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Dealing with water hazards in a changing climate by implementing a sound spatial planning and technical solutions

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Abstract: Water based disasters are typical examples of people living in conflict with the environment considering that floods and droughts have enormous environmental, social and economic consequences and it is expected that climate change effects will exacerbate their occurrence and impacts in the future. The vulnerability of populated areas to water natural disaster is partly a consequence of decades of spatial planning policies that have failed to take adequate account of hazards and risks in land use zoning and development decisions. Therefore it is critically important to develop more effective methodologies and tools for incorporating water natural disaster reduction into spatial planning. Meanwhile, management of these events requires an integrated risk management approach that includes prevention, preparedness, response and recovery. Furthermore, education, awareness-raising and communication to the general public and economic actors are needed to allow them to deal with transitions and change.

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Keywords: water based disasters, spatial planning

1. INTRODUCTION

Climate changes, the significant increase of world population, the lack of sustainable measures for soil and water conservation are all factors leading to an increasing of water based hazards frequency and intensity around the world.

Climate change may severely alter the risk of hydrological extremes over large regional scales, and that human water use will put additional pressure on future water resources. The region's most prone to a rise in flood frequencies are northern to north-eastern Europe, while southern and south-eastern Europe shows significant increases in drought frequencies.

The security against extreme water-related hazards can be achieved through an integrated approach including proper spatial planning at the local, regional and river basin scale, but also implementing structural and non-structural measures.

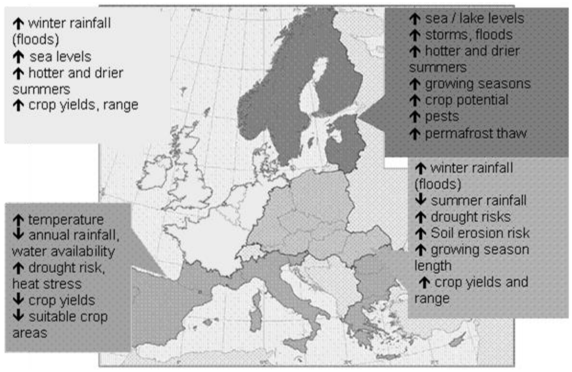

Figure 1 Projected impacts from climate change in different EU regions (Source: http://ec.europa.eu/agriculture/climate-change/index_en.htm)

A spatial view of natural hazards needs to consider all kinds of hazards through a multi-hazard or multi-risk approach on all spatial levels (regional and local) [1]. So far, multi-hazard approaches do hardly exist. At the end of twentieth century as well as the beginning of twenty-first century numerous projects dedicated to research concerning floods management and water scarcity (drought) management have been carried out but never in the same conceptual framework. Valuable contributions have been brought by EU funded projects like DROUGHT R&SPI, DROP, WATER CORE, CRUE ERANET, STAR-FLOOD, MARE, FRC, URBAN FLOOD, SMARTeST, FloodProbe, Flood-Wise, CORFU, FloodFreq, etc. More complex and competitive projects were AQUASTRESS, EPI-Water, STREAM, Water-Bee, NeWater which studied water management systems in various ways.
There are numerous definitions of spatial planning. Probably the most relevant is the definition adopted in 1983 by the European Conference of Ministers responsible for Regional Planning (CEMAT): "Regional/spatial planning gives geographical

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expression to the economic, social, cultural and ecological policies of society. It is at the same time a scientific discipline, an administrative technique and a policy developed as an interdisciplinary and comprehensive approach directed towards a balanced regional development and the physical organisation of space according to an overall strategy." [2] Therefore, water-related hazards risk management should be integrated into spatial planning policies at all levels to enhance certainty and clarity in the overall planning process. Spatial planning is a key instrument for reducing the vulnerability of society against natural hazards, but its potential is yet to be fully utilised [3]. Moreover, the history of spatial planning as a policy tool in identifying key measures of adaptation to climate changes is relative short and its effectiveness in mitigating water-related natural hazards events is under questioned [4, 5, 6].

Land management and spatial planning are closely linked to the adaptation of water management to climate change impacts. Land management has an influence on the ability of the soil to retain precipitation or flood water and sustainable land use can help to better manage risks related to both increased precipitation/flooding and water scarcity. Land and soil management can also realize significant synergies between climate change adaptation and mitigation. Agriculture as a key form of land use will play a crucial role in adaptive spatial planning approaches. Intensive agriculture in flood-prone areas is at risk of substantial economic loss in the case of flooding. On the other hand, the increased challenges for flood risk management will create a demand for new ways of accommodating flood water and managing flows, which may increase economic opportunities for water farming [7, 8].

The ability of local and regional spatial planning in preventing water related natural hazards to cause damages should be linked with solutions for water and soil resources conservation. Water is becoming more and more a scarce and valuable resource as population and consumption rise. Current practices to manage variability are also far from adequate and new information and solutions are needed, including new technical and economic assessments and designs of diverse water storage “portfolios”. These water storage portfolios should combine both human-made and natural structures that safeguard essential ecosystem services and maximize the development benefits [9].

The inclusion of ecosystem services in spatial and policy planning is important since an adequate inclusion may have the capacity to reduce or mitigate the effect of climate related extremes.

2. ROMANIAN APPROACH

According to the “Adapting to climate change: the challenge for European agriculture and rural areas” study, southern Romania will experience the combined effect of large temperature increases and reduced precipitation in areas already having to cope with water scarcity and where there is a heavy dependency on irrigation. More than that, climate models predict increases in precipitation during the winter and the possibility of large reductions in summer precipitation in several areas (e.g. northern Romania). Climate variability is likely to increase and agricultural activities are likely to be affected by high temperatures and summer droughts, increased risk of soil erosion, soil organic matter decline and the migration of pests and diseases [10].

According to a study realized in 2010 (Flood and Drought Strategy of the Tisza River Basin) [40], Romania considers land use and spatial planning as a crucial point in flood risk management. Flood risk mapping is on top of the agenda. The flood risk maps have to be reflected in the spatial planning and construction licenses. Limitations on regularly or potentially flooded regions are to be set. Romania has set some individual targets and planned some measures to answer at these problems. The main target is to show the flooded areas on local urban plans using historical data and/or study results. These maps are from the Local Flood Protection Plans and are updated every 4 years. The planned measures consist in:

- Implementation of the medium- and long-term flood risk management strategy by Land-use control and Relocation, land purchasing & cultural changes;
- Including the results of the study “Identification and delimitation of the natural hazards (earthquakes, landslides and floods). Hazards maps at county level” into local and regional developing plans;
- Including the maps from Local Flood Protection Plan (Contingency Plans) into the Urban Development Plans [11].

It is very interesting to observe even drought affected large areas from Romania covered by Tisza River Basin, this phenomenon is not mentioned as a priority for being part of these hazards maps. Drought will lead to soil degradation, which is a major threat to the sustainability of Romania’s land resources and may impair the ability of Romanian agriculture to successfully adapt to climate change.

Because in Romania, floods are one of the most common disasters which may occur at different scales - from large to small rivers – in September 2010 it was adopted the National Strategy for the Management of the Flood Risk, for medium and long terms. This strategy address issues such as integrated management of the water sources, land management and urban development, environment protection including forestry and agriculture, protection of the transport infrastructure, tourist areas, and individual protection.

One of the key principles of Romanian National Strategy for flood risk management is the apply an interdisciplinary approach to the problem of flooding in which all aspects relevant of water management, spatial planning, land use, agriculture, transport and urban development, nature conservation, must be dealt at national, regional and local level.

In order to ensure a better management of flood risk in the Danube Basin, the Ministry of Environment and Climate Change, in partnership with another 19 stakeholders from 7 countries, implemented Danube FLOODRISK project (2007-2012). Danube Floodrisk was a transnational, interdisciplinary and stakeholder oriented project focusing on the most cost-effective measures for flood risk reduction: risk assessment, risk mapping and risk reduction by adequate spatial planning. The project outcome is an Atlas containing hazard and risk maps for the entire basin for 3 scenarios: frequent event with 30 years return period, medium event with 100 years return period and extreme event with 1000 years return period. This atlas will enable decision makers to compare different types of risk and to optimize measures for risk management.

3. NORWAY – AREALKLIM PROJECT

Northern countries are experiencing more rapidly increasing temperatures than the global average [12]. As a consequence, adaptation to climate change and sustainable spatial planning policies become highly relevant for these countries.

Studies developed in the last years in Norway show that the actual increase in precipitation is 6 times higher than what was forecasted to happen in 2016 by the climate models 15 years ago. This situation indicates that some areas from Norway are already experiencing levels of precipitation that are predicted to occur at the end of this century according to climate models [13].

In a global context, Norway is projected to experience quite dramatic changes in climate, in terms of changes in temperature and precipitation.

The damages caused by water-related natural disaster events on infrastructure have increased the last decades. This is not a result of an increase in extreme weather events, but as a consequence of increased infrastructure development in hazard prone areas [14, 15].

In the Nordic countries, spatial planning is the responsibility of municipalities. In Norway, this is supervised by the regional authorities with the county governor and the elected county board's administration. Existing infrastructure are also often not adapted to the current climate [14]. The increased infrastructure development in hazard prone areas as well as its vulnerability to current conditions justifies the necessity to identify, adopt and implement new sustainable measures necessary to increase the adaptive capacity of spatial planning. Through revisions of regulations, more precautions towards natural hazards is now necessary when making land use plans. Adaptation guidelines for regional and local governments are also being produced.

Western Norway Research Institute sustained these efforts in developing new planning tools for increased adaptive capacity by implementing Arealklim project between 2012 and 2015. This project had as main aim to increase the ability of spatial planning to prevent damages from weather related natural hazards.

This three-year project analysed 10 former and 4 ongoing land-use planning processes in which water related natural hazards events have taken place or been identified in the region of Western Norway.

The project was structures on three main parts:

1. Analysis of earlier natural hazards events and related planning processes;

2. Use insights from (1) to inform ongoing planning processes in natural hazards prone areas; Develop new management tools.

3. Develop course modules on natural hazards, climate change and spatial planning for educational purposes, based on (1) & (2).

Some of the Arealklim findings are:

- Spatial planning is a key aspect and plays an important role in natural hazards prevention:
- Local knowledge of earlier natural hazards events could have prevented damages if taken into account in spatial planning;
- The capacity of local and regional authorities to use effectively spatial planning in adapting strategies to future climate changes is still under questioned despite technical, social and legislative progress. This situation is due also to delays in anticipating new patterns of natural hazards and different types of uncertainty issues which are delaying specific and effective actions.

Several municipalities from Western Norway increased their adaptability to climate changes as result of being involved in Arealklim project.

4. NORWAY – EXFLOOD APPROACH

Norwegian Institute for Bioeconomy Research carries on the ExFlood project, which has as main objective to define and analyse measures to combat negative impacts of extreme weather events on infrastructure in small watershed areas in Norway, and to incorporate this in a land use planning tool. The approach of the ExFlood project is to reduce the peak flow and delay the peak time to avoid damages on infrastructure. The hypothesis used in this project is that upstream measures are more efficient in terms of reducing peak flow, and more economical, than traditional downstream flooding protective measures such as constructions near the built infrastructures [16].

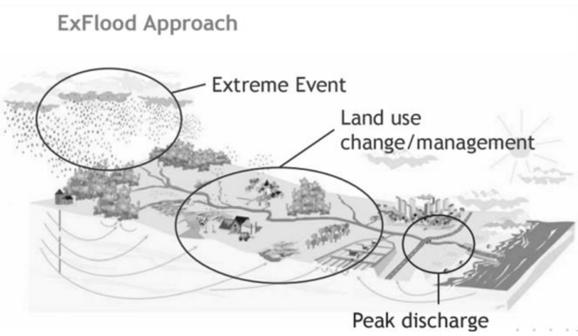

Figure 2. ExFlood project approach

The specific objectives proposed by this project are:

- To classify and review existing approaches dealing with extreme weather events identified by different stakeholders
- To identify and develop modeling techniques to quantify discharge from multi-functional catchments (i.e. urban, agriculture, nature, infrastructure elements etc.);
- To develop and analyze land use strategies and local measures based on interaction with identified

stakeholders;

- To produce a planning tool to be used for land use planning in catchments to deal with extreme weather events.

ExFlood will seek for modeling approaches (e.g. MOUSE; LISEM, SWAT) to model impact of future extreme weather events for an entire catchment. The modelling concept will be used at identified study areas to quantify present situation and potential future situation with climate change and possible land-use changes (e.g. increased urbanization) as well as flood preventing measures. Statistical analyses using Monte-Carlo and/or stochastic modelling on the outcome will be performed to identify the set of most sensitive parameters, which determines the data gathering for other areas. Using the same approach, a risk analyses on flood prediction will be conducted.

Based on the selected modelling approach, new construction of technical measures in urban areas (e.g. swales, rain gardens etc.), upstream (e.g. flood control systems, flood plains) and at the outlet (e.g. inlet constructions of drain systems, flooding overflow etc.), will be tested on their efficiency resulting in a matrix of measures and their suitability for different identified extreme events (autumn flooding, snowmelt induced flooding, extreme erosion etc.). Efficiency in terms of flood reduction, costs, design and suitability of measures in Norwegian natural landscapes, in agricultural and urban areas and along infrastructure elements will be analysed. Adaptation and stimulation results of these measures will be analysed during workshops with responsible stakeholders [16, 17]

The project identified a number of potentially interesting measures which aim in delaying the peak discharge. These measures were organized in several categories according to the areas which are targeted by them: forest, agricultural, urban. Using the tool proposed by ExFlood, land use planners are able to define the (economically) optimal measures to control the negative impacts of extreme weather events [17].

5. CONCLUSIONS

Natural hazards are inherently a part of life both in Norway and Romania. A good water hazards risk management is the result of intersectorial, interdisciplinary activities, including water management, spatial planning and urban development, nature conservation, agricultural and forestry development, transportation infrastructure protection, protection of construction and protection of tourism zones, community and individual protection, each sector having its specific activities.

Local and regional authorities should activate a special service on analysing the local knowledge on historical water related natural hazards events, and implement the results in land-use planning policies. This approach will enable the development of a database of water-related natural hazards events, potentially stimulating community commitment to hazard prevention.

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