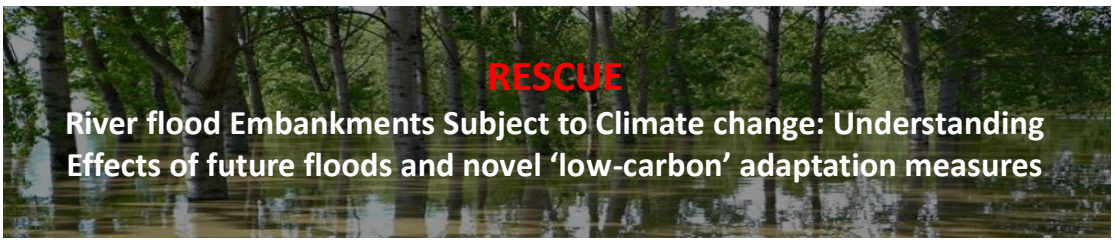
European Commission - FP7
Marie Curie Intra-European Fellowships (IEF)



Impact of climate change on flooding in the EU

The consequences of climate change are increasingly being felt in Europe and worldwide. The average global temperature continues to rise and some natural processes are being altered, e.g. precipitation patterns are changing and glaciers are melting. The impact of climate change will increase in the coming decades because of the delayed impacts of past and current greenhouse gas emissions. Climate change has already a tangible impact on flood risk. Between 1980 and 2011, direct economic losses in the EU due to flooding amounted to more than €90 billion. This amount is expected to increase, as the annual cost of damage from river floods is estimated at €20 billion by the 2020s and € 46 billion by the 2050s. The social cost of climate-induced floods can also be significant. Floods in the EU resulted in more than 2500 fatalities and affected more than 5.5 million people over the period 1980-2011.

Geotechnical Challenges in Flood Risk Management

Adaptation measures to address flood risk are a priority at European level. Flood defence embankments are and will remain the major asset in a flood defence system and they are therefore one of the major focus of flood risk management agencies. Key steps in the adaption process are

i) Assessing hazard of embankment failure
ii) Identifying adaptation options.

Hydro-mechanical models for the stability flood river embankments subject to flood are traditionally based on the assumptions of steady-state through-flow and zero pore-pressures above the phreatic surface, i.e. negative capillary pressures (suction) are ignored. RESCUE aims to introduce a step-change in the approach to the assessment of embankment stability by considering more realistic transient flow conditions establishing upon a flood and taking into account the effects of suction on the hydro-mechanical response of the embankment. This allows for flood duration, antecedent flood, and antecedent precipitation incident to the embankment to be taken into account.

RESCUE aims

The aim of the RESCUE project is to develop an approach to assess the impact of climate-induced floods on stability of existing river flood embankments, at both local and regional scale, and to explore low-carbon remedial adaptation measures. The approach includes strategies for geotechnical characterisation assisted by field monitoring, real-time monitoring to support emergency management, and 'accessible' tools for numerical modelling of the embankment stability conditions .

Adaptation strategies are centred on the concept of suction-reinforced flood embankments, i.e. suction is considered an untapped natural reinforcement that can be successfully exploited to strengthen the embankments. In this respect, vegetation is considered a remedial measure in the sense that it promotes the generation of suction via evapotranspiration.

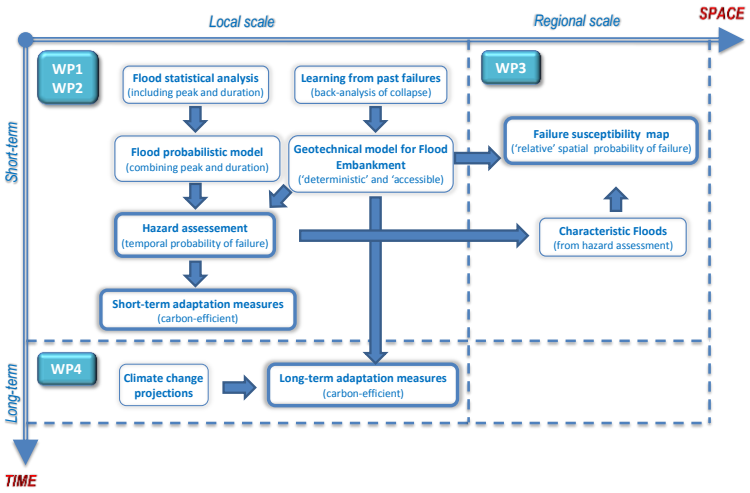
The approaches developed by RESCUE were validated against the case study of the Adige River embankment made available by the Agency for Civil Protection in Bolzano, Italy.

RESCUE achievements

WP 1 - Hazard assessment of flood embankment failure at local scale

A hydro-mechanical model for the flood embankment, which takes into account the effect of suction and partial saturation, has been validated against two embankment failure case studies in the Alto-Adige region in Italy. Geotechnical characterisation of the two segments subjected to instability upon the 1981 flood has been carried out based on boreholes logs and DPH profiles, field testing (falling head hydraulic conductivity tests), field monitoring (tensiometers and piezometers), laboratory testing (shear strength, water retention behaviour, and saturated hydraulic conductivity).

Probabilistic analysis of the factor of safety associated with stochastic variability of the hydrograph and hydro-mechanical soil parameters allowed to capture fairly well the instability conditions observed upon the 1981 flood. This analysis demonstrated quantitatively the role played by partial saturation on the mechanisms of instability of flood embankments.



WP 2 - Short-term carbon efficient adaptation measures

The effect of suction on the response of the flood embankment is twofold. It reduces the hydraulic conductivity of the embankment therefore preventing the penetration of water from the river-side slope and increases the shear strength along the portion of the failure surface above the phreatic surface. We have demonstrated that suction is an untapped soil reinforcement. If taken into account in the design, suction can allow for significant financial and carbon savings. Remedial and adaptation measures can therefore be based on promoting the generation of suction within the embankment and vegetation therefore represents an excellent low carbon and climate-smart solution in this respect. To this end, we have put forward a novel approach to model evapotranspiration in the water limited regime based on the concept of Soil-Plant-Atmosphere-Continuum (SPAC). Finally, we have demonstrated that geophysical techniques can be successfully used to monitor the water regime within the embankment and, hence, to verify the 'suction-based' design of flood embankments.

WP 3 - Map flood embankment susceptibility to failure at regional scale

An approach has been developed to characterise susceptibility to failure of flood embankments at the regional scale. This is based on the identification of 'homogenous' segments and the assessment of the factor of safety associated with the same flood event. The approach has then been validated against the susceptibility of failure observed on a 13km long segment of the Adige river embankment.

WP 4 - Long-term carbon efficient adaptation measures

The effect of climate change has been analysed for the Adige River flood embankment in Italy. A study of the effect of climate change on hydrological response of nearby catchment in the Alpine region has been considered as a reference. The increase in temperature expected to reduce the amount of snowfall during winter and also anticipate the snowmelt. As a result, floods are expected to occur in spring time, with relatively low peak discharge but prolonged duration. This has been demonstrated to potentially increase the hazard to failure of the flood embankments.

For more information on the RESCUE project, email Dr Annarita Pozzato (apozzato79@gmail.com) or Professor Alessandro Tarantino (alessandro.tarantino@strath.ac.uk) and visit the project Website http:// www.rescue-ief.com/ .