TITLE OF THE RESEARCH PROJECT

Cartographic Heritage to model the impact of land changes on the hydrological and river systems in Europe

SUPERVISORS

	First name	LAST NAME	University	Research Unit
Supervisor	Roberto	Ranzi	University of Brescia (UNIBS)	Department of (DICATAM)
Co-Supervisor	Carmen	Maftei	Transilvania University of Brasov (UNITBV)	Faculty of Civil Engineering

Fields of study

Cartographic heritage, Digitalization and digital tools, heritage management, cultural landscapes, climate impact on mountain and rural areas.

Requirements (academic background, languages...) needed to apply for this research topic

A Master of Science in Architectural Engineering, or Geomatics, or Civil engineering or Environmental engineering or equivalent is requested. Knowledge of English at level B2 is required. Reading and understanding of German is an added value. Skills in managing GIS systems, cartography are needed. Knowledge of the basics of the hydrological cycle are requested.

5 main KEYWORDS

Historical cartography, cultural landscapes, natural heritage, hydrology, agricultural heritage.

ABSTRACT *(250 words max.)*

The main goal of this proposal is to develop strong research and analysis skills of a PhD student, including the ability to collect, generate, manage and analyse ancient cartography and spatial data, to use and develop hydrologic models, to perform and to critically discuss results. Through this project, we will provide young scientists with the opportunity to develop research skills in a stimulating interdisciplinary environment. PhD candidates will acquire specialized technical skills relevant to historical European cartography and hydrology, guided by experts also on the technical themes, and through advanced digital techniques. More specifically, the research will deal with the assessment of land use and land cover transformations over a long period (first half of the XIX century until present) with reference to some selected case studies placed in Italy and Romania. Ancient maps developed by the military service of the Habsburg Empire will be exploited to classify the land use-land cover featuring

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Europe in the early XIX century. Current and recent landscapes will be acquired by using the CORINE project, that monitors the present landcover transformations in Europe. This analysis is expected to reveal important information about the evolution of the cultural landscapes, agricultural and forestry practices in mountain and rural areas. The digitization of ancient maps unveils effects of the complex interaction between humans, nature and climate. In particular, the analysis will be the base to develop hydrologic analyses aimed at investigating the change in water balance (evapotranspiration, water demand and availability) in the selected case studies.

Research aims and methodology

In Central and Southern Europe, the maps of the Second and Third Military Survey of the Habsburg Empire depict the landscape at the end of the Little Ice Age, at a major turning point of its evolution. Presently, such maps have been digitalized and georeferenced as raster images, covering the whole territory of the Habsburg Empire at the end of the Napoleonic Wars. Based on these maps, the candidate will need to identify and vectorize the landscape classes of the Adda and Adige river basins (Central Italian Alps) and of a test site in Transylvania (Romania) in the XIX century, when the surveys were performed, by using GIS techniques. The vectorization of the raster images is crucial to make any quantitative assessment of landscape transformations possible. Land use and land cover classes including forest, grassland and pastures, urban and rural areas, bare rocks, glaciers etc. will be identified according to the legend of the Military Survey and reclassified according to the legenda of the CORINE project (https://land.copernicus.eu/en/products/corine-land-cover). Then, the digitized ancient maps will be compared to current CORINE land cover maps, in order to quantify the magnitude of the land use transformations in the analysed basins. The understanding of the landscape evolution is a key step to the assessment of non-climatic trends, that affect the freshwater availability and demand, the evapotranspiration losses and ultimately the hydrological cycle as a whole. This will pave the way to the understanding of many aspects of the evolution of humans and nature interactions in rural and mountain areas in Europe. The development of spatial data and analyses will accomplish EU INSPIRE Directive (https://knowledge-base.inspire.ec.europa.eu/legislation/inspire-directive_en9) in order to provide a spatial information compatible, usable and comparable in all European Countries.

Relevance and added-value of the proposed research in relation to the current state of knowledge

The research will develop and implement the original ideas, already outlined in Ranzi et al. (2021, 2022) and tested by Umair et al. (2025) in Northern Italy, of vectorizing XIX century maps to produce land use land cover of Europe in that period. The idea, shared in the community of the Cartographic Heritage in the International Cartographic Association https://cartography.web.auth.gr/ICA-Heritage/ became also the subject of a national project developed by the German Bundesamt für Kartographie und Geodäsie that is now producing its first results (Herold et al., 2025). The first added value of this research will be the development of similar maps in the mountain and rural environment in Italy and Romania. As can be seen in the following reference list, a vast body of research is now growing on this topic (Hargreaves & Allen, 2003; Timar et al., 2010; Konkoly-Gyuró et al., 2017; Nistor, 2018; Salbitano et al., 2018; Wang et al., 2020; Umar & Shuaibu, 2021; Nasiri et al., 2024; Herold et al., 2025; Umair et al., 2025).
A second added value will be the demonstration that the monitored changes in the land use are useful to assess their impact on the crop water requirements, evapotranspiration and runoff at the catchment

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area (Al-Sudani, 2019; Ranzi et al., 2021; Serban et al., 2022; Serban & Maftei, 2015, 2025a, 2025b). this non-climatic trend is crucial to the assessment of the impact of climate con mountain/rural areas.

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Interdisciplinary nature of the research together with the alignment with the CHORAL programme and complementarity expertise of the teams

The research is characterized by a strong interdisciplinary nature. The performed activities will involve the analysis of agricultural and natural landscapes in the XIX century, the production and the quantitative analysis of digital cartography (geomatics skills), the assessment of hydrologic fluxes of the hydrologic cycle (hydrology skills). Such skills align with the CHORAL programme as geomatics skills suit the topics of cultural landscapes, digitalization/digital tools, and heritage management, whereas hydrology skills suit the topic of climate impact on mountain/rural areas. Both supervisor and co-supervisor already have deep skill on the topics involved in the research, as can be seen in the above reference list: historical chartography digitalization (Ranzi et al., 2021, 2022; Umair et al., 2025); hydrology (Ranzi et al., 2021; Serban et al., 2022; Serban & Maftei, 2015, 2025a, 2025b).
The supervisor, Prof. Roberto Ranzi has been Member of the Commission on Cartographic Heritage into the Digital of the International Cartographic Association from 2019 to date https://cartography.web.auth.gr/ICA-Heritage/2023-2027/Members.html and published already four papers on its official open access journal e-Perimetron.

Output plan including publication and dissemination activities

It is planned that the candidate will write two proceedings papers in international conferences and will have two papers submitted to international peer-reviewed journals by the end of the doctoral programs. The vectorized maps will be archived being compliant with the standards of the INSPIRE EC Directive.

Estimated schedule

The start of the Doctoral programme will be in the second semester of 2026 and will last for 3 years.

Months 1 to 12 M1-M12 will be dedicated to the collection and eventually purchase of the digital maps in raster format and to the bibliographic collection about cartography, cultural and natural landscape of the investigated areas.

M13-M18 will be dedicated to the identification of the appropriate land use and land cover classes (LULC) in the ancient maps of the Habsburg 2nd and 2rd military survey maps compatible with the modern Corine classes.

M19-M24 vectorisation of the raster maps in the investigated areas in Italy and Romania

M25-M30 estimation of the impact of land use changes in the evapotranspiration and hydrological fluxes

M31-M36 Thesis writing and dissemination

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