AUTOMATED MODEL-BASED FLOOD RISK MAPPING FOR FUTURE SCENARIOS OF URBAN GROWTH AND CLIMATE CHANGE

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EXTENDED SUMMARY

The Floods Directive (2007/60/EC) requires flood risk management plans to be implemented for rivers and coastal areas with a substantial flood risk based on flood hazard and risk maps. The directive calls for a revision and update of these maps and plans every six years taking into account the possible impacts of climate change. Likewise, socio-economic change and its manifestation in the form of urban development was found to be another significant driving force of flood risk, especially in areas featuring unconstrained urban growth. The CORFU approach (Djordjević et al.,2011) formalises the dynamic interplay between regional economic and urban growth, climate change and the resilience of an urban system to flooding in a drivers-pressures-state-impacts-responses (DPSIR) framework (see Figure 1). Within this approach, we have implemented a chain of computational models in order to automate one cycle in the proposed DPSIR framework.

The CORFU approach assumes that economic growth *Drives* the development of certain economic sectors and land demand, a competition in space, spatial planning, and consequently land-use change through urbanisation. Cities in highly developed countries in Europe may follow different growth patterns than the highly dynamic cities in the emerging countries of Asia. A regional economic growth model and spatially explicit urban growth model are used to derive a set of socio-economic scenarios showing possible future economic sector and land-use distributions. These drivers create *Pressures* on the urban system (*State*) in the form of increased flood vulnerability and surface imperviousness. Independently, climate change is likely to lead to more frequent and extreme flood events.

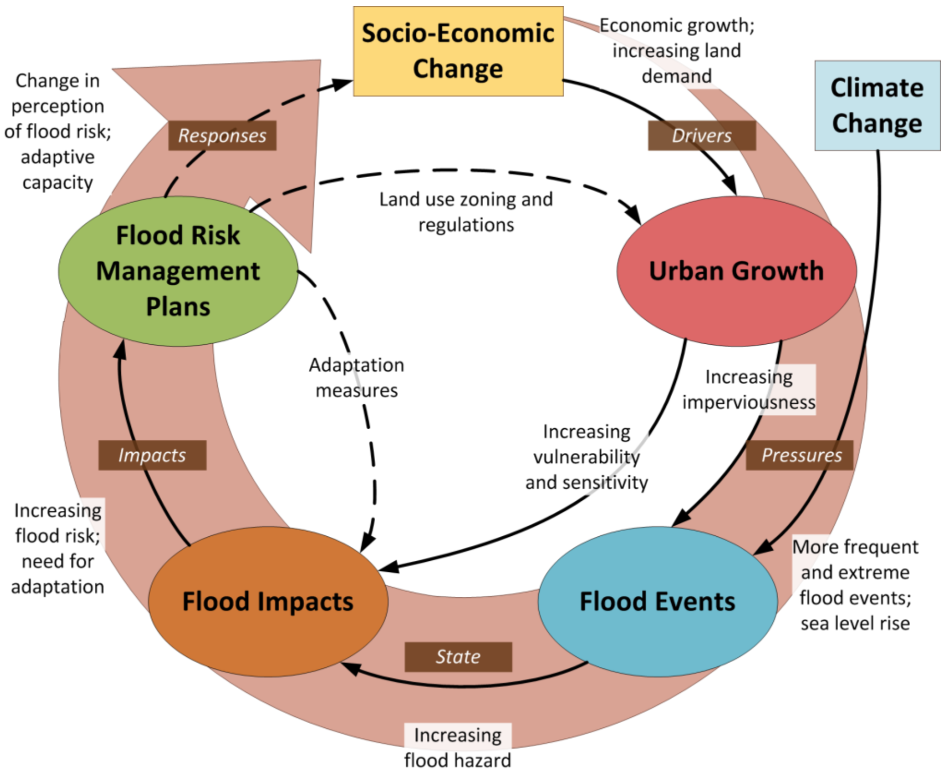

Figure 1: The CORFU Drivers-Pressures-State-Impacts-Responses (DPSIR) framework.

Our implementation of this approach has been made part of the Kalypso Planner Client (PLC) decision support tool (cf.Shaikh et al., 2013). It uses a sequence of existing Kalypso simulation models for calculating the map expected future annual flood damages (EAD) for pluvial-fluvial-type flooding processes. First, the future land-use maps and long-term future rainfall time series are fed into a semi-distributed rainfall-runoff model (KalypsoHydrology) that simulates a statistical future distribution of river discharges. The resulting statistical discharges for river flood events of defined probability (e.g. one in 10, 50, 100 and 200 years) are then assigned to a one-dimensional water surface profile model (KalypsoWSPM) or a one- and two-dimensional unsteady hydrodynamic model (Kalypso1D2D). In the next step, KalypsoFlood is used to derive the detailed flood depth maps for all events. Finally, the specific flood damage maps for these events and the EAD are computed by KalypsoRisk based on future land-use maps and damage functions. The PLC model chain is based on the standard Web Processing Service (WPS) interface issued by the Open Geospatial Consortium (OGC). We found WPS to be suited for the automated execution of computational models in the flood and risk assessment domains. Each Kalypso module provides such a WPS interface to its simulation. Model inputs and outputs are exchanged in the widely accepted OGC Geography Markup Language (GML) according to an intermediate data model (GML schema) that is independent of any concrete computational model. In this way, PLC enables a server-side simulation decoupled from the client. Individual models in this chain can be substituted and may be deployed on simulation servers in different physical locations. This black-box approach also allows deployment scenarios where proprietary simulation models or restricted data can be integrated into the chain, because all internal model data (e.g. a digital terrain model or numerical simulation core) reside on the respective server and are never transmitted over the interface. This is made possible by WPS as inputs and outputs may specify a reference to a web-accessible resource instead of containing the data themselves.

Automated flood risk mapping with Kalypso PLC is a powerful tool for flood risk management planning. In addition to analysing the potential future changes in flood risk due to socio-economic and climate change, as required by 2007/60/EC, the tool enables stakeholders to evaluate the effectiveness of adaptation measures under current and future conditions (cf. Hellmers et al., 2013). Without any user intervention required, the software applies adaptation measures to the intermediate data model prior to running the model chain. It currently has support for SUDS (sustainable drainage system) measures, retention areas, natural restoration of rivers and flood barriers. Non-structural measures like land-use regulations can be considered in the form of a scenario modification. A limitation of PLC is that all of these measures can only be applied to computational models that follow our intermediate data model (e.g. the Kalypso suite of models). Kalypso is an open-source product currently being extended with support for the Telemac-2D flow model and is open for contributions from other parties.

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