COST
EUROPEAN COOPERATION IN SCIENCE AND TECHNOLOGY
COST Action ES1306

Connecteur
Connecting European Connectivity Research

Short Term Scientific Mission

Watershed Dynamics, with focus on connectivity index and management of water related impacts on road infrastructure

COST Action: ES1306
Reference code: COST-STSM-ECOST-STSM-ES1306-010415-053194

Beneficiary: Dr. Zahra Kalantari, Department of Physical Geography, Stockholm University, Sweden

Host institution: Dr. Marco Cavalli and Dr. Stefano Crema, National Research Council, Research Institute for Geo-Hydrological Protection, Padova, Italy

Introduction:

Changes in climate variables will have a substantial effect on hydrology in general, including local hydrology near roads. Changes in land use conditions will also have a large effect on watershed hydrological responses. An increase in the occurrence of extreme weather events will impose greater strain on the facilities for dewatering and drainage of roads. Concerns about flood hazards have generated a particular need to methods for studying the interaction between the watershed descriptors in the vicinity of roads. Such methods can help the relevant authorities to avoid critical areas during construction. These methods can also provide information indicating the need of modifying practices in areas prone to flooding. By determining vulnerable areas and incorporating the information about these in the decision-making process, it is possible to avoid or reduce the potential harm. Because of that, it is important to study the causes and the dynamics of sediment connectivity, intended as the potential of sediment derived from soil erosion and remobilization of storage to be transferred from the source to the natural sink (river, road, urban area).

Aim of the STSM:

This project was a collaborative effort between Stockholm University (Sweden) and the National Research Council in Padova (Italy). The purpose of this project was to integrate SedInConnect, a tool for computing sediment connectivity which has been proposed by Dr Cavalli and his research group at the Research Institute for Geo-Hydrological Protection on a case study in Sweden. In this work, we focused on the effect that the combined action of soil morphology, climate and land use change will cause on road safety, in order to find a tool to help decision-makers for the long term management of resources with the aim to minimize damages due to washed-out embankments or flooding events. Our goal was to promote a more integrative policy-making that works for risk mapping of roads in order to be aware of the current situation.

Method and case study application:

To test the SedInConnect model, we applied it to a case study example in an area of western Sweden between the towns of Hagfors and Munkfors north of Karlstad, in the county of Värmland (Fig. 1). In this region, forest and grassland are dominant land uses, occupying more than 85% of the area and the main soil type is glacial till, with some glacial river sediment and sand. The climate is moderately cold with moderate precipitation and snowfall in winter. Mean annual precipitation is 798 mm and mean annual temperature ranges between -5.6 C in January and 15.7 C in July (Swedish Meteorological and Hydrological Institute, SMHI). For the case study, we consider heavy rain in August 2004 that resulted in several road and embankment failures in the area and damage to infrastructure, such as transport infrastructure and sewage treatment plants (Eriksson, 2004; Magnusson et al., 2009). Both public and private roads (with or without government support) were damaged due to high flows and extreme flooding. The most severe damage was observed in the municipality of Hagfors, to the major roads 240 and 824 running along the eastern and western sides of Lake Rådasjön, respectively. This damage defines a case study area measuring about 16 km*25km (400km2) to be used as a proof-of-concept for the following method as it included flooded catchments and non-flooded catchments located near the towns of Hagfors and Munkfors along major roads.

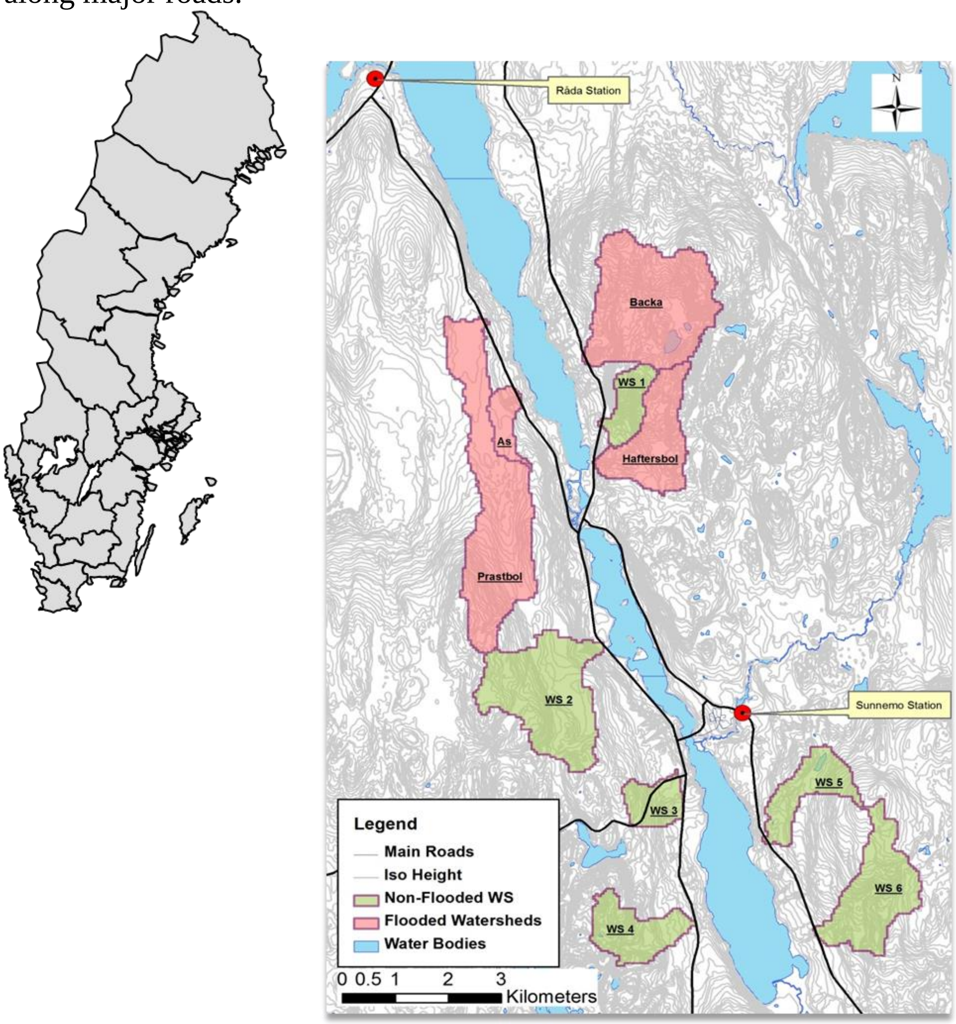

Fig. 1. Case study area in western Sweden. Catchments upstream of road sections which flooded (red) and did not flood (green).

Description of the work carried out during the STSM:

The first step was to study the literature concerning the definition and theory behind the concept of sediment connectivity, with the aims to study dynamics of transportation and to identify main parameters (such as shape and size of the catchment, morphology, soil roughness, rainfall characteristics, climate, land use, hydrologic parameters) and in what extent they can affect connectivity.

The method uses spatial data (e.g. high resolution DEM, soil maps and land use data) in combination with multivariate modelling in a GIS environment. As a first step (acquisition of data), the transformation of base thematic maps into appropriate formats was required. Next, we used SedInConnect: a free and open-source model to simulate connectivity index (IC). Sediment connectivity analysis was carried out on ten catchments including both flooded and non-flooded ones in our case study with the goal of achieving a fast and objective characterization of the topographic control on sediment transfer.

The SedInConnect was used to evaluate the potential connection between hillslopes and features acting as targets or storage areas for transported sediments. IC consists of the *upslope component*, potential for downward routing of the sediment produced upslope, and the *downslope component*, that takes into account the flow path length that a particle has to travel to arrive to the nearest target or sink. Both components depend on a factor weighted on either/both land use or/and soil roughness. In this way the assessment of sediment connectivity is achieved by taking in consideration effective sediment contributing areas and the dominant land use and soil type in the area.

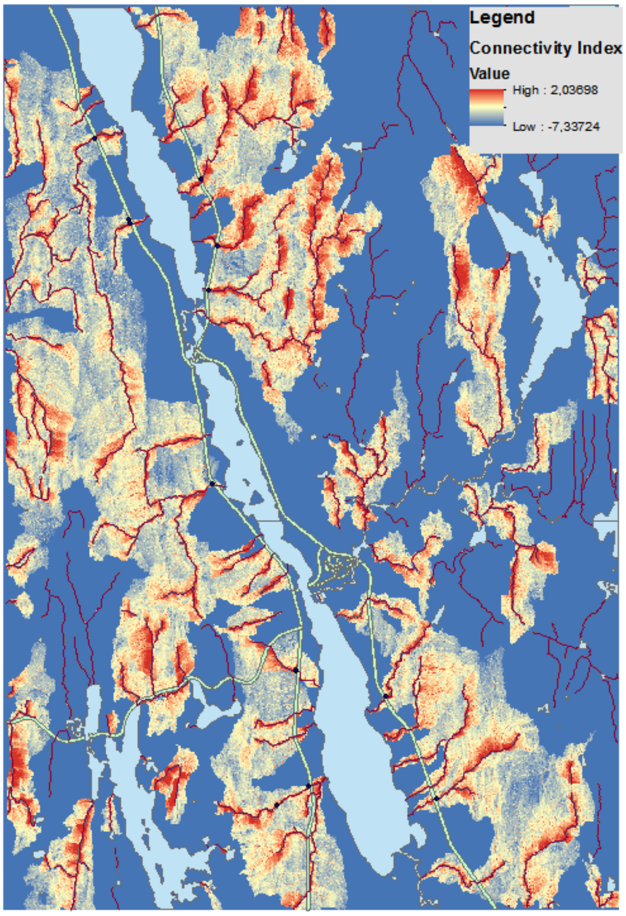

Fig 2. Connectivity Index at the case study area in western Sweden

Description about how the results contribute to the Action aims:

One of the outcomes of this STSM is to create a practical and useful planning tool that can facilitate the decision makers to identify vulnerable places within watershed exposed to high flows and places where measures and mitigations are needed. The outcome of this STM work is inclined with the Action ES1306 aims followed in the working Group 4: Usable Indices for Connectivity.

Future collaboration with host institution:

This STSM has given us the chance to start a collaboration regarding a master thesis with focus on implementing the SedInConnect tool at different regional contexts (e.g. in Sweden and Italy). We will integrate SedInConnect with hydrological models that can simulate catchment response for rainfall with different return time, at given climate and land use changes. We will also apply this integrated model on real catchments in regions of Sweden and Italy with different topography and land use, in order to calibrate and validate the model at large scale and obtain a realistic spatial characterization of sediment connections. This master thesis will lead to a peer-reviewed scientific publication.

Confirmation by the host institution of the successful execution of the STSM:

The letter of confirmation by the host institution of the successful execution of the STSM is attached in a separate file.

Acknowledgements:

I would like to thank the Connecteur Cost Action (ES 1306) for funding this STSM. I would also like to thank Dr Marco Cavalli and Dr Stefano Crema and their team for all the support and brainstorming sessions during my visit. I learned a lot during this stay and it gave us the chance to develop our ideas for further collaboration through this COST Action.

This report may be posted on the Action website.