Ph.D. in Information Technology:

Ciddio, Cominola, and Schmitt Final Dissertations

DEIB Conference Room

January 12th, 2016

2.00 pm

First Ph.D. presentation and discussion:

Manuela CIDDIO – XXIX Cycle

"Analysis, Control and Forecast of Schistosomiasis Spatiotemporal Dynamics via Network Modelling"

Advisor: Prof. **Marino Gatto**

Abstract:

Schistosomiasis is a parasitic, water-related disease that is prevalent in tropical and subtropical areas of the world, causing severe and chronic consequences especially among children. In this dissertation, different modelling frameworks are proposed, focusing on the main environmental and socioeconomic aspects considered to be relevant in schistosomiasis spread. These models are used to analyze transmission patterns in different settings, ranging from purely theoretical ones to real case studies. First, the mechanisms that drive the temporal variability of disease severity and prevalence are explored introducing nonlinearities in demographic and epidemiological dynamics. Then, the impacts of different sources of local and spatial heterogeneity are investigated, together with their implications on effectiveness of possible intervention strategies. Spatially explicit network models, properly informed by socioeconomic and environmental data, are thus used to study the spread of schistosomiasis in Senegal, where the urogenital form of the infection is widespread. The analysis is performed by integrating proxies of human mobility (inferred from a very large database of mobile phone traces) with a geospatial analysis which includes georeferenced data on demography, water supply/sanitation, and schistosomiasis prevalence. Results are presented and discussed in the perspective of using epidemiological models as tools for disease control. In this respect, the effects of intervention strategies based on human development, exposure and contamination prevention, awareness about risk factors, and biological control of snail intermediate hosts are evaluated by means of model simulation.

Second Ph.D. presentation and discussion:

Andrea COMINOLA – XXIX Cycle

“MODELLING RESIDENTIAL WATER CONSUMERS' BEHAVIOR - From smart metered data to demand management”

Advisor: Prof. **Andrea Castelletti**

Abstract:

Water demand in the residential sector is forecasted to grow in the next decades, under human population growth, urbanization, and climate change. Worldwide experiences have been proving that demand management strategies can complement supply-side management to meet future demands, potentially leading to significant reductions in residential water consumption, as well as reducing short- and long-term utilities' costs. Yet, the design of effective demand-side management strategies relies on our understanding of consumers' behaviors. On this regard, the advent of smart meters in the late 1990s made available new water consumption data at very high spatial (household) and temporal (from several minutes up to few seconds) resolution, enabling the development and application of data analytics tools and mathematical models to accurately characterize sub-daily water consumption behaviors, as well as end-use consumption profiles.

The main goal of this thesis is advancing data analysis and mathematical models to extract information on water consumersÃ‚Â¿ behavior out of smart-metered data, ultimately informing and proposing recommendations to customized demand management.

More specifically, in this thesis we contribute novel methodologies for profiling, analyzing, and modeling residential water consumers based on high temporal and spatial resolution data of residential water consumption, and also coupled with several qualitative and quantitative data describing consumers' psychographic features. The main focus is on water demand modelling and management. However, in this thesis we either assess the inter-portability of the methodologies between the water and energy fields of applications, or present integrated water-energy applications.

The first outcome of this research is the first published comprehensive review of more than 130 studies on high and low resolution residential water demand modelling and management.

Secondly, we developed two novel Non-Intrusive Load Monitoring algorithms demonstrated to achieve high electric power and water disaggregation performance, to be robust to signal noise and data resolution, and to be portable between the two fields of application of water and energy. Thirdly, we developed two novel descriptive and predictive modelling tools to infer water consumers' habits and routines, as well as identify the most relevant determinants of their water consuming or saving behaviors, at the household level. Finally, we implemented a three-phase data-mining procedure to capture heterogeneous water-electricity consumption profiles, highlighting differences between daily time-of-use of water and electricity,

and allowing for the characterization of users based on psychographic and behavioral factors. Applications of the developed methods onto synthetic data, as well as onto real-world case studies demonstrated that our tools constitute important contributions towards an effective and efficient exploitation of smart metering data to develop models of water-energy users' behavior at the household scale, and advance the customization of demand-side management strategies.

Third Ph.D. presentation and discussion:

Rafael J. P. SCHMITT – XXIX Cycle

"CASCADE - a Framework for Modeling Fluvial Sediment Connectivity and its Application for Designing Low Impact Hydropower Portfolios"

Advisor: Prof. **Andrea Castelletti**

Abstract:

Dam constructions have altered water and sediment fluxes in river basins with an unprecedented rate over the last decades, changing river and delta processes, and posing a major risk to ecosystems and human livelihoods. However, dam sediment trapping is rarely considered in planning of dams, or only for single dams, neglecting the cumulative impact of dams on network-scale sediment inputs. Omitting dam sediment trapping from planning hydro-power development is caused by the absence of data regarding network sediment transfers or models to describe such processes.

This thesis sets out to answer the research questions of what would be optimal trade-offs between dam sediment trapping and economic hydropower benefits in large river systems? To answer this research question, the objectives of this thesis are 1) developing a network-scale sediment transport and connectivity model, 2) test its application for various, data scarce river basins and evaluate the robustness of results, and, 3) apply the model for quantifying cumulative dam sediment trapping and network-scale trade-offs between sediment trapping and hydroelectric production.

Towards this aim, this thesis introduces the CASCADE (CAtchment Sediment Connectivity and DElivery) modelling framework.

Various stochastic and deterministic approaches for model initialization are presented, making CASCADE applicable also for large, poorly monitored basins. CASCADE was also applied to determine trade-offs between energy production, costs, and sediment trapping in a large hydropower portfolio in a tributary of the Mekong River. We find that an optimal placement of dams in the network allows to strongly reduce trade-offs between dams and sediment trapping and that dam portfolios with a minor sediment trapping allow developing a major part of the basin's hydro-electric potential.