in the graph at the upper right corner of this case study sheet. This graph shows the expected present value of different flood-defence strategies' costs and residual damages taking into account the cumulative impacts of flood events in 100 year-period in the Hungarian section of the Tisza River (source: EPI-WATER Project. Deliverable 4.2 - WP4 - Floods and Water Logging in the Tisza River Basin (Hungary) – Corvinus University of Budapest, REKK). The following notes should be considered when referring to the graph:

- *Values are in billion HUF, discounted at a 3% real discount rate. HUF 1,000 billion is equivalent to about EUR 4 billion. MÁSZ stands for the construction of dikes able to contain a 100 year return period flood;*
- *Investment costs: cost of the hydraulic infrastructures proper of this flood risk mitigation strategy. In some cases the temporary flood water storage reservoirs are coupled with the increase of the dike height;*
- *Defence operation cost: dike protection during high water level episodes;*

- *Damage costs: compensation of the losses suffered by the agricultural sector and cost of reconstruction;*
- *Eventual positive externalities of the strategy adopted (restoration of ecosystem services, biodiversity, etc.) have not been considered in the cost-benefit analysis.*

Each of the possible strategies has been designed as a scenario. The performance of each scenario have been ranked in terms of total costs: investment costs (building infrastructure: dikes, reservoirs), operational costs and residual damages. The implemented scenario, with 6 reservoirs and no modification to the existing dike system reduces substantially the risk compared to the baseline (no intervention). It represents a trade-off between efficiency in risk reduction and relatively low initial investment costs. The scenario designed based on the implementation of all 11 reservoirs was found to be the best performer in terms of cost-efficiency, but proves to be significantly more expensive to implement. The deep floodplain scenario is characterised by lower initial investment costs, but it was rejected by policy makers as it would have required a significant area to be modified in terms of land use. From a technical point of view, this solution lacks the flexibility of opening the flood gates only at the time of peak floods, but it would provide the most effective adaptation response to the projected changing conditions. The scenario analysis highlights also that further investments in flood defence infrastructures are economically justified. The only doubts are focused on the choice of the optimal strategy mix. The scenarios characterized by the lowest investment (VTT6; deep floodplains) are affected by the largest residual damage.

Legal aspects:
The solution of establishing the temporary flood-water retention areas is in line with the requirements of the EU Water Framework and Flood Directives. The integration of the two Directives is formulated in a way that requires the adoption of flood mitigation strategies more compatible with the natural ecosystems and the natural structure of the river hydraulic dynamics. This suggests solutions more oriented towards green infrastructures, such as the so called “room for the river”, and river ecosystems and wetland restoration. These strategies need large portions of land, typically used for agricultural production, to be implemented. The solution chosen for the Tisza River Basin is not a permanent river restoration strategy. It is designed to temporarily flood agricultural areas to provide space for the river (intentionally and under controlled conditions) in case of extreme events. Unfortunately the EU Directives do not provide clear instructions about the compensation for the impacts that the adoption of these strategies could have for landowners and farmers.

In this specific case, the current legal setup specifies the obligation to provide compensation to the impacted farmers, but its implementation left a considerable uncertainty with regard to the agricultural production process, raising the direct costs as well as the opportunity costs for the farmers. A more complex compensation scheme with more incentive towards adaptation is needed to meet the interests of the local populations (those benefiting from an increased level of flood protection) and the economic interests of the local agricultural community.

Implementation time:
All the six planned temporary reservoirs have been completed.

Reference Information
Contact:
Gábor Ungvári
Corvinus University of Budapest
Regional Centre for Energy Policy Research
Tel.: +36 1 4827073
E-mail: gabor.ungvari@uni-corvinus.hu [3]

András Kis
Corvinus University of Budapest
Regional Centre for Energy Policy Research.
Tel.: +36 1 4827073
E-mail: andras.kis2@uni-corvinus.hu [4]

Attila Lovas
Middle Tisza District Water Directorate
H-5000 Szolnok, Boldog Sándor I. krt. 4.
Tel.: +36 30 2797727
E-mail: lovas.attila@kotivizig.hu [5]
Generic e-mail: tiszaoffice@kotivizig.hu [6]

Websites:
http://www.feem-project.net/epiwater [7]

Sources:
EPI-WATER Project

Links

[1] https://adaptecca.es/en/temporary-flood-water-storage-agricultural-areas-middle-tisza-river-basin-hungary
[2] https://adaptecca.es/sites/default/files/11210497.png
[3] mailto:gabor.ungvari@uni-corvinus.hu
[4] mailto:andras.kis2@uni-corvinus.hu
[5] mailto:lovas.attila@kotvizig.hu
[6] mailto:tiszaoffice@kotivizig.hu
[7] http://www.feem-project.net/epiwater