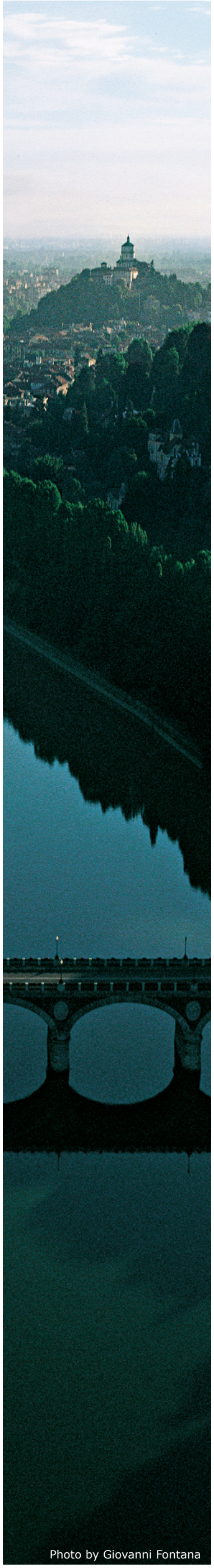

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Abstracts

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Scientific and Organizing Patronages

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Enel small hydropower projects development and their economic analysis according the Italian law renewable energy supports

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The support for energy production from renewable sources, today is a central aim for both European and National legislation. This objective is generally accomplished by means a regulated tariff system, which promotes the renewable sources with respect the other conventional ones. In Italy the energy from renewable sources is mainly promoted through a quota system, which obliges all producers to generate every year a certain quota of electricity with renewable sources or to purchase a certain amount of "*green certificates*" as compensation. In addition, in Italy, the construction of new renewable energy plants and the refurbishment of those existing, may participate in a price regulation system, which provides feed-in tariff. This tariff system is graduated, with the aim to support the development of the more expensive technologies and the lowest capacity system. Among the main renewable natural sources (sunlight, wind, light, tides, water, geothermal), hydroelectricity is the most widely used form of energy and its development is still growing in the world. The energy market liberalisation has led competition between hydroelectric producers: owing to improve their activities, the producers actually are interested both in increasing the installed capacity and in taking advantage of the tariff system. ENEL Group too, which is the most important hydroelectric energy producer in Italy, has developed a lot of projects of new plans, in order to improve the efficiency, and to take advantage of feed-in tariff system. Three are the aspects which constrain the ENEL Group hydroelectric projects: a) the safety, b) the environmental protection and b) the economic turn back. The article deals with the third of the above aspect and, while presenting the main technical characteristics of the most recent of the hydroelectric projects developed, particularly examines their expected profitability, based on the up to date Italian tariff system, by means of well known economic indicators and an useful chart.

Compact evolution of bulb turbine in order to exploit low head opportunities in small hydro power plants (SHPP). An environmentally friendly solution.

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The problem of energy needs versus environmental impact has been one of the most important matters in recent years. The project proposed by EPF Energy is focused on the technical solution able to cross over the environmental impact of a low head hydropower plant. This solution merge the requirement of renewable energy related to the possibility of low head exploitation that represents the residual opportunities available in Italy and in Europe. The underlying idea is to avoid most of intervention on the morphological structure of the site using the technical evolution of the classic propeller bulb turbine. These kind of machines are axial turbines, equipped with blades and hub mounted on the generator shaft. The bulbs are installed in many large hydro power plants across the weirs on the big rivers: in general the bulbs are used in low heads with very low speed rotation and coupled with the generator by a mechanical gearbox.

The application developed by EPF is suitable for small hydropower plant, and insures a multiple and modular installation in order to respond at any flow variation in low head HPP. The proposed turbine is a compact evolution of a traditional bulb turbine. The mechanical aspects are simplified and the turbine is smaller and cheaper than the traditional solution. In this application variables (head and flow capacity) are regulated case by case by the installation of a mechanical blades regulation and an electronical regulation in order to optimize the machine behaviour versus the condition changements, where both head and flow capacity change time by time (installation of a magnet generator with an inverter).

This compact solution allows:

- to limit the overall dimensions of the machine
- to reduce the civil works
- to reduce the environmental impact
- to reduce the noise impact

The system doesn't need a cooling system, and no pumps are required. Concerning the moisture issue, a special pressurized seals, designed specifically for this application, guarantees the dryness of the generator. The pressurized gas inside of the generator frame doesn't permit the water entrance, reason given by the fact that the pressure value of the water is lower than the one inside of the generator. The consequence is that the air goes out from the hole creating a tap against the water. Also the gate upstream to the turbine makes becoming dry the area close to the machine (if both a tube turbine and a compact turbine is installed). In case of fail or lack of pressure, a sensor provides to switch the turbine off.

EPF Energy is developing an *on site* application where seven horizontal axis compact turbines are installed on a river's weir discharger. On this site we are working on the possibility to move up every single group in order to avoid damages during the flood events. Every single element of the design is focused to keep very low the overall environmental impact.

Combined mid- and short-term operational planning of hydropower reservoir systems based on hydrologic forecast uncertainty

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The optimal planning of reservoir system operation has been subject of intensive research in the last four decades. A variety of optimization methodshave been suggested to maximize the efficiency of reservoir operation with respect to an objective function.In case of hydropower reservoir systems, a common choice for the objective function to be maximized is the total energy productionover a control period. The optimization is constrained by several factors, such as lower and upper bounds on water levels and releases, and by a target reservoir level at the end of the planning period. The operational planning of hydropower reservoir systems requires the consideration of the available water inflows over a spectrum of timescales. An important distinction is made between the optimization of reservoir operation on an hourly scale within the one-week time horizon, typically referred to as short-term planning, and the optimization of theweekly scale operation within the one-year horizon,referred to as mid-term planning.Operational decisionsare based on hydrological forecasts that arecharacterized by various degrees of uncertainty depending on the forecast horizon. The role of uncertainty in determining the effective forecast horizon has recently been investigated by Zhao et al. (Water Resour. Res., 48, W01540, 2012). In the present work,the optimization of reservoir operation under uncertain hydrological forecasts is approached using a stochastic optimal control methodwith a risk-based objective function. Following Zhao et al. (Water Resour. Res., 48, W01540, 2012), streamflow series are generated for a givenreservoir using a stochastic generation model,which are assumed to be representative of the real time series. Synthetic reservoir inflow forecasts are then generated by perturbing the streamflow series with Gaussian noise. The variance of the noise is assumed to increase linearlywithin a prescribed time-range and converge to a constant value corresponding to the streamflow variability. A stochastic optimization model is applied in combination with a Kalman filter to maximize the energy production over a one-year time horizon. The resulting energy production is compared with the maximum production in case of perfect a priori information and the expected production from the mid-term planning.
A case study of a multi-reservoir system in the river Dälalven, Sweden, is presented where the effect of forecast uncertainty and the efficiency of the proposed stochastic control modelis investigated using the same methodology to generate synthetic inflow forecasts from the observed time series.Simulation results are compared with real production data.

The role of environmental auditing in sustainable development of hydropower generation: lessons from Kapichira Hydropower Station in Malawi

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An environmental auditing of Kapichira Hydropower station was carried out with the view of improving the design of the second phase of the project. A combination of methods were employed in the assessment of the environmental impacts of the first phase and included field visit of the area, transect walks, consultation with stakeholders and discussion with the surrounding local communities. The main objective of the environmental audit was to collect post-construction environmental and social data of the project area and assess the implementation of the mitigation measures proposed in the environmental and social impact assessment report (ESIA) in compliance with the Environmental Management Act of Malawi of 1996. Our study observed that some of the recommendations were carried out such as the implementation of the reviewed design during construction which resulting into a smaller reservoir with a throwback of only 2.6 km compared to the original 4.5km which could have resulted into large land surface area being inundated. Our study also found out that the inundation of the rocks around Kapichira Embankment had reduced the breeding habitat for Rock Pratincole as reported in the environmental and social impact assessment report (ESIA), however, the birds had found alternative habitat upstream and away from the stream. These provide evidence that to some extent the ESIA had indeed reduced the predicted adverse environmental impacts. However, our study also observed that a number of the mitigation measures proposed in the ESIA were not implemented such as the formation of a steering committee of sixteen institutions which were to oversee the construction and operation of the Hydropower station and the management of the river catchments contributing to the Shire River on which the Hydropower was constructed. This has led to total absence of inter-sectoral management and joint planning of natural resources of these catchments between various institutions at all level and was contributing to heavy sedimentation of the hydropower reservoir. The other significant observation is that the ESIA did not predict the impact of scouring and therefore did not propose any mitigation measures for this operational activity. Souring is the opening of the gates along the embankment to remove the sediment that had accumulated in the reservoir. However, these processes have major adverse environmental and social impacts such as: causing human fatalities, loss of livestock, crops, and properties downstream as a result of the huge flood wave. These flood waves have also carried large amount of fish and deposited them in the oxbow lakes downstream where they are harvested unsustainably by the surrounding communities. These observations raises the question: is Malawi applying the ESIA tool for achieving sustainable development for hydropower projects effectively?

Addressing hydropower policies at a trans-national regional scale: The RENERFOR - ALCOTRA project

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These Implementation of policies in terms of reduction of CO2 emissions at the European scale have originated funding of international projects with different aims. Besides pure research projects, the Interreg funding instruments address capacity building development among transnational regions and represent interesting opportunities of technical and scientific interchange within areas sharing common socio-economic and geographic features. The Interreg-Alcotra Italy-France instruments has been the funder of the RENERFOR project, which encompasses Western Alps Region provinces between Italy and France with the goal of addressing increment of renewable energy production both by the biomass and the hydropower viewpoint. In particular

Hydropower plans, in the era of the 2000/60 Water Framework Directive require balanced approach to the assessment of available water resources and of global impact of new production projects. Consequently, decision makers need to face technical issues vis à vis society and economical pressures, to assume decisions in terms of hydropower exploitation authorizations. The production of scientific and technical knowledge in this project will help bringing critical awareness into decisions having mainly a political nature.

The development of knowledge implicit in the project –for the Hydropower part- are therefore of two kinds: a. water resources assessment is now required at finer resolution and higher reliability than in the past, to account larger availability of data and the need of accouting for the hydrological effects of existing plants on time series recorded downstream; b. Global impact of new production projects requires to be assessed taking into account not only living species in the river and morphological changes but also effects related to the construction and management of the intake and production structures.

Studies on these two issues are under development by the Politecnico di Torino and can be of interest to all administrations in charge of the authorization process for new hydropower plants proposals.

The parameterization-simulation-optimization framework for the management of hydroelectric reservoir systems

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The optimal control and management of large-scale hydroelectric reservoirs remains a challenging issue in water resources modelling and its importance increases, as the growing penetration of renewable sources in the actual energy scene creates additional requirements for energy regulation and storage. In this respect, it is essential to review both the current management policies and the related methodologies for supporting decision-making in reservoir management problems, which are rather insufficient. Older approaches, based on systems analysis (i.e. linear, nonlinear, dynamic or stochastic dynamic programming), as well as more advanced concepts and tools, such as fuzzy logic and neural networks, fail to provide the essential holistic approach, with regard to the various complexities of the problem. Such drawbacks arise due to the large number of variables, the nonlinearities of system dynamics, the inherent uncertainty of future conditions (inflows, demands), as well as the multiple and often conflicting water uses and constraints that are involved in the management of such systems. On the other hand, the parameterization-simulation-optimization (PSO) framework provides a feasible and general methodology applicable to any type of hydrosystem, including complex hydropower schemes. This uses stochastic simulation to generate synthetic system inputs and represents the operation of the entire system through a simulation model as faithful as possible, without demanding a specific mathematical form that would possibly imply oversimplifications. Such representation fully respects the physical constraints, while at the same time evaluates the system operation constraints and objectives in probabilistic terms, through Monte Carlo simulation. Finally, to optimize the system performance and evaluate its control variables, a stochastic optimization procedure is employed (in particular, the evolutionary annealing-simplex method). The latter is substantially facilitated if the entire representation is parsimonious, i.e. if the number of control variables is kept as small as possible. This is ensured through a suitable system parameterization, in terms of parametric expressions of operation rules for the major system controls (e.g. reservoirs, power plants). The PSO framework is implemented within the "Hydronomeas" decision support system (DSS), which has been successfully applied for the operational management of water resource systems of various levels of complexity, including the water supply system of Athens. Recently, both the modelling background and the functionalities of the DSS were upgraded to also handle hydropower generation components, as well as pumping-storage facilities. This new version is tested in a challenging case study, involving the simulation of the Acheloos-Thessaly hydrosystem. Acheloos is characterized by very high runoff and hosts 1/3 of the installed hydropower capacity of Greece. Apart from the existing scheme of projects, future configurations are also investigated, involving the diversion of part of the upstream water resources to the adjacent plain of Thessaly. For each configuration, the optimal management policy is located, on the basis of multiple performance criteria that account for both economy and reliability. Various formulations of the objective function are examined, combining different types of benefits from water and energy production (distinguishing for firm and secondary energy) and costs (due to pumping). Finally the sensitivity of solutions against the assumptions of the stochastic simulation model is examined. Emphasis is given on the effect of long- vs. short-term persistence of the simulated inflows.

Residual hydropower potential assessment with spatially smooth hydrologic and morphometric methods

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Even in regions with mature hydropower development, needs for renewable energy suggest to revise plans of exploitation of water resources, in the framework of EU and national regulations. High resolution hydrological analysis is then needed to comply with the effects of existing hydropower plants or of other water withdrawals.

Flow duration curves (FDC) are the tool usually adopted to represent water availability and variability for hydropower purposes. They are usually determined in ungauged basins by means of regional statistical analysis. The presence of existing reservoirs and hydropower plants can affect the FDCs and must be taken into account in both local and regional analyses. For this study, a regional "spatially smooth" model has been developed for FDC estimation: the method is characterized by keeping the estimates of mean annual runoff congruent in the confluences. This feature is particularly important in high resolution analyses and is obtained considering only raster-summable explanatory variables.

The procedure adopted here relates the L-moments of the FDC to several geomorphoclimatic parameters, with the purpose to directly reconstruct a "naturalized" FDC. The proposed procedure is systematically extended to all the gauged basins located in Northwestern Italy, which is an area characterized by the presence of a large number of dams. For each basin the annual average FDC is computed, its L-moments are calculated and corrected using a simplified model that takes into account the effect of upstream reservoirs and power plants. Then, we regionalize each corrected L-moment using multiple regressions techniques, allowing one to reconstruct the L-moments at any ungauged basin. Finally, the "naturalized" FDC is reconstructed at the ungauged site on the basis of the predicted L-moments.

The residual hydropower potential is evaluated by mapping the mean naturalized flow estimated for each pixel of a DEM-derived river network raster model. Spatial algorithms and data management are developed by the use of Free&OpenSource SW GRASS GIS and PostgreSQL/PostGIS. In two case studies, we used a 50 m DEM to compute, for each network pixel, the upstream watershed and all the morpho-climatic characteristics needed in the regional model.

Maps obtained return flow-altitude relations for each pixel along a drainage path assuming different possible headrace length (1, 2.5 and 5 km). This approach is associated to the RENERFOR project to support hydropower potential survey studies and to assist impact assessment of the existing derivations.

A new approach to evaluate eco-sustainable flow releases in run-of-the river power plants.

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Water demand for hydropower exploitation is increasing together with the scientific and social consciousness of the importance of riparian ecosystems and biodiversity. Some Cantons in Switzerland and other alpine regions in Austria and northern Italy started replacing the inadequate concept of Minimum Flow Requirement (MFR) with a dynamic one, by releasing a percentage of the total inflow (e.g. 25 %) to the environment. In the same direction Perona et al. (submitted) mathematically formulated a method particularly suitable for small hydropower plants, handling the environment as a non-traditional water user which competes with hydropower. This model is based on an economic technique, the Principle of Equal Marginal Utility (PEMU), and suggests a way of generating quasi-natural flow releases while maximizing the aggregate economic benefit of all uses. In this paper we evaluate both ecologic and economic benefits of dynamic release policies from practitioners, and compare them to those generated by Perona et al.'s method. A classic issue in small alpine projects is the lack of site-specific data, indicators and adequate knowledge to quantify ecological alterations induced by streamflow modifications. In order to overcome this issue we compute the statistics of the flow releases polices using the Indicators of hydrologic alteration (Richter et al. 1997) and linking the environmental benefits to the hydrological differences from the natural flow regime. Eventually, we monetize the value of ecosystem healthiness underlying each policy by means of the PEMU and use the long term mean of the ratio between the allocated flows between traditional and non-traditional users as a suitable engineering parameter. We refer to Calanca valley in southern Switzerland, as a good example of the anthropic pressure caused by energy demand which concerns small valleys: in the near future the realization of 4 new projects of mini hydropower plants in less than 4 Km along the valley can be an example of such a pressure. We focused on one of these projects simulating all proposed scenarios and evaluating them. As observed results show how performances can be increased both economically and ecologically with respect to classic MFR approaches. For instance we show that regulations approaches based on fixed percentages can be improved by simply applying the PEMU approach. Furthermore, we propose to look at traditional alternatives in terms of PEMU: such a point of view can be a powerful instrument for political managers to reach the best compromise. Finally, we discuss how the theoretic efficient redistribution law obtained by our approach is actually feasible and doesn't imply high costs or advanced management tools: a shaped water deflector would be the only additional cost.
This method is a simple but effective step towards eco-sustainable exploitation of the water resource in the growing market of mini hydropower plants, where operation rules like MFR are still widespread.

Impact of flow regulation on fluvial systems with special reference to hydro-power

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Hydro-power operations have a wide range of impacts on river flow regimes. These changes in turn influence sediment transport and storage in fluvial systems. Such changes have been widely studied but relatively less attention has been placed on their influence on riparian vegetation dynamics and consequent interactions between vegetation and fluvial processes. These interactions can have profound effects on the nature, distribution and dynamics of channel and riparian habitats. This paper will consider the above interactions under particular types of flow regime change imposed by hydropower development, including the effects of diversions, hydropeaking and changes in the form of the flow duration curve. Coupled with the hydraulic stresses imposed by the changed flow regime, these adjustments have complex consequences for the river ecosystem.

The necessity for large-scale hybrid renewable energy systems

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Since global economy is dominated by the energy sector, the planning and management of energy systems is a prerequisite for a sustainable future. It is widely recognized that the existing paradigm, based on the intense use of fossil fuels, if far from sustainable and thus a substantial shift is needed, in the direction of energy saving and developing renewable sources. Yet, current energy planning in Europe, while it strongly promotes the penetration of such systems, has failed to account for the significant differences thereof with conventional energy sources. Small scale energy production units are encouraged and even subsidized. In addition, their piecewise view and the lack of an integrated development plan at country scale, results in increased costs and puts significant restrictions on energy management. It is well-known that renewable energy is highly varying and unpredictable, as it strongly depends on the hydro-meteorological conditions. The inherent uncertainty of the related natural processes is directly reflected in energy production, which cannot follow the temporal distribution of the corresponding demand. An additional drawback is the lack of regulating capacity, which makes impossible to store the excess of production. In this context, the concept of a future scene in which renewable sources dominate will be feasible only if renewable energy resources are combined with technologies for energy storage. The proven technique of pumped storage (i.e. pumping of water to an upstream location consuming available energy, to be retrieved later as hydropower) represents the best available technology since it does not emit any by-products to the environment, and is cost efficient, with loss ratios less than 10% (in large scale projects). In addition, hydroelectric energy production does not consume water (only converts its potential energy) while it can also be combined with other water uses (domestic, agricultural, industrial). Hybrid systems, combining multiple sources of renewable energy with pumped-storage facilities, are generally viewed as proven technology to increase renewable energy source penetration levels in power systems. However, such systems have, in general, limited capacity and are mostly implemented in relatively small areas, e.g. to serve autonomous island grids. On the other hand, the dominant ideological views especially in the European Union disfavours the building of new dams and large hydro-projects. However, the issue of scale, which refers to both the size of energy units and their spatial extent, is of major importance, since efficiency (in terms of produced energy to installed capacity) increases with scale, as does reliability (in terms of covering energy demand). For this reason, it is impossible to envisage a future energy landscape without large-scale hydroelectric reservoirs, equipped with pumped storage. To this extent, a holistic planning for large-scale hybrid renewable energy systems, in which water, wind and solar radiation are the sources of energy, with water in an additional integrative and regulating role, becomes plausible and desirable.

Hydrological Prediction for Hydropower Production

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The present paper describes a hydrological model aimed at improving prediction systems for a hydropower production plant. A significant merit of the work lies in the model structure that incorporates physically based processes allowing a new strategy of model calibration. In fact, calibration procedure is made decomposing calibration phases according to the processes simulated. The procedure is made of the following steps: parameters of snowmelt module are calibrated using the snow coverage obtained by satellite images, baseflow is identified using a mathematical filter in order to allow the calibration of the parameters controlling surface runoff with the time series of surface streamflow. This allows to define a reliable model structure able to provide good estimates of the streamflow. This information is crucial for the day-ahead market that enables participants to buy and sell electricity for any of the 24 hours of the following day. Model is used on the Aniene river basin generating deterministic forecast obtained from COSMO-LAMI. Analyses have been used to make prediction with 1, 2 and 3 days in advance. Results show a good level of the performances of the forecast with 1 day in advance while errors increase more markedly at 2 and 3 days. Model may represent a useful tool for power production optimization in hydropower plants.

Evaporation from reservoirs and hydropower water footprint estimation

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Renewable energy sources are imperative for reduction of greenhouse gas effects on climate change caused by human activities. Hydropower is a renewable source that uses natural resource, water, for energy production. The water, as a fuel, stays in the production process unchanged in the quality and quantity and the energy production process is free of any generation of CO2 or other GHG. Hydropower plants, especially big plants, are not free of environmental and social impacts and they should be seriously considered and minimized during the design process and during operation, yielding to the sustainable hydropower energy generation. Free water surface has higher evaporation potential than the ground covered with vegetation and therefore reservoir origins higher evaporation than the originate state before reservoir construction. The natural evaporation process represents an energy loss for hydropower and should be included in the power plant energy calculations, but evaporated water could also change the water balance in the downstream river basin part. The water footprint of a product (a commodity, a good or a service) is the total volume of freshwater used to produce the product, summed over the various steps of production. The water footprint of a product refers not only to the total volume of water used; it also refers to the place and the time when the water is used. The water footprint characterizes the water evaporated or incorporated in the product and distinguishes between rainwater (green water footprint), ground or surface water (blue water footprint) and volume of polluted water (grey water footprint). The hydropower is only loaded by evaporation, the blue water footprint. The run-of-river plants are the designed in the existing riverbed mostly without any additional flooded areas and therefore not producing any additional evaporation - have no footprint. In case of the storage plants the evaporation from the reservoirs cannot be suppressed and have to be considered. The evaporation from the several reservoirs in different climatic zones (continental, semiarid and tropical) is estimated based on the different methods (measurements and estimation by combined energy budget and mass balance techniques). The annual evaporation is set in relation with the annual energy production and the hydropower water footprint is calculated. The total hydropower water footprint is a function of climate zone, size and operation type of the reservoir, but also of the produced energy. The reservoirs have mostly the multipurpose function and are additionally used as drought/flood control, irrigation, navigation, human or industrial use and communal amenity use such as for tourism, sports fishing etc. In case of multipurpose need and use of the reservoirs also the footprint should be shared between different clients. Multipurpose water usage and share of the evaporation between different clients additionally complicate the footprint calculation procedure. Therefore hydropower water footprint, calculated under assumption that total evaporation is born by electricity production, could be used as an indicator for water usage. By design of the power plants all ecological and environmental influences on the ecosystem have to be taken into consideration in order to assess plant sustainability and the water footprint could be one of the factors achieving sustainable objectives.

Environmental Challenges and Management Issues Associated with the Exploitation of Hydropower Potential in India

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Exploitation of hydropower potential under a changing climate is a challenging issue in India. Demands in energy are escalating, whereas the gap between production and consumption is increasing. Nearly 600 million out of the 1.2 billion population has no access to electricity. Since 2004, the Indian economy has grown at a rate of over 9%/year, supported by an energy growth rate of less than 4%/year. Enhancing energy supply and access is a key component of the development strategy. Development of environment friendly, sustainable, relatively cheaper and efficient hydropower is one of the ideal sources of clean energy. India is endowed with economically exploitable and viable hydropower potential, ranking 5th in global scenario. However, exploitation of this potential is not up to the desired level due to various administrative, socio-economic, environmental and political constraints. One of the major challenges is the changing climate, especially the extremes and changes in rainfall seasonality. In certain parts, rainfall is becoming more seasonal and intense, leading to wasteful runoff, as reservoir capacity is fast exceeded. Fall in the rate of groundwater recharge in the hills where the rivers originate reduces summer flow in rivers. In the Western Ghats Mountain region, intense rainfall with large cloud drops from convective clouds causes more erosion and sedimentation, considerably reducing the reservoir capacity. Abnormal melting of the Himalayan glaciers is a threat to all hydropower projects in north India. Opposition from the ecologists is one of the major hurdles in hydropower development. Rehabilitation and resettlement of the evacuated people from the project area is a complicated issue. Another challenge is the disputes over the transboundary rivers. Issues worsen when the monsoon fails. The ongoing national river linking project is likely to make the situation more complex. Government machinery is slow and corrupt, and there is a lack of coordination among different departments. National action plan on climate change has considered energy sector seriously. The suggestions include step-by-step increase in the production of renewable energy. Today, 31 % of the energy is from renewable sources, mainly the hydropower that provides 26%. Government has set efficiency benchmarks in energy sector, targeting greater efficiency in the coming years. The Energy Conservation Building Code encourages the design of 30% more energy efficient buildings. A trading scheme for Energy Efficiency Certificates is being developed. State governments have also undertaken efforts to increase energy efficiency at the domestic level. To achieve an 8-10% growth rate that is necessary to eradicate poverty, the country has to overcome its rising energy constraints. India is still in the process of building its energy infrastructure and it has the opportunity to invest in energy efficient technologies that can help the country to overcome energy crisis with non-conventional sources. The Integrated Energy Policy (2006) has suggested the accelerated development of hydropower for clean energy. Changes in climate can be beneficially utilized through proper adaptation strategies and management practices. More multipurpose reservoirs with major and minor power development schemes can solve energy crisis and control the impact of extremes. There are other options to produce more hydropower and save energy like making reservoirs multipurpose, reducing transmission loss and controlling overuse and misuse. India needs a better policy for water and energy, an appropriate adaptation strategy to face the climate change and an efficient mechanism for their implementation. This paper assesses the impact of climate change on hydropower generation in India and of the associated environmental and management issues. Current policies, management practices and adaptation strategies have been critically reviewed to provide guidelines for an improved energy policy.

Implications of Water Stress Impasse on Large Hydropower Systems in Nigeria

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Coupled with the water stress from the impacts due to climate change on the major hydro systems in Nigeria, the recent additional water stress emanating from some of the several major new dams authorized and currently being constructed on the Niger River system, the two major hydropower systems in Nigeria are experiencing turbulent and distressed flow conditions which have raised some ecological and energy concerns. The current knowledge and critical review of these water stress impasses on these hydro systems have been evaluated and bankable sustainable adaptation strategies and complementary mitigation plan actions to be implemented to reduce these impacts on long and short term basis are opined in this study.
Keywords: Hydropower systems, climate change, water resources, impact, environment, mitigation plans.

What if Brazil runs out of energy for the coming 2014 Football World Championship?

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Population growth, economic development, urbanization, changes in hydrological regimes and land use are the main drivers affecting allocation and exploitation of water resources. The pressure exerted by these global changes on the five countries -Argentina, Bolivia, Brazil, Paraguay and Uruguay- located in La Plata Basin over the last decades has raised the need for assessing trends in future electricity demand and energy production in the basin. The aim of this research is to assess whether (and when) shortage and vulnerabilities in terms of hydropower generation are to be expected in La Plata basin in the next decades. The methodology proposed has focused on two aspects to reach the objectives: 1) assessment of hydropower production and electricity demand in the basin over the last twenty years (1987–2008), in order to establish growing trends for the next thirty years; 2) computation of maximum potential hydropower using the newly developed Arc-GIS based tool VAPIDRO–ASTE. The assessment and calculation have been applied to La Plata River and its main tributaries: Paranaiba, Grande River, Tiete, Paranapanema, Iguaçu, Uruguay, Negro River, Paraguay and Paraná. The first outcomes of this research show that La Plata Basin has high hydropower potential. About 40% of the hydropower potential is already used to produce and supply energy. Out of the remaining 60% potential, about 25% could hardly be exploited because of environmental issues or low cost/benefit ratio. Thus, the estimated residual potential hydropower is about 35% of the maximum potential hydropower calculated. Despite the high hydropower potential, the electricity demand trend grows faster than the hydropower production, so other sources of energy such as thermal, nuclear, solar, wind or hydropower produced outside the basins are necessary to supply the shortage and avoid the potential energy vulnerability.

Coupled water-energy modelling to assess climate change impacts on the Iberian Power System

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Water resources systems and power systems are strongly linked; water is needed for most power generation technologies, and electricity is required in every stage of water usage. In the Iberian Peninsula, climate change is expected to have a negative impact on the power system: changes in runoff are expected to reduce hydropower generation and cooling water availability for thermal power generation; and higher temperatures are expected to increase (decrease) summer (winter) electricity demand, when water resources are already constrained. We use coupled hydrological and power system models to study the effects of climate change on the current Iberian power system.
The Iberian power system is a competitive power market where power price is determined by power supply and demand, and which can be simulated by a market equilibrium model considering the power demand function and the installed capacities and marginal costs of the power producers. Two effects of climate change on the power system were studied: changes in the hydropower production caused by changes in precipitation and temperature, and changes in the electricity demand over the year caused by temperature changes. A rainfall-runoff model was established to estimate the impact of precipitation and temperature changes on reservoir inflows. The model was calibrated using observed precipitation, temperature and river discharge time series. Potential evapotranspiration was estimated from temperature data, and snow accumulation/melt was modelled using a temperature index method. The delta change approach was used to generate synthetic precipitation and temperature data based on observations (1961-1990) and three regional climate models (2036-2065, CLM, RACMO and REMO). Because modelling generation on 1000+ hydropower plants is intractable, the capacities, inflows and minimum releases of all reservoirs were converted to energy and power units, and then aggregated into an equivalent energy reservoir. Irrigation water demands were also converted to power units and added to the minimum releases of upstream reservoirs and to power sinks of downstream ones. The water value method, an adaptation of stochastic dynamic programming, was used to estimate the marginal costs of hydropower as a function of the time of the year, the energy storage and the inflow state. The power system was simulated with estimated power demand, and the installed capacities and marginal costs of every generation technology, providing estimates of electricity prices and power production per technology under different climate scenarios.
The simulation results indicate that hydropower production is likely to decrease as a consequence of reduced inflows, causing higher electricity prices. Temperature changes will shift a portion of the electricity demand from winter to summer months, resulting in increased electricity prices. The reduction of water availability caused by climate change will increase the competition between irrigation and power production, leading to a sharper trade-off between electricity prices and agricultural benefits.

Solutions to harmonize clear water & clean energy

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Hydropower is still the most important renewable resource for electricity production in Europe: it shows clear advantages for the global CO2 balance but creates ecological impacts on a local scale. Therefore, hydroelectric production has to be maintained and likely increased following the demand trend. EU countries must also achieve their share of renewable electricity production according to the 2001/77 (RES-e Directive). On the other hand, hydropower utilisation often involves severe hydrological changes, damages the connectivity of water bodies and injures river ecosystems. The 2000/60/CE (WF Directive) obliges member States to reach by 2015 a "good" ecological status in water bodies.

One of the main problems to be faced is the contrast between Public Administration and Environmental associations on one side and the hydropower producers on the other side, for the exploitation of water bodies. Competition between water users (for drinking, irrigation, industrial processes, power generation, etc.) is becoming a serious problem, and there is a strong need of a more accurate planning and management optimization of the resources. Usually stakeholders lack reliable tools to evaluate the effects of water withdrawal, deal with water conflict, and be supported in taking policy decisions.

Proposed solutions to harmonize water and energy deals with the following topics: *Use-friendly tools*, available for public administrations, environmental agencies and hydropower investors *for planning and managing* water resources and hydropower concessions, considering multi-purposes uses, and taking into account river's environmental values; *Guidelines for preserving rivers* with particular concerns to aquatic ecosystems, considering the required Environmental Flow, macro-habitat quality and related environmental issues; *Common strategies & methods* to promote the *development of small hydropower plants (SHP)*, distributed in the territory recovering the remaining water power availability, and using an "ecological" approach; Promotion and *dissemination of experiences* in solving problems among target groups of European countries.

Minimum Vital Flow: the experiences in Aosta Valley Autonomous Region

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The main goal of the Water Protection Plan of the Aosta Valley Autonomous Region is the improvement of the ecological status of the water bodies.
During the first phase of application, since hydropower is the most important regional renewable energy source, the actions directed to improve the hydro-morphological and biological status of the water bodies have been focussed on hydroelectric derivations, with the involvement of the main regional producers. The Water Protection Plan has established that the Minimum Vital Flow to be released downstream the main existing hydroelectric derivations, should be individuated either through hydrological criteria or experimentally by means of a 5-years experimental plan. Such plan is based both on the measurement and evaluation of the water courses ecological status, and on the individuation of an adequate amount of water, identified as the best compromise between keeping the river equilibrium and using the water resource. The widest experiment is involving the Water Regional Company (CVA) with a survey plan regarding the Company 28 main hydroelectric derivations, some of which chosen as basin samples on the basis of their representativeness of the different regional characteristics. The experimental plan has been articulated in three phases. During the first phase, an environmental characterisation campaign has been developed for the involved territory, subjected to hydroelectric derivations pressures for decades. During the second phase, environmental measures (IBE, LIM, IFF, ichtyofaunistic analyses, photographic surveys, STAR-ICMI, IFIM, morpho-hydraulic sheet, water flows of downstream stretches) and different levels of releases (0, 20, 60, 100% of the hydrological component) have been carried out in the specific basins. During the present last phase the data collected are being entered in a geo-database functional to the application of the MultiCriteria Analysis (MCA).
The main problems encountered are related to the specific structure of the aggregate indexes and to their lack of sensitivity in recording the different alternatives of release, except the chronic effect due to historical alterations. Only the hydro-morphological indexes seem to best characterize the transformations occurred in the riverbed. The Minimum Vital Flow assumes more and more the characteristic of a choice connected with the objectives of functionality and fruition of the water course stretch, than of a quantity of water bound to the intrinsic conditions of the river. The utilization of the MCA will allow to rationalize such process, by evaluating different alternatives for the management of the water course, defined by criteria (environment, landscape, energy production, tourism, fishing) described by indicators constructed for the purpose.

A Reservoir Geosimulation using Remote Sensing, Multi-Agent Systems and Participatory Geoinformatics

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In managing a multipurpose dam, knowledge of water inflow or the amount of water entering the reservoir is essential in planning and scheduling discharges for optimal power production and irrigation supply, and in flood control. Utilization of satellite imagery improves inflow estimates provided by digital spatial data rather than calculations from drawn maps. Satellite imagery yields measurements over an area are obtained instead of extrapolations from point measurements.
Using remote sensing data and GIS, two approaches are developed in this study to estimate inflow: (1) Creation of IMBAC (Inflow Monitoring from Basin Assessment Calculations), a new inflow estimation system using available satellite-derived data and JAVA® programming; and (2) Maximizing the use of satellite-derived data for inflow estimation in an existing hydrologic modeling system, the US Army Corps of Engineers' HEC-HMS® (Hydrologic Engineering Center-Hydrologic Modeling System), where three different basin models are used to validate the results--the initial constant model, the SCS curve number model, and the soil moisture accounting model.
The developed approaches to estimate inflow are applied to the Magat watershed; its dam is one of the largest multipurpose dams in Southeast Asia. Its 117-km2 reservoir stores water to irrigate 85,000 hectares of farmland and its 360-MW hydro-power plant provides electricity for Luzon, the Philippines' largest island. Due to the implementation of the Philippine Electric Power Industry Reform Act (EPIRA) in 2001, management of the reservoir and the dam facilities has to be shared. The dam and the plant intake gates are owned and operated by the National Irrigation Administration. Management of the plant itself is transferred to SN Aboitiz Power Incorporated (SNAP). Authorization of discharges during extreme weather conditions comes from the country's meteorological agency, the PAGASA. With such a complex nature of the dam's multi-stakeholder management involving private and public entities with different discharge motivations, a vital decision support system that concerns inflow estimation is paramount.
This study presents the results of the developed methodology to estimate inflow using remote sensing as an alternative to the current water-level approach being used locally. It shows that both the IMBAC and the HEC-HMS® approach were successful in showing the behavior of watershed response. The second approach was more successful in terms of the immediate potential for operational use.

Simulating seasonal variability of runoff regimes in mountainous regions

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Reliable estimation of the available water in mountainous basins is important in the management of these resources in support of different uses such as ecological and hydrological integrity, hydropower, water supply etc.. Estimation of the available resource is, however, challenging given the difficulty of measuring precipitation and snow in mountainous areas. Underestimation of the resource is common, due in many cases to undercatch in the measurement of both solid and liquid precipitation. Underestimation of the observed precipitation clearly results in the underestimation of the runoff regime.
In this paper a parsimonious water balance model is used to simulate the seasonal variability of runoff regimes in mountainous catchments. The gridded water balance model is applied at a monthtly time-step using mean areal precipitation and elevation lapsed temperature as an input. A threshold temperature is defined to seperate monthly solid and liquid precipitation, with the distribution of sub-monthly temperatures parameterised using a probabilistic distribution. A modified degree-day snow model is used to estimate the snowmelt. Precipitation correction factors to reduce the bias in the runoff are determined through an inverse approach, and several methods to distribute these corrections across the different seasons are tested. The model is applied to 39 basins in the North-Westerrn Italian Alps, including basins where the runoff is dominated by snowmelt, by rainfall, or by a combination of both. Results show that the model can provide a reasonable simulation of the seasonal runoff regime, with the ranges of the calibrated values for the melt factor and standard deviation of the temperature distibution found to be quite (physically) reasonable. Redistribution of the rainfall bias as a function of the fraction of the month with negative temperatures is found to give best results, though this varies depending on the dominant processes in runoff generation in the basin. Other approaches to disrtibution of precipiation correction factors such as a dependency on elevation are found to be less relibale as the spatial distribution of precipitation is shown to not depend only on elevation. In the 39 basins tested, precipitation trends are found to both increase and decrease with elevation, depending on the basin topology and climatology. This is supported by trends found in precipitation data across from the Swiss Alps.

Implication of water travel time distributions in operation of multi-reservoir systems

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Saint Venant Equations are often used for describing water flow in stream flow networks. Solving these equations requires extensive calculations, which is often considered the reason for extensive simplifications in analysis of regulatory control of a river system with cascade reservoirs, such as e.g. a single time-lag for water flow between reservoirs. This study focuses on the effect of the mean and the variance in water travel times between reservoirs on regulatory state variables for a hydropower system in River Dalälven, Sweden. Dynamical waves can be neglected for sufficiently small dimensionless wavelengths, which thus lead to a simplified problem formulation where we retain only the kinematic and diffusive waves in the formulation.

The kinematic-diffusive wave equation is used to describe flow on stream reaches and implemented in combination with a series of reservoir equations and used for investigation of the short time scales of the hydropower system. Hence, the combined compartmental and kinematic-diffusive wave model is used to study the importance of the kinematic-wave celerity and wave diffusion coefficient on the regulatory behaviour in terms of constraining power demand, energy output and rest energy in reservoirs. To do this we start by optimizing the model parameters versus operational and hydrological data, which is followed by a sensitivity analyses in alternative regulatory schemes. For a sufficiently high Peclet number, however, the distribution of time-lags become narrow enough to motivate being replaced with a simple kinematic wave. The model is tested using flow and production data collected from hydropower systems.

The study puts in effect the identification of waves in a regulated river. The causes and effects are identified as well as the implication of simplifying the dynamic wave in a hydropower system in an effort to promote effective hydraulic practice.

Science-Policy Interactions in Participative Drought Planning and Management in Jucar River Basin, Spain

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Most watersheds in East and South-East Spain can be classified as semi-arid or arid with large space and time variability in precipitation and river flows. Therefore, water resource systems planning and management must be done with emphasis on drought preparation and mitigation. Administration of water is performed at basin scale by Basin Agencies (Confederaciones Hidrograficas) since early in the 20th century, and water laws enforce the design and implementation of Basin Plans (BP), since 1985, and of Special Drought awareness and mitigation Plans (SDP) at basin and local scales, since 2000. The use of models and Decision Support Systems (DSS) has played an important role in the development of the Jucar Basin Plans for almost two decades, as well as for the development and implementation of the Special Drought awareness and mitigation Plans (SDP). The SDP's have been formulated according to a proactive approach to drought preparedness and mitigation. They include long term (planning), medium term (alert) and short term (emergency and mitigation) measures that are activated using Standardized Drought Monitoring Indicators (SDMI) based on the use of combinations of data provided by the Automatic Data Acquisition System (ADAS) on precipitation, storage in reservoirs, groundwater levels, and flows in rivers. The SDMI and the curves of thresholds for assessment of the drought situation have been calibrated by intensive use of DSS for drought risk estimation. In order to manage a drought, a participatory Drought Permanent Commission (DPC) is set up, including representatives of all stakeholders in the basin. Besides of the regular use of the SDMI, DSS are also permanently used at the real time management DPC meetings to assess drought risks and vulnerability at medium and short terms. When entering into a drought alert or emergency situation, DSS are a way to evaluate the effectiveness of the measures to modify the risks and to mitigate the impacts of the drought. This is of great help in the negotiations among the parties in the participatory DPC set up in emergency situations. In this contribution, the experience using these tools during the 2005-2008 drought is reported. This is the most intense hydrological drought registered in the basin in recorded history (since 1940). Due to the high degree of water scarcity in the basin (ratio of used to renewable resources is around 0.8) situations like this threaten economic uses of water and environment, with big potential damages. Among the measures used during this drought we can find increase of efficiency in water use; improvement in control devises for surface water diversion, groundwater abstraction, and environmental flows; continuous monitoring and inspection of water use and environmental state; anticipated conjunctive use of surface and groundwater, direct reuse of treated wastewater, combined use of two neighbor basins, temporary water rights purchases, and emergency works to improve connectivity in the system. As a result, the worst drought in modern times has been passed with relatively low economic and environmental damages; urban supply was always fulfilled; and conflicts among users solved in an atmosphere of transparency, and cooperation fostered by the mentioned methodologies. DSS for Jucar Basin has been developed using Aquatool DSS Shell developed at Technical University of Valencia (UPV), facilitating the development and use of hydrological, management, water quality and risk assessment models by the Basin Agency professionals.
Keywords: Science-Policy Interface, Decision Support Systems (DSS), Drought Planning and Management, Participatory conflict resolution, Spainthe character size and abstract length used in this templateThese instructions explain how to prepare your Abstract. They are presented exactly as your final text should appear. It is requested to comply with the character size and abstract length used in this template.

Soil and Water Conservation measures in the Sahelian region - the Laaba catchment case study, Burkina Faso

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In the Sahelian region, the high precipitation intensity and daily rainfall extreme values are currently the main cause of soil erosion and land degradation. The rill and gully erosion, the progressive disappearance of the vegetation and the extension of soil surface crusting result in a massive reduction of soil thickness and decrease of nutrients holding capability. In addition, solid transport often leads to reservoir siltation and the reduction of the amount of water available for agriculture. To cope with these issues, Soil and Water Conservation (SWC) measures, such as permeable rock dams and gabion check dams, along with other water-harvesting practices (e.g., tillage, mulch covering, earth bounds), have been widely employed during the last decades with the support of international cooperation and development projects. A proper effectiveness analysis of the impact of SWC interventions on the catchment sediment budget requires quantitative surveys on erosion and sedimentation processes, which are often expensive and time-consuming. Where data for calibration and validation of models are scarce, an overall methodology to evaluate the economical sustainability of a proposed intervention can be of paramount importance.
The study herein proposed aims to assess the effectiveness of SWC measures in limiting the reservoir siltation of the Laaba reservoir (Yatenga District, Northern Region of Burkina Faso), through the comparison of catchment sediment budgets before and after the implementation of SWC measures. The limitations in collecting a large amount of data and the need of a low cost methodology for the area of interest were the starting points of this work. Field data collection and remotely sensed data provided the general information on the main geomorphological and pedological parameters leading the soil erosion and sedimentation processes in the catchment. Finally, using a semi-quantitative approach, a cost-effectiveness analysis is proposed to assess the economical sustainability of a possible SWC intervention. The proposed methodology shows interesting potentials for land and water management in the Sahelian region, particularly when data and financial resources are limited and where the application of detailed process-based models is not possible.

Risk governance of water-related hazards: a combination of top-down and bottom-up approaches

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The Hyogo Framework for Action (HFA) for building the resilience of nations and communities to disasters is a 10-year plan to make the world safer from natural hazards. It was adopted by 168 Member States of the United Nations in 2005 at the World Disaster Reduction Conference held n Hyogo, Japan. "Risk governance" is one of the five priority actions set by the HFA, which suggests to built, in every country, multi-sectoral and integrated National Platforms.
In addition to HFA implementation, in the European Countries the prevention-related policies and legislative frameworks are experiencing a process of harmonization, as indicated by some European instruments, such as the Flood and the Seveso directives. In general, both UN and EU set down general principles and objectives, to be adopted by Member States and implemented by Local Communities, following a traditional top-down process.
However, the whole risk governance process is more complicated than a schematic implementation at the local level of upper-level laws. "Governance" involves structures and institutions that determine the amount and the quality of social protection that people have access to, disaster preparedness and opportunities for livelihoods. Policy makers are required to take difficult decisions about what and to what extent must be protect from hazards (accepting *residual risks*), how to protect it, and at which price. These are tricky choices, that can turn against the administrations, especially if they are not explained and accepted by stakeholders and citizens. A good risk governance requires a participative and bottom-up process among policy makers, scientific and research institutions, stakeholders and citizens, through an integrated, knowledge-based and interdisciplinary approach. The local governments are the administration level closest to citizens and deliver essential services, such as health, education, transport and water services. They are the first to respond to emergencies and also the first to be blamed in the case things turn bad.
Risk governance requires strong accountability mechanisms, also at local level, for weighting hypotheses and decisions: the access to information is essential, while barriers still exist. Data of past events are important, because they represent a quantifiable evidence and create the condition for evidence-based, transparent decision making on the economic feasibility and effectiveness of investments in risk reduction.
All these aspects have been considered in the on-going EU project KULTURisk, of the FP7 theme "Environment, including climate change". The project, to be completed by the end of 2013, is aimed to increase the culture of prevention for risk reduction in Europe by means of a comprehensive demonstration of the benefits of prevention measures and providing a correct framework for decisions to policy makers and administrators. KULTURisk is focussing first on water-related hazards, as the likelihood and adverse impacts of water-related catastrophes might increase in the near future because of land-use and/or climate changes. A variety of case studies characterised by diverse socio-economic contexts, different types of water-related hazards (floods, debris flows and landslides, storm surges) and space-time scales are utilised.
In this field, the terminology used is often not clear nor stable. The established approach for the calculation of risk refers to the *expected damage*, which is a function of hazard, vulnerability and exposure. However, it considers only direct and tangible costs, which is a limited notion of risk, that fails in considering the complexity of the social components. Even the concept of *vulnerability* is mainly studied as a physical concept instead of an output deriving from social conditions and processes (e.g. coping and adaptive capacity).
Research in the field of disaster reduction is facing the issue of *measurement*, in particular when considering indirect and intangible damages and the issue of "*monetisation*", to find different indicators, as simple and universal as the money.
The integration framework developed in KULTURisk will allow for an integrated assessment of the potential benefits of measures to cope with flood risk, going beyond the 'traditional' approaches to risk assessment, by enhancing the consideration of social and economic dimensions of vulnerability: in this frame, solutions for the assessment of 'total costs' will be provided, not guaranteeing – and even searching for – full monetisation. Generalised implementation rules will be derived from different case study results, where the participatory approach has been put into practice and different stakeholders are involved.

Interdisciplinary research: evaluating its role and potential for understanding water resource systems

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Water resource systems span across academic borders. Our capacity to manage vulnerable systems in a sustainable way reflects our knowledge and understanding of the systems. Knowledge tends often to be fragmented and synthesis enables a fuller understanding. Interdisciplinary research is often promoted as a strategy to bring together fragmented knowledge and understanding. The Vienna Doctoral Programme aims to educate students in interdisciplinary water science through cutting edge research at an international level. It has been running since 2009 and offers an opportunity to explore in detail how interdisciplinary research takes place and what it is capable of achieving. Using the Vienna Doctoral Programme as a case study, we investigate whether an interdisciplinary approach is good for developing and addressing science questions in water resource systems. A range of performance indicators are used to "measure" interdisciplinarity. These include the degree of interaction or connectivity between researchers, the number of research disciplines involved in addressing a science question, how researcher attitudes to interdisciplinary work change through time, and amount of researcher involvement in interdisciplinary activities. Comparison of the degree of interdisciplinarity to the number and type of science questions developed, and to research achievements, such as the number of publications enables us to empirically assess the scientific value of interdisciplinary research in water resource systems.

Active stakeholder involvement: an opportunity or a challenge for river basin management?

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Individuals, communities and stakeholders are often encouraged to participate in water resource management. The European Water Framework Directive identifies participation as occurring through information exchange (e.g. education and consultation activities) or active involvement. A literature analysis of work which evaluates examples of stakeholder involvement in water resource management has been conducted. This shows that participatory activities most frequently achieve information exchange (either in one direction such as education programmes, or in two directions such as information provision followed by consultation to receive feedback). Active involvement of stakeholders in decision making and management seems to be achieved less often. By examining the cases where active involvement has been achieved several trends can be seen. Process factors such as impartial and skilled facilitation, inclusion of participants' knowledge and values, broad representation and participant access to information and resources seem to be essential. Inadequate processes also seem to directly lead to failures such as participant distrust of science and failure to reach agreements on strategies to be implemented. This analysis brings together the findings in the literature which collectively highlight that careful attention to the processes by which participation is implemented is essential to ensure positive outcomes emerge. Data which directly relates stakeholder participation to resource management outcomes (such as improved ecological functioning, or more cost-effective implementation of strategies) is limited. Future work which aims to find ways to identify these outcomes and relate them to participation is planned.

A WEB-GIS platform for water resource management: a case study in the province of Perugia

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Introduction

Water is strategic but also highly vulnerable natural resource, this because the increasing demand from multiple uses, in many cases competing amongst them, seems to influence the concepts of sustainability of the exploitation. In this context, many are the mathematical models known in bibliography and the approach of the proposed model is focused towards a natural integration of the two processes of evaluation and management of the available water resource, in an operating context that is shared amongst managers, users and the local administration concerned. From the operational point of view, the PIVRID system (Italian for: PRELIEVI IDRICI E VALUTAZIONE DELLA RISORSA IDRICA DISPONIBILE) is an integrated DSS that is not only a platform to exchange information and assessments, but is an tool for conflict resolution, in the management of water resources, and consensus reaching among all participants in the decisional processes. So the "top-down" approach has been replaced with a "bottom-up" approach where all stakeholders become decision makers themselves. Innovations do not only concern the philosophical aspects of management, but also technological aspects. In fact, for the development of this integrated tool a considerable effort in adapting existing technologies and developing new capabilities has been required, especially in the integration of modeling engines in a single GIS platform available on the WEB.

Methods

The application of the aforementioned approach was studied for the Tiber River basin and has been applied to the Province of Perugia area. It has also been focused to the building of a spatial database of hydrological data and multipurpose water withdrawals, together with the setting of the evaluation model for the surface water resources. This model bases its algorithms on regionalization procedures of flow parameters derived from the geomorphologic features of the basin (Area, BFI Base Flow Index) and returns, as output, a set of Flow Duration Curves (FDC) for each arc of the simplified network. For the definition of the river condition hydrological indices such as BFI, Q7,10, Q355, Q347, entire FDC, calculated from the hydrological database have been used, while for the existing withdrawals an analysis procedure has been developed, that from the point of interest selected directly on the map, finds out the upstream basin and, by means of overlay procedures, identifies the upstream water uses and the total flow that could be extracted.

Results and discussion

The data collection and validation phase brought to the compilation of an hydrological database, already accessible online, that has different levels of access according to the typology of user, ad that is made of about 11800 years of hydrometeorological data and about 10 000 information regarding the uses and the withdrawal licenses. The data can be viewed both in a numeric format and a graphic visualization and if needed, easily exported in various file formats. The potential of the system and the technologies used are contained in the section of the portal that allows the analysis of the database of water uses/withdrawals on the cartography. This is probably the most significant part, in terms of low flow management, because the search engine points out the situation even at the sub-basin scale and allows a comparison with the hydrogeological characteristics of the sub-basin examined, particularly influential especially during droughts, making the spatial distribution of licences and their information easily understandable.

Conclusion

The purpose of this study is to provide software tools that can be used as a support in water resource evaluation and management policies at the basin scale, with particular attention given to the creation of a database of uniform data that can be easily updated, and to the development of mathematical models that are easy to use, both for the interpretation of output data and for the choice of management hypotheses.

Contribution to the knowledge of the Danube River impact on the quality status of some Danube Delta lakes.

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Introduction: Danube Delta represents a vast and complex hydrological system, consisting of a series of aquatic ecosystems, represented by the Danube River branches, lakes, ponds, marshes, streams, natural and artificial canals etc. The interconnection of these aquatic systems can be permanent or temporary; these systems are interrelated being governed by the intake of water and sediments of the Danube River. Thus, persistence, stability and time evolution of an aquatic ecosystem is controlled by fluvial intake and also of spatial and temporal relationships between its components – water, biota and sediments, where there are permanent exchanges of matter and energy. Danube River crosses a number of industrialized European countries and transport pollutant elements and chemical compounds (heavy metals, nutrients etc.) coming from urban waste, industrial or agricultural runoff, affecting every water system traversed. Due to upstream anthropogenic activities, Delta lakes are vulnerable to pollution, receiving considerable quantities of industrial, agricultural and urban wastewaters. The main aim of this work focuses on assessing the current status of water quality and lacustrine sediments composition of some deltaic lakes and to determine seasonal trends of these aquatic ecosystems in 2010 and 2011.

Methods and materials: For this purpose, surface water samples from some control sections of Danube River, surficial lake water and sediment samples were collected from a series of sampling stations during the four campaigns held in 2010 and 2011. The basic assessment approaches used various field and laboratory techniques in order to examine seasonal variations in surficial waters (dissolved oxygen, temperature, electrical conductivity, total dissolved solids, pH, redox potential, nitrates, nitrites, phosphates, sulphates), fluvial and lacustrine sediments (total organic matter, carbonates and siliciclastic fraction).

Results and discussions: The water physico-chemical parameters investigated in some control sections of Danube River, deltaic lakes and connection canals show low variations. Thus in some samplers were registered some diminished concentrations of oxygen level and some fluctuations of pH from slightly alkaline to alkaline. Chemical analyses (nitrates, nitrites and sulphates) record normal values accordingly to standards and regulations for surface waters, though for phosphates were related some overruns above the maximum allowable content (in Danube River control sections and some deltaic lake samples). Bottom sediments collected along the Romanian Danube River sector, comprise a complex grain-size spectrum, with a tendency to fluctuation from boulders, gravels (coarse-medium into upstream sector) to sands (coarse, medium, fine – into the Danube Branches) and silts (fine and very fine – into the dam lakes). Lacustrine sediments belong to the group of silty to silty clayey (fine and very fine) and rarely sandy deposits. Organic matter, carbonates and siliciclastic fraction distribution is influenced by local geological background, hydrogeology, lake depths and morphology, climatic parameters, fluvial sedimentary input. Generally, eloquent discrepancies in sedimentary organic matter, carbonates and siliclastic material were not observed within and between the investigated lakes.

Conclusions: The results indicate that investigated lakes are quite influenced by various elements as: morphological features, water level, climatic parameters and their direct interrelation with Danube River fluvial and sedimentary input.

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Areas of extinct ponds – the assessment and recommendations for the future use

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The fish farming had undergone boom in the Lands of Bohemian Crown in the Middle Ages. During the ages, a lot of ponds have been destroyed or ceased to exist by different reasons. It is referred that the total number of ponds at the end of 15th century had been about 40 000 in the area of present Czech Republic. Currently, the number of pond at this area is about 21 000 which means that about one half of them are not water bodies anymore and that the land use type is there other. A lot of ponds have been cancelled due to increasing demand on arable land in 17th and 18th century and turned to fields. At present, the situation has changed again and there is a pressure on the arable land to be turned to other land use type. The change is mostly from the field to permanent grassland if the urbanisation is not considered. On the other hand, the demand for the space for expansion is getting stronger as the society is developing even faster than in recent past. Also the situation with water supply is changing which is connected to possible climate change. It results from above mentioned that there is an important area of extinct ponds in the Czech Republic and that there is a demand for a tool which would be useful for the decision on their future use.

The research project NAZV KUS QJ1220233 "Assessment of former pond systems with aim to achieve sustainable management of water and soil resources in the Czech Republic" focuses on the assessment of extinct pond areas from the point of view of their further use. Its aim is besides others to define methodology for the assessment of areas of former ponds. Two important tasks to be solved within the project implementation are to identify extinct ponds and to be able to assess this area from the point of view of its further use. Identification of extinct ponds and the digitization is carried out using historical maps. It is necessary to do this manually due to the quality of these maps. The methodology for the classification of former ponds areas is based on multicriterial assessment. It considers all natural conditions, safety, socio-economic criteria as well as ecology. The project has started at the beginning of 2012 and until now, the concept of the methodology has been worked out including its structure and detail list of criteria. One of main tasks was to define how each criterion should be assessed and how to include it in the final classification. In principle, the use of different spatial data and the application of GIS tools is there is emphasised and considered as suitable way to get objective classification.

In this paper, the methodology is presented including its structure, all criteria and the links between them. The areas of former ponds are specific from different points of view. The methodology must take this fact into account. It considers all possible future types of land use in which the areas of former ponds can be turned. It is of course also assessed if the maintenance of current state is not the best option. The reason is mainly the low expensiveness. On the other hand, also the option of the pond rebuilding must be taken into account as it can be important resource of water for different purposes. The specific type of use is the building of polders which could be the way of former pond areas use for safety purposes.

Testing a method to classify flow regime alterations in temporary rivers. The Candelaro river case study

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The evaluation of the "Hydrological Status" (HS) of a water body in a catchment is of the greatest importance in order to achieve the final objective of the European Water Framework Directive (WFD). It represents the distance of the actual hydrological regime from its natural condition and it may be responsible for the ecological status of a river. The WFD doesn't provide specific guidelines or recommendations on how the alterations should be evaluated and quantified. In this paper a new approach to evaluate the Hydrological Status of a temporary river was tested. The flow regime of a river has been classified through the analysis of two metrics: the degree and the predictability of dry flow conditions which were evaluated on monthly streamflow data. Both indeces were also used as indicators to assess the river's natural flow regime and its alterations. This method was applied to the Candelaro river basin (Puglia, Italy) where we had to face the problem of limited data availability. The SWAT model was used when streamflow data were not available, and a GIS procedure was applied to estimate potential water abstractions from the river. Four types of rivers were identified whose regimes may exert a control on the aquatic life. By using the two metrics as coordinates in a plot a graphic representation of the regime can be visualized in a point. Hydrological perturbations associated with water abstractions, point discharges and the presence of a reservoir were assessed by comparing the position of the two points representing the regime before and after the impacts. The method is intended to be used with other biological metrics in order to defining the ecological status of a stream. It is a useful tool when identifying river bodies under hydrological pressures and it can be used in planning the "measures" towards the WFD goals.

Floods and Society: Who Shapes Whom?

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Since the earliest recorded civilizations, such as those in Egypt and Mesopotamia that developed in the fertile riparian areas of the Nile and and Tigris and Euphrates rivers, many human societies have developed in floodplains as they offer favourable conditions for economic development. It is estimated that almost one billion people currently live in flood prone areas and, as a result, flooding is among the most devastating natural hazards. A number of studies have explored the links between floods and societies. However, this has been typically carried out by looking at either how flood occurrences affect human developments or how human activities impact flood frequency and magnitude. For instance, some studies have examined human adjustments to floods and identified the so-called "levee effect"; whereby building and raising levees might paradoxically increase flood risk as protection from frequent flooding changes the perception of risk and might encourage inappropriate development, which is then more vulnerable to high-consequence and low-probability events. Meanwhile, some other studies have investigated the human impacts -such as land use changes, river training, and modes of governance- on the frequency and magnitude of floods. Yet, the dynamic interactions between floods and societies and the associated feedback loops remain largely unexplored and poorly understood. This study is a first attempt to examine the interactions between floods and societies, by exploring the feedback mechanisms, reciprocal effects, surprises, and threshold mechanisms, taking place in floodplains as human-water systems. To this end, the Po River (Italy) is used as a case study and long time series of hydrological and population data are explored. The outcomes of this study contribute to a better understanding of how the occurrences of floods shape human developments while, at the same time, human activities shape the magnitude and frequency of floods.

Human pressure and flood-risk: a large-scale analysis for the middle-lower reach of River Po

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The increase of flood risk observed during recent years could be ascribed to many factors which only in part are of hydrological nature (e.g. climate variability and change). Human factors, like demographic dynamics, land-use practice, urban expansion and uncontrolled floodplain development are only some examples on how human pressure could contribute to increase potential flood damages and losses. The awareness of the anthropogenic impact and the recent European Flood Directive (Directive 2007/60/EC) are important triggers for advancing the development of new risk-based approaches to the identification and design of flood-risk mitigation measures, moving from a traditional approach to flood-risk mitigation (e.g. levee system strengthening and heightening) to alternative measures (e.g. controlled flooding of areas located outside the embankment limits). The assessment of how socio-economic dynamics may influence flood-risk represents an additional skill that should be considered for planning a sustainable industrial and urban development of flood-prone areas, for promoting appropriate land-use practices in these areas and reducing their vulnerability, therefore minimizing socio-economic and ecological losses due to large flood events. A robust and reliable evaluation of potential flood damages and losses is a fundamental component of flood-risk assessments and an essential information for the definition of sustainable and robust flood-risk mitigation strategies as prescribed by the European Flood Directive (2007/60/EC). In this general context, our study highlights the potential for large-scale analyses of a combination of simplified vulnerability indices with a quasi-2D model. In particular, this paper focuses on the identification of large-scale flood-risk mitigation strategies for the middle-lower reach of River Po (~350km), the longest Italian river and the largest in terms of streamflow, whose floodplain is densely inhabited and highly agriculturally and industrially developed producing nearly 40% of the total national gross product. First, referring to a high magnitude event (i.e. one in 500 years flood), we set up a quasi-2D hydraulic model which we use for flood-hazard assessment along the Po River and its major tributaries considering different geometrical configurations of the embankment system (e.g. overtopping without breaching or simulation of levee breaches as a consequence of overtopping). Second, considering recent land-use and land cover data and dynamics (CORINE land cover data sets for years 1990, 2000 and 2006), we formulate simplified indices to assess whether and how industrial development and population growth experienced in the recent past by River Po floodplain impacted vulnerability to floods. Finally, we couple the large-scale numerical tool (i.e. quasi-2D model of the middle lower reach of River Po) and the simplified vulnerability indices to tackle the delicate problem of formulating appropriate flood-risk mitigation strategies for very large flood events (i.e. 500-year flood event) that include controlled flooding of flood-prone areas located outside the main embankment system. The results of our study provide stakeholders and decision-makers with a preliminary yet fundamental piece of information when, for instance, they are called to define sustainable spatial development plans for the study area, or when they need to identify priorities in the organization of civil protection actions during a flood event.

To store or to drain – to loss or to gain? Economic evaluation of water storage role of wetlands as an element of the stakeholder dialogue in adaptive management in protected areas

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Storage role of wetlands becomes one of the hottest topics in contemporary worldwide discussion on possible benefits, which can come along with an appropriate status and function of those ecosystems. Main driving force, which underpins other-than-environmental approach to wetlands is the increasing importance of social communication in decision making, in which ecology-based messages and facts can hardly find a positive feedback. Also the watershed approach to water management, implemented nowadays throughout the European river basins, induces the need of finding a common level of communication with the stakeholders of different background (i.e. engineers, planners, local authorities, regional development boards, farmers) are involved and frequently even legislatively responsible for water management measures implementation. Therefore, to reach the goals of environmental conservation on protected wetlands it seems, that the economical valuation of their role in local and regional scale should be emphasized. Among the human activities, which potentially disturb the function and state of wetlands, drainage becomes the most challenging for environmental conservation. Drainage influences contiguity of water supply to wetlands – a dominant factor of wetlands stability and function. So far, in result of human-enforced adaptation of those ecosystems in purpose of agriculture, industry and urbanization, majority of European wetlands in their pristine extent could have been degraded. This fact entails the emphasis on that the drainage, as a general threat for wetlands regardless their ecological and hydrological type, should be carefully considered in adaptive management on protected areas, to fulfil the demands of wetland ecosystem conservation.

In recent years, dynamic changes of summer sums of precipitation within the Central Europe entailed summer flooding of riparian wetlands. Within agriculturally managed river valleys, such as the Biebrza Valley (NE Poland), the social pressure aimed at intensification of drainage arose. The main aspect underlined by stakeholders (farmers, local authorities) in discussion on appropriate management of wetlands is the loss of their income due to flooding. Their economical message in the discussion on wetland ecosystem value is based on precise quantification of financial loss on hay and connected milk production. However, other ecosystem services of floodplain wetlands (e.g. biodiversity and water storage) are not considered by stakeholders and treated as indirect and impossible to be economically quantified.

In our study we quantify economical dimension of water storage role of wetlands within the selected period of summer flood. In the first step of our approach, the average unit cost of water storage (in monetary unit per m3) was calculated. The estimation was done on the basis of available data from the projects, implemented within the Biebrza catchment and aimed at increase of water storage in a catchment scale, namely: constructed wetlands, minor reservoirs and storage ponds. In the second step, we present a GIS-based hydrological approach in the quantitative assessment water storage. In the third step, the economical and environmental gains and losses are critically reviewed and the economical balance of summer flood due to loss of agricultural productivity of wetlands and gain of water storage is provided.

In our study we prove, that the economically quantified opportunity cost of wetland ecosystem service, which is water storage, is incomparably higher than potential gain, which comes along with wetland drainage and agriculture. We state, that the drainage of wetlands and the loss of water is economically inefficient in a catchment scale, if compared with the gains obtained in result of intensification of agricultural activity.

Modelling the regional application of stakeholder identified land management strategies.

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The EU-DESIRE project trialled a series of sustainable land management (SLM) technologies. These technologies were identified as being beneficial in mitigating land degradation by local stakeholders from a range of semi-arid study sites. Hydrological field results and the qualitative WOCAT technology assessment from across the study sites have been used to develop the adapted PESERA SLM model. This paper considers the hydrological development of the adapted PESERA SLM model and the potential for applying locally successful SLM technologies across a wider range of climatic and environmental conditions with respect to degradation risk, biomass production and the investment cost interface (PESERA/DESMICE).
The integrate PESERA/DESMICE model contributes to the policy debate by providing a biophysical and socio-economic assessment of technology and policy scenarios.

Social networks monitoring of water resources – towards self-regulation of hydrological systems

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Participation is one of the eight key elements of common pool natural resources management and is a prerequisite for integrated water resources management. A review of various possible means of stakeholder involvement in integrated water resources management reveals that monitoring is not among the most prominent areas of participation. This is a surprising negligence for a number of reasons: Monitoring provides sensors for the system's state. Hydrological systems are often very heterogeneous regarding the spatial and temporal distribution of water resources and require a dense monitoring. The activity of monitoring hydrological system state is economically expensive and time consuming. Today, developing countries are often struggling to maintain and run monitoring networks developed in the 1960ies and 1970ies during the International Hydrological Decade at a desired optimal density as required by recommendations of WMO (2002). Monitoring networks often fall short of the recommended density and parameters. At the same time, dimensions of natural systems to be monitored increase. Instead of 'just' monitoring rainfall, stream gauges and groundwater levels, integrated and complex information is required such as biodiversity, ecosystem service availability, water and resources quality and sustainability indices. It is difficult to translate classic monitoring data to such complex indicators but often simple by local residence (farmers, water users) to judge these indicators directly on the ground. Information technology provides networks through which communication at second intervals is available among social groups. This technology is also broadly available in many developing countries in Africa and Asia and in rural areas at affordable costs. Data on the functioning of monitoring services during civil wars and crises in Burundi and Rwanda showed that community based monitoring networks were by far more robust and reliable than high technology systems. A network of local residents reading and writing down gauges and being linked by several sentinels worked throughout the dark years of the civil war in Central and Eastern Africa and was the only active source of information on the distribution of water resources. Therefore, in a project for a National Master Plan for Water Resources of Rwanda, a resident-based monitoring strategy is being developed. The working group on Social Hydrology at the IHF has launched training of locals that monitor hydrological system state and report to a processing unit by sending information through a *ShMS* (a *Short hydrological Message Service)*. A fall-back to non-digital mode is possible during emergency. The regular monitoring system provides central processing of data and re-distributes results back to all monitors and to regional and national agencies and stakeholders. Methods to evolve this approach towards self-regulating systems have been and are being investigated. The role of the *social hydrologist* is merely to simulate behavioural rules using resident-based monitoring data. During preliminary studies, patterns of behaviour have been observed, analysed and translated to agent behaviour. Agent behaviour has then been simulated and modelled figuring observed rainfall distribution, runoff in tributaries, and modelled recharge and storage in aquifers based on physical process models. This approach required a complex physical simulation. The current approach is based on simultaneous monitoring of actions, behaviour and observed environmental data by independent monitor groups (social and hydrological). The identification of best practice as a set of rules relies on correlation analysis and multiple regression joining resident actions and environmental impact. Results indicate that resident-based monitoring leads to improved and inherent sustainability and higher resilience.

Analyzing water metabolism in Socio-Ecological Systems: A Multi-Scale Integrated Approach

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Human societies and ecosystems use water in different ways and at different scales thus complicating the study of water-use sustainability in socio-ecological systems. We present here a multi-scale integrated assessment of societal and ecosystem metabolism (MuSIASEM), an innovative approach to the quantitative analysis of water use. This approach adopts a holistic narrative for the perception and representation of water flows across different scales. It builds on interdisciplinar concepts such as Societal Metabolism and the Flow/Fund Theory of Georgescu-Roegen. The Societal Metabolism refers to the biophysical dependence of societal systems when they are represented as living systems. From this perspective, the metabolism is also a characteristic of ecosystems. The Flow/Fund Theory define Flow elements as those coming in or getting out of a system, and Fund elements as those remaining the same and giving the system its identity. It helps to represent the role of water at the scales of both metabolisms at both scales and their necessary relation when they are studied as Socio-Ecological Systems. We show how to define water resources and water use for socio-economic systems in relation to the identities of relevant social fund elements (relevant categories of human activity or land use) over a time span of one year. Similarly, we define the limits on the human appropriation of water (aggregate withdrawal or damping per year) on the basis of the structural and functional stability of ecological funds (defined over a much larger time scale) and the related land-use pattern.

Crossing the Science-Policy Chasm: Water Management Next Frontier

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Competition for water, between economic and environmental demands is becoming increasingly acute in many river basins around the world. Future demand projections based on population and economic growth show an increasing gap between supplies and demand, with some river basins already in a closing or a closed state. Reducing this gap (estimated at 2,000 km3 of water worldwide) will require improved efficiency of use based on the dual principles of improved technical and economic efficiency.

Achieving the quantum improvement in efficiency needed to meet the projected water demand can only occur if sound water management policy is employed, one that is based on factual and objective evidence. A great deal of the knowledge that is needed to achieve efficiency improvements is already available in the scientific literature; however, this knowledge seldom is actually applied by the community of practitioners and decision makers.

While it is a necessary condition that the policies and actions of governments in resolving these issues needs to be appropriate, this is not a sufficient condition for successfully resolving them. Governments are but one organization in the water resource sector and policies implemented by them affects many individuals who are not strictly under their control. This means that those who are interested in improving the allocation of the resource should assess its governance, rather than just the Government.

The role of good governance is clearly to control the water resource system in a manner that is most beneficial to the society in which it exists. So the first question to be addressed is a clear statement of what society expects from the system (physical, economic, environmental, political etc.). In answering this question, it is always instructive (in a preliminary way) to identify the groups who are likely to lose from those who are likely to gain. It would be an act of bad governance if any particular group was deliberately excluded at this stage. Good governance requires an understanding of the principle that water resources are scarce and that any redistribution of those resources means that while some gain others may lose. Good governance would require the recognition that the gains from redistribution should be greater than the losses.

Policy formation and decision making in water management is rarely driven by hydrologic and technical considerations alone. Policy makers always consider a number of aspects such as economic, environmental and social impacts that play a considerable role in the formation of water management policy to the extent that hydrologic and technical considerations often become less important. Often decisions about water management are subsidiaries to higher level economic or environmental policies. This process makes good governance difficult because a range of objectives are usually pursued. Each of these usually has a different measure and need to be assessed across a number of disciplines. Thus, good multidisciplinary based science is required if good governance is to be achieved. In delivering good governance it is also necessary provide each interest group with all the measures over all the objectives. Good science is required to assess these types of impacts if good governance is to result. This implies that evidence based support for policy and decision making in water management must also reflect these other disciplinary dimensions in an integrated manner, so that the scientific sphere converges around the concerned decision problem. decision makers to support decision making and policy formation.

The science domain in the framework is designed to address the key dimensions of water resource management. These include the water cycle analysis, eco-hydrology analysis, economic analysis and policy analysis. Critical to the integration of the science with decision makers and stakeholders is the design of policy scenarios that will be evaluated through the application of the integrated scientific analysis. This suite of scenarios forms the core of the Knowledge Brokering process between scientists and the policy makers-stakeholders agents. Scenarios in this context also provide the integrating mechanism by which results from the different science disciplines and are harmonised to provide a comprehensive and multi-dimensional assessment of each policy alternative.

The framework described above was applied to design and evaluate multiple water management strategies in the South Creek catchment, in Western Sydney, NSW . In this case study, a suite of 30 scenarios generated through a consultative process were analysed. These scenarios combined multiple sources of water with multiple demands on a fit-for-purpose basis. Each scenario was analysed and results from the water cycle, economic, environmental and policy analysis enabled decision makers to obtain an integrated assessment of each scenario's performance.

In this paper we present a trans-disciplinary integrated science- policy framework titled "System Harmonisation." The framework integrates four key disciplinary dimensions - hydrology, economics, eco-hydrology and policy evaluation - which are interfaced with policy makers and stakeholders through a Scenario Planning (SP). This process of Knowledge Brokering between scientists and decision makers enables a dual flow of information between stakeholders and decision makers to support decision making and policy formation.

The IAHS Decade 2013-2022: A Perspective On The Research Challenges In Hydrology For The Next 10 Years

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The year 2013 will mark the start of the new scientific decade 2013-2022 of the International Association of Hydrological Sciences (IAHS), after the success of the Prediction in Ungauged Basins (PUB) science initiative which is closing in 2012. To identify the subject of the new decade, IAHS has launched a consultation process in December 2011, to identify the most challenging research questions in hydrology for the next 10 years. The consultation is taking place through a blog (http://distart119.ing.unibo.it/iahs) and a series of dedicated meetings. The discussion led to identify the subject of "changing hydrology for a changing society and environment" as the general focus of the new initiative. It is being proposed to concentrate on understanding and modelling the two-way interactions between hydrological systems and society, which presupposes to study how hydrological systems themselves react to human-induced and natural changes. To this end, three research targets have been identified, namely: (*1) Understanding* hydrological systems, and in particular variability, indeterminacy, impacts of change and interaction with humans. (2) Estimation and prediction of the behaviours and patterns of hydrological systems, with uncertainty assessment to support risk evaluation. (3) *Science in practice, to ad*dress societal needs, policy making and implementation. A set of science questions related to the above targets have been identified as well. The purpose of this contribution is to present an overview of the above discussion and a preliminary proposal for the Science Plan for the new IAHS decade, with the purpose to stimulate a further discussion on the subject.

A Blueprint for Process-Based Modeling of Uncertain Hydrological Systems

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We present an integrated methodological scheme for building process-based models of uncertain hydrological systems, thereby unifying hydrological modelling and uncertainty assessment. Within this view randomness, and therefore uncertainty, is treated as an inherent property of the nature of hydrological systems. This scheme accounts for randomness by shifting from one to many applications of the selected hydrological model, thus formalizing what is done by several procedures for uncertainty estimation. We introduce a probability based theoretical scheme to support the new methodological scheme and to ensure that uncertainty is efficiently and objectively represented. We discuss the related assumptions in detail, as well as the open research questions. The theoretical framework is illustrated by presenting real-world applications which show features and drawbacks of the underlying assumptions. In our opinion, the new blueprint could contribute to setting up the basis for a unified theory of uncertainty assessment in hydrology.

Remote sensing of water erosion assessment: a case study in the north of Burkina Faso

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Soil erosion by water is responsible of relevant land degradation problems in the Sahel. It affects agricultural production causing strong economical losses. The soil erosion is also responsible of reservoir sedimentation that may dramatically reduce the capacity of water intakes in a few years. The problem is expected to become more important in the next years as global warming may increase erosion rates. The soil erosion is very difficult to measure because of high variability in space and time of the process. The usual form of data collection is the observation of small plot for a limited period of time. This leads to uncertainties in the mean value estimated and in the extrapolation of erosion rates at regional scales. However, the implementation of development policies, especially when dealing with the allocation of scarce resources, requires erosion assessment at regional scale. In this contest the remote sensed data may give an important contribution providing homogeneous data over large regions at regular time intervals. In the present research the potential use of Cosmo-SkyMed high resolution synthetic aperture radar data has been investigated. The project was approved by the Italian Space Agency, that provided Cosmo SkyMed Stripmap (3m resolution) and Spotligth (1m resolution) SAR images. A case study was developed in Burkina Faso, one of the poorest countries of the world, where almost 80% of the population lives in rural areas depending from agriculture and livestock. It is characterized by the alternation of a rainy (3 months) and a dry (9 months) season, with extreme climate conditions. As the precipitations occur only during three months, it is crucial to collect water in the rainy season, by the means of artificial basins, in order to irrigate the fields in the dry season.
A digital elevation model was extracted by a couple of images with a temporal interval of one day. The images were acquired during the dry season, when the temporal decorrelation is expected to be much lower than in the wet season. As the reservoir of small and medium size are completely dry in this season, it was also possible to observe the elevation of the reservoirs bottom. The importance of a digital elevation model is due to the fact that in that area, it was not easy to obtain a similar product. Thank to the high resolution of CosmoSkymed, the spatial resolution is significantly higher than the one of previously available products. The DEM has been tested trough comparison with the measured elevation of a limited number of points. Moreover, from the SAR images recorded at different times in the rainy season, the shape of the reservoir corresponding to different water depth has been derived. As the lake shoreline is a contour line, the comparison of these lines with the contour lines, derived by the DEM, has provided another test of the DEM quality.
The actual reservoir capacity has been estimated by the DEM and compared with the original capacity in order to obtain the total volume of deposited sediment. The average soil loss per year has been then estimated for the catchments drained by the reservoirs. In the same catchments, the areas prone to erosion have been identified by comparing SAR images acquired during the rainy and the dry seasons. The humidity and, as a consequence, the dielectric constant and conductivity of eroded soils are almost independent by the precipitation; consequently the eroded soils do not change their reflectivity and they can be identified by change detection techniques. In this work we employ innovative fractal change detection techniques, based on the image spectrum evaluation and the comparison of the fractal dimension.

Grabbing of land, water, and energy

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Since 2008 more than 50 million hectares worldwide have been subjected to "transnational land negotiations". Land acquisitions by foreign governments and corporations are occurring at alarming and unprecedented rates in many regions around the world. Because in many cases the acquisitions occur in conditions that lack transparency and respect of the rights of former land users, this phenomenon has been named "Land Grabbing". Population growth, changes in diet (China and India), water shortage (middle east countries), and new energy policies (EU, USA) have increased the pressure on agricultural land. The lands targeted by transnational investments are used for food crops, bioenergy, and other ecosystem services. Because agricultural production is limited both by the availability of suitable land and water, the grabbing process involves an appropriation both of land and freshwater resources. Moreover, when grablands are used for biofuel production, land grabbing entails the grabbing of energy. While recent a number of studies and reports have quantified the land grabbing process, the associated grabbing of water and energy remains poorly investigated. Here we use the case study of Sierra Leone to quantify the amount of water and energy that are virtually grabbed in this country, where major large scale land leases have been signed with companies investing in bioenergy despite the high levels of water stress and food insecurity. Using soil, climate, and land grabbing data, we calculate the blue and green water used by grabland crops , along with the energy produced in the form of biofuel crops. The hydrological, agro-ecological, and societal implications of virtual water grabbing are discussed in detail.

The transboundary Soča and Vipava River flood problems

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The contribution discusses the transboundary flood problematic of the Soča and Vipava River in the western part of Slovenia. Vipava River originates under the slopes of the Nanos plateau on a geological contact between flysch and limestone. Vipava is a specific river which springs from many springs in the headwater part of the watershed. The number of springs depends on the abundance of rainfall in the karstic headwater parts. Some of the karstic springs do not dry out even during prolonged dry periods so the Vipava River never dries out even though it has a character of a karstic river. Most abundant springs are at 98 m a.s.l., during the intensive rainfall periods the springs from the karstic cracks rise up to 125 m a.s.l. Hydrographical basin of the Vipava River spreads over the hill slopes of the Nanos and Hrušica hills, the total basin area comprises 600 km^2. Due to Vipava River hydrological characteristic and specific valley topography, floods were frequent along whole the river corridor and the soil in the Vipava River was moist and marshy. In the 80s, extensive melioration on the agriculture land in the Vipava River valley was carried out by a network of drainage ditches. The main Vipava River channel was in some sections widened and deepened; meanders in the middle river section were straightened and cut off from the main channel. However, the regulation works didn't solve the flood problem, what became apparent during recent flood events. Two major flood events were recorded in 2009 and 2010. During the flood event in September 2010 Vipava River overtopped the channel banks in the downstream part of the Vipava River valley. The towns of Renče and Miren were completely cut from the rest of the Vipava valley. In order to study the hydrologic and hydraulic situation at the Vipava River state border section, 4 additional water gauges were installed which enabled us to get an insight into water level dynamics. Based on a detail hydrologic and hydraulic study it became clear, that the flood problematic of the Vipava River in Slovenia is not only a consequence of insufficient hydraulic conveyance of the main Vipava River channel but is also influenced by hydraulic conditions at the outflow section to the Soča River in Italy. Namely, based on the water stage data, it became apparent, that Soča River obstructs the discharge conditions along the outflow section of the Vipava River. The Soča River flood wave can enter the Vipava River channel and spreads several kilometres upstream causing a barrage of the Vipava River. The questionnaire for flood impact assessment and development distributed among the inhabitants in flooded area.

Hydrologic risk in agriculture: probabilistic description of yields under unpredictable rainfall

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Globally, agriculture is the primary user of freshwater, with irrigated agriculture providing 40% of current food production. The relevance of irrigation in mitigating the effects of climatic variability and stabilizing yields and profits is expected to further increase in the near future, in face of the projected alterations of rainfall patterns and increase in food, fiber, and biofuel demand. Vast regions of the world are already experiencing freshwater shortages and supplying the water necessary for irrigation will become increasingly difficult. In this context, strategic irrigation choices are required to ensure sustainable water management, while preserving productivity and profitability - a nontrivial task given the unpredictability of the rainfall forcing. To facilitate decision making under uncertainty, a widely applicable probabilistic framework is proposed. The goals are to obtain the probability density functions of yields under limited water availability and to define the hydrologic risk of yield reduction for both rainfed and irrigated agriculture. To these aims, the occurrence of rainfall events and irrigation applications are linked probabilistically to crop development during the growing season and yields at harvest. Based on these linkages, the probability density function of yields and corresponding probability density function of required irrigation volumes, as well as the probability density function of yields under the most common case of limited water availability are obtained analytically, as a function of irrigation strategy, climate, soil and crop parameters. The full probabilistic description of the frequency of occurrence of yields and water requirements is a crucial tool for decision making under uncertainty, e.g., via expected utility analysis. Furthermore, the knowledge of the probability density function of yield allows us to quantify the yield reduction hydrologic risk. Two risk indices are defined: the long-term and the real-time risk. The former risk index is suitable for long-term irrigation strategy assessment and investment planning, while the latter risk index provides a rigorous probabilistic quantification of the emergence of drought conditions during a single growing season in an agricultural setting. Our approach employs relatively few parameters and is thus easily and broadly applicable to different crops and sites, under current and future climate scenarios. Hence, the proposed probabilistic framework provides a quantitative tool to assess the impact of irrigation strategy and water allocation on the risk of not meeting a certain target yield, thus guiding the optimal allocation of water resources for human and environmental needs.

Use of Prospect Theory to assess the implications of probabilistic and deterministic flood maps in planning decisions

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Probabilistic visualization of flood hazard is theoretically more correct than the visualization provided by deterministic maps, because it accounts for uncertainty in the modelling process [Pappenberger and Beven, 2006; Di Baldassarre et al., 2010]. However, there is still some reluctance from decision-makers and practitioners in general to actually use probabilistic floodplain mapping, mainly because there is a common believe that people find wet/dry maps easier to understand and because binary maps tend to relief decision makers from having to deal with the uncertainty associated to water-related hazards [Pappenberger and Beven, 2006]. These psychological aspects may influence strongly the decision-making process even if it is based on traditional expected utility analysis. In order to explore the implications of utilising either deterministic or probabilistic flood maps in decision-making related to land use planning, we evaluate hypothetical decisions with the assumption that they are entirely based on the available hazard and land use maps. The evaluation is made by assessing the potential value of losses and gains that are consequence of a decision that involves choosing between an uncertain output and a deterministic one. In principle, losses are related to direct flood damages and gains are related to the projected economic growth of the region under study. Decision consists of choosing whether urbanising certain areas, based on two sources of information of different nature, namely an uncertain outcome, reflected by the probabilistic map and a certain outcome, reflected by the deterministic map. Two cases are considered, in which a decision-maker is exposed before the options of choosing between a certain outcome and a gamble: 1) a 100% chance of a small gain if urbanisation takes place at dry areas (from a deterministic map), and a gamble offering no-gain with a known, location-dependant probability p and low gain with a probability of 1-p if urbanisation takes place at flood-prone areas; and 2) a 100% chance of a small loss if urbanisation takes place at dry areas (from a deterministic map), and a gamble offering high loss with a known, location-dependant probability p and no-loss with a probability of 1-p if urbanisation takes place at flood-prone areas. The methodology follows the concepts of behavioural economic theory, in particular Prospect Theory (PT, Kahneman and Tversky, 1979; Tversky and Kahneman, 1992), which focuses on real-life choices instead of optimising the expected utility of decisions. PT states that people value gains and losses differently, and, as such, will base decisions on perceived gains rather than perceived losses, or, more directly, losses hurt more than gains feel good. The analysis is carried out by assuming a s-shaped, asymmetrical value function that passes through a given reference point equal to the value of the current economical activities of the region.

Uncertainty driven design flood estimation with cost-benefit assessment

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The evaluation of the design flood for hydraulic infrastructures requires application of flood frequency analysis, accompanied by the assessment of the uncertainty inherent in the estimation process. Generally, this leads to the definition of confidence bands for the flood frequency curve. Although this result is important from a statistical point of view, the information provided by the confidence bands could be critical to be properly used in practice, because a range of possible design floods for a given return period is obtained, instead of a single value.

The proposed procedure aims at combining flood frequency analysis (with uncertainty) and cost-benefit analysis to provide a practical method to exploit the information content of confidence bands. When discharge data are available at the design site, for a given return period, T, a design flood estimate is first obtained using standard statistical inference; Monte Carlo simulations are then performed to quantify the uncertainty of the design flood. Cost and expected damage functions are then adopted; these functions are related to the return period, T, so that they can be easily parameterized and no parameters and sources of uncertainties are added to the model. All discharge values within the confidence bands can finally be tested within the cost-benefit analysis, and the value minimizing the total expected cost function can be taken as the actual design flood estimator.

The method has been applied to the series of annual maxima recorded in 10 discharge stations in North-Western Italy, and results show that the 'optimal' value does not correspond to the one obtained from a standard flood frequency analysis; in fact, uncertainty plays a role and moves the design curve toward the upper part of the confidence band. This suggests that the curve obtained from traditional flood frequency analysis might lead to underestimation of the design flood.

The increment in magnitude of the design flood obtained when properly accounting for uncertainty may be up to 75-100% in case of high return periods. The result is also dependent on the sample length, with higher increments arising from short samples.

Keywords: Flood frequency analysis, parametric uncertainty evaluation, confidence bands, cost-benefit analysis

The effects of risk communication on property owners' hazard-related social capacities

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Property owners are key actors for a successful implementation of hazard maps and more generally – for an integrated hazard management. In many European countries, however, the state has assumed together with organisations of the civil protection the principal responsibility of protecting the population from natural hazards during many decades, so that the property owners were given little incentive to develop their capacities for an active involvement in hazard protection. To stimulate property owners' active role in hazard management and build the required social capacities is therefore a key challenge of an integrated hazard management. The publication of local hazard and risk maps that have been elaborated in most European countries in the last decade can be considered as a favourable occasion for sensitising property owners for their responsibility in hazard prevention. There is, however, so far little experience how to communicate this risk information to the property owners and to encourage them to implement private prevention measures.

In the city of Zurich, the local authorities involved in the implementation of the local hazard decided to launch an information campaign (written risk information and a link to the online hazard map) to inform the affected property owners about the hazard risks (mainly flood risk) in Zürich, the new instrument and its legal consequences. This intervention offered an occasion to elicit property owners' hazard-related social capacities and the contribution of risk communication to enhance them. Recent research suggests that written information has only little effect on publics' risk behaviour, and first explorative studies on the effects of publicly accessible risk maps on publics' risk awareness showed inconsistent results. With our project, we wanted to scrutinize affected property owners' flood-risk related social capacities (risk awareness, risk preparedness, sense of responsibility), the influence of the risk campaign on them and the underlying factors of property owners' sense of responsibility for the prevention of flood risks. To achieve this goal we developed a standardised questionnaire and sent it four month after the campaign to a random sample of 1400 affected property owners. The questionnaire included questions on attendance and perceived quality of the information campaign, owners' hazard-related social capacities (risk awareness, risk knowledge, preparedness to implement protection measures, sense of responsibility for risk prevention, trust in authorities) and potential influence factors. The analysis of the data revealed that most of the real estate owners respond spent only very little time for

studying the flood risk information. The contribution of the risk campaign to property owners' social capacities was found to be significant but very limited. A regression analysis showed that property owners' level of attendance of the information campaign, but also their preparedness to implement prevention measures was significantly influenced by property owners' risk-knowledge before the information campaign. The results suggest that information campaigns are a viable tool to increase property owners' preparedness to implement prevention measures. Regular information of property owners on hazard risks, however, appears to be a more promising strategy to improve their hazard-related social capacities than single more comprehensive information campaigns.

Use of flood forecasting in reducing flood losses in an agricultural area

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Losses in agricultural areas due to floods are often considered to be low when compared to losses in urban areas. The focus of measures to reduce flood risk, including non-structural measures such as provision of flood forecasting and warning is then often on urbanised areas. However, the economic benefits of agricultural areas in floodplains may be significant, and both direct and indirect losses due to flooding may be large. In this paper the potential of flood forecasting and warning for an intensely used agricultural area on the floodplains adjacent to the city of Bogotá, Colombia is researched. The Ramada irrigation district is intensely farmed, with crops such as vegetables and flowers (in greenhouses), as well as livestock farming. The district has been severely affected by flooding in the flood events of recent years. Flooding is caused by the medium sized Bogotá River, the upper catchment of which includes high altitude montane wetlands (paramó), before it flows across the flat floodplain in which both the Ramada irrigation district and the city of Bogotá are located. Potential economic losses due to floods are assessed through depth-damage curves developed for the different assets withing the district. Due to lack of data in the region relative depth damage curves were adopted from the Netherlands, and adjusted to the economic value of assets and market prices of agricultural products in Colombia. A simple forecasting model to provide forecasts at Puente La Virgen, a key gauge in the main river near the Ramada district, was developed based on regression analysis of the available gauged data in the basin. The hydraulic behaviour of the river is quite complex as it flows across the very flat high altitude floodplain, with both the upper catchment and tributaries downstream of Puente La Virgen found to have significant influence in flood levels at the bridge. Forecast verification statistics were used to establish the skill of the forecasts provided to the bridge, showing these to be skillful up to a lead time in the order of 20 hours. The effeciveness of the response taken by farmers and residents in the floodplain were defined as a function of the lead time provided.
With the lead time at which a skillful forecast could be provided, and the assessment of the actions taken by farmers and residents in the floodplain within the time available, results show that losses due to flooding in the Ramada district could be reduced by some 28% through the provision of a warning at Puente la Virgen. This reduction could increase further through improving the skill of the hydrological forecasts using for example hydrological, hydraulic and reservoir models and improving the data collection network. Additionally, losses could be reduced through procedures and education on appropriate responses to be taken to flood warnings, leading to a more effective flood warning response.

Streamflow regime in South Tyrol: possible recent changes and regional analysis

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The mountain environment has always been characterized by a delicate ecological balance, in which water plays a fundamental role. This balance can be seriously compromised by the increasing human pressure, which in mountainous areas consists of multiple forms that may be particularly water-demanding in some instances. In mountain areas the drinking-water demand has to be managed concurrently with the valley agricultural and industrial needs, and the water demand associated with hydropower production and touristic activities (e.g. winter programmes for artificial snow). The scientific community seems to agree on the existence of significant evidences of environmental change in mountainous areas in the last four decades, and it is often speculated that this change mainly originates from increased temperature that produces more frequent precipitation extremes, as well as less snow precipitation, and tends to exacerbate the hydrological cycle and flood extremes. Concerning these issues, the Italian Alps represent a particularly sensitive geographical context, in which an accurate assessment of present and future surface water availability represents a fundamental prerequisite for any planning activity that focuses on sustainable development and water-use. Our paper considers 23 river basins located in South Tyrol (Italy), for which at least 5 complete years of continuous observation of daily streamflow are available in the time span 1990-2010. The drainage area of the study basins varies between ca. 50 to 6900 km^2 (mean value: ~1100 km^2), while their minimum elevation ranges between ca. 230 and 1600 m above sea level (asl) (mean value: ~820 m asl). The set of study basins is characterised by a number of physiographic and climatic indices referring to the considered time span, such as the average snow-cover duration, the percent of glaciers and forested areas, the mean annual precipitation, as well as the series of annual precipitation. The aim of our paper is twofold, first we check the presence of recent changes in the daily streamflow regime, and secondly we develop a regional model for assessing the surface water availability in ungauged basins of the study area. We addressed the first point in the study by referring to annual sequences of cumulative precipitation and dimensionless daily runoff associated with three given durations (i.e. duration D=0.50, 0.75 and 0.95), which were selected for characterizing streamflow regime for medium-to-low flows. We retrieved the dimensionless daily runoff values from dimensionless annual runoff-duration curves, obtained by dividing the annual streamflow duration curve by corresponding value of the annual precipitation. We then applied Pettitt´s change point test, the non parametric sign test and Sen´s test on trends to the four considered sequences for all study basins. Results of the study suggest that no significant trend can be observed in the last two decades for annual precipitation and medium-to-low streamflow values. Concerning low-flows, our analysis seems to point out a weak tendency of the dimensionless runoff associated with D=0.95 to increase in time, which can be explained by recent efforts to restore environmental flows. We addressed the second point by developing regional model for estimating the flow-duration curve for a typical hydrological year in any ungauged basis of the study area. The model adopts a non-parametric representation of the dimensionless flow-duration curve, which is assigned to the target ungauged basin from a set of three dimensional regional curves on the basis of the geomorphologic and climatic characteristics of the basin itself, and a regional regression model for estimating the mean annual flow. The reliability and accuracy of the regional model is assessed through a comprehensive leave-one-out cross-validation.

Floods and societies: Do people learn from past disasters?

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For centuries human societies have been living in floodplains and dealing with the related flood risks. Despite the imminent threat of flooding, a number of studies reported a continuous development of flood-prone areas all over the world. Human societies have learned to cope with flood risks in several ways, the most prominent way being the mitigation of risks by engineering solutions. The second way societies have learned is by implementing adaptive measures, decreasing the potential damage of flooding by adapting to it. These types of learning are inherent to the strictly economic argument that, when the benefits outweigh the costs, it is profitable to keep developing in the floodplain. However, from a more sustainable point of view it is possible to argue that a third way of learning from floods is by leaving or at least minimizing the development of these floodplains. Avoiding the risk by leaving the floodplain or to stop settling in these areas is the type of learning that is of interest to this study. Many scientists have studied the impact of society on flood risk, but little studies investigated the opposite relationship, the impact of flood events on societies. In this research a first step is made to study the impact of the occurrence of flood events on the spatial distribution of population change in floodplains. Two distinct methodologies are used to uncover this relationship, a large-scale study for the USA and a case-study analysis of the 1993 Mississippi flood. The large-scale analysis is performed at county level scale for the whole of the USA and indicates a positive relationship between property damage due to flood events and population growth, implying that flood events actually enhance population growth. The case-study analysis zooms in on the Mississippi river and territory that was affected by the flood event in 1993. Contrary to the large-scale analysis, no significant relationship is found in this detailed study. The outcome points out that the 1993 Mississippi flood did not significantly affect the population growth in the inundated area. This research is a first attempt to improve our understanding of the impact of flood disasters on human societies. Problems for future research are indentified and directions are given for future studies in this new exiting field of research.

Development of a tool for emergency management during urban flooding: the interplay between research institutes, Civil Protection and local authorities

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During the last 5 years, the urban area of Rome experienced at least 7 extreme rainfall events, causing flooding of basements, subway stations and places of historical heritage. In particular, during the event of 20th October 2011 one people died and damages are estimated around 8 mln Euros. This storm has been the second in intensity per hour since systematic rainfall records are available in Rome (i.e. 1941) and its return period is estimated about 50 years. Floodings are linked to the urban development and the lack of sewer maintenance, coupled with an increasing number of high intensity rainfall events. Authors present the procedure developed by CNR-IGAG and Civil Protection Department to manage flooding events; the work was carried out in the framework of the UrbiSIT project, aimed to provide tools and guidelines for natural hazard evaluation in urban areas. Thanks to the collaboration with local authorities, the 7° Municipality of Rome has been chosen as study area. High resolution surface terrain model (2x2 meters) and the sewer network pattern were processed through a series of ArcHydro® tools in the GIS environment to find areas of topographic low ('SINKS') and relative sub-catchment areas. Both sinks and catchments are characterized by their geometric features in the attribute table (i.e. area, volume and fill height). The minimum rain height over the sub-catchment areas that fills each sink over a critical threshold of 40 cm was derived; a reduction coefficient proportional to the sewer trunk dimension has been applied whereas the presence of sewer network can drain part of the rainfall. High resolution rainfall data (10 minutes) of 30 different intensity events from 2001 to 2011(coming from the Hydrographic and Mareographic Institute of Latium Region), have been processed to obtain maps of total and hourly rainfall height by using geostatistical interpolator. Rainfall maps were compared to weather forecast satellite images to check their homogeneousness. A spatial-temporal analysis of each event was carried out, detecting events of maximum total rain height or maximum rain height per hour; graphs describing the trend of storm events were elaborated.
The overlay between rainfall maps and the sink distribution allowed to highlight those sinks exceeding the critical filling threshold for a given rainfall height. The procedure is actually being calibrated with data of emergency calls (firefighters - VV.F., Municipal police) during the studied events; the calibration is fundamental to check which sinks were effectively filled during the studied storm. By coupling storm warnings coming from the Functional Centre of the Civil Protection Department and the distribution of sinks susceptible to flood for expected rain height and time interval, this work is aimed to provide a tool for national and local authorities for managing flood emergency,

Analysis of flash flood hazard in an urbanized small catchment

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In November 2011, the city of Genoa and several towns and villages in Northern Italy were hit by catastrophic flash floods, mostly caused by extreme rainfall events over small and steep catchments. In the urban area of Genoa, the flooding and the consequent damages and loss of human lives were caused by the presence of culverts along water courses, which were insufficient to drain the runoff. Prevention and mitigation of flash floods calls for a better evaluation of flood risk due to minor water courses in urban areas, which is often not considered or underestimated. In the present study we use a simple 2D hydraulic model to analyze the flood hazard related to a small stream located in the city of Bologna, Northern Italy. The upper part of the catchment and drainage network is in natural conditions, while the lower portion is urbanized and the main water course flows in a culvert underneath the city urban area. Historical records report severe flood events in this area, occurred before the culvert construction. Given this framework, the 2D model is applied to simulate at catchment scale the runoff produced by different synthetic and real rainfall events. Combined observations of rainfall and runoff are used to calibrate model hydrological parameters, such as roughness and surface storage. The effect of the culvert in the urban area is analyzed in detail, to evaluate the maximum discharge that can be drained and the flood hazard in case of failure. Scenarios in which the culvert is partially obstructed are also considered. Model results show that the culvert is able to drain the runoff from ordinary rainfall events, whereas a failure could occur both for more intense events and in case of obstructions, causing the inundation of downstream and surrounding urban areas. The results suggest that the use of simple 2D hydraulic models as hydrological models can be a valid method to assess the risk and hazard related to flash flood events in small catchments.

Modeling of flow dynamics on catchment area Rufisque consideration of climate change application to structural design of hydraulic evacuation of rainwater

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In a context of climate change (CC), the statistical analysis of historical precipitation, to detect a recent trend, and simulation of future trends in climate models, posing real challenges, events so-called extreme precipitation being localized and, by definition, rare. However, we understand the importance to consider the impact of CC on the recurrence of extreme events in urban drainage. Thus, in the hypothetical case where an event of recurrence once every ten years would occur every five years from now, the damage may be associated with such an event would be likely to occur twice as often. In this context, a risk that, at first, was considered acceptable, could become unacceptable. The work conducted as part of this study is a contribution to the assessment of surface water resources in the area of Rufisque. From topographic maps at 1/50000, scanned, digitized and geo-referenced, we identified and delineated 10 watersheds using AcrView. Morphometric characteristics of these basins have been determined. A principal component analysis was performed on these characteristics. Groupings between stations have been identified through this process. Statistical analysis of rainfall series at monthly and annual basis was performed using the software KHRONOSTAT the period from 1920 to 1993. The EPA SWMM hydrologic model is a conceptual model of distributed event-or DC is developed by Division of Water Supply and Water Resources of the United States Agency for Environmental Protection National Research Laboratory Management risk was then used to calculate for each basin and to scale daily runoff, evapotranspiration, and infiltration. The ten year rate was estimated for each watershed, the flow of the project was concluded by the formula of the CIEH. The objective of this project which deals with hydrological modeling is to understand and describe the formation of urban runoff, to propose scenarios for stormwater management on the example of some selected urban basins in Senegal The study will take advantage of recent advances in defining the "standard models" to examine a wide range of adaptive strategies to flooding including storm water management and mobilization of resources through development.

Keywords: morphometry, water balance element, elements hydrometric, AcrView, KhronoStat, time series, EPASWMM, rainfall-discharge models, CIEH.

Vipacco Laboratory: an innovative tool for developing a new approach of risk prevention

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The European Directive 2007/60 strongly emphasizes the need in its premise that the existing flood risk management should be focused on the prediction, protection and preparedness. In the context of managing flood risk the directive shows that the principle of solidarity is extremely important in order that member states are able to reach an equitable division of responsibilities, particularly when the measures for preventing flood risk are managed collectively with the aim to pursue the common interest. To follow up the implementation of the principle of solidarity, the directive - with Articles 9 and 10 - states the need to adopt appropriate measures for the active participation of all stakeholders in order to encourage their involvement at different stages of the plan, i.e. in its preparation, review and update.
In order to achieve these purposes it's fundamental developing a device, whose basic function is to build a collective consciousness, indispensable tool for making effective and shared choices. Public participation, in fact, is revealed as a necessary step, and not complementary, to develop and implement the plan with the sharing of all stakeholders. Achieving a common understanding on flood risk-related issues helps to increase the degree of acceptance of possible choices. How to achieve this result? The participatory process can be divided into three phases: information, consultation and participation. Following these procedures, the Basin Authority has been able to develop some positive experiences of public participation. These took place through the activation of specific workshops that were attended by all the parties involved. In such contexts it has been developed an experience of dialogue and collaboration between stakeholders and competent authorities, with encouraging results which allowed to exploit the mutual synergies and reach collective benefits. Within the European research project called KULTURisk - funded by the Seventh Framework Programme with the aim to develop the culture of risk prevention - has been activated a workshop, specifically for the transboundary basin Vipava. Despite the reduced scale of the basin under consideration, the workshop gave the opportunity to experience the process of information promoted by Directive 2007/60, with particular reference to flood risks. The experience was particularly interesting because it involved two different countries (Italy and Slovenia) joined by a common river basin and a common flood event (September, 2010). The results of this experience were subsequently studied by various European partners involved in the project and belonging to the most prestigious European centers for research on these topics. In fact, stakeholders and researchers have expressed their opinion independently on similar topics, and have indicated the priority that, according to them, should be assigned to these issues. The comparison between the different points of view and the resulting conclusions were of particular interest.
The experience gained has resulted in a pilot project of communication and public participation on Flooding (implementing Directive 2007/60) which is the basis for the definition of the measures provided in Articles 9 and 10 of the European Directive 2007/60.

AMICO: the early warning system in Eastern Alps river basin District

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AMICO (italian acronym for "Alto adriatico Modello Idrologico e idrauliCO", that in english means "friend") is the early warning system proposed for the Eastern Alps river basin District.
The instrument, already operating in the Civil Protection of Veneto Region for the Bacchiglione river, has been developed, within the KULTURisk project, for the Vipacco transboundary river basin that flows through western Slovenia and northeast Italy. The river is 44 km in length with a watershed of nearly 700 km^2; it rises by a large group of karst springs at the foot of Mount Nanos, which are the main feeders of the river. Among its major tributaries we remember the Hubel, which flows near Aidussina, the Branica and the Liak, also fed by karstic springs. After the confluence with the Liak, Vipacco river assumes a meandering course which leads it to join Isonzo river.
AMICO platform's heart consists of a geo-Oracle database, which contains data, parameters, geometry and GIS themes. A planning function supervises the automatic launching of model chain, taking data from the database and providing them as input to the models, which are executed in cascade. To ensure the robustness of the system, in case of errors during a launch the system is restored to previous conditions, including parameters and models' state.
AMICO processes climate data (both real-time and forecasts to 5 days), estimates the basin hydrological response using a geomorphoclimatic approach and determinates the hydrodynamic propagation along the river network.
The hydrological response of the catchment is estimated using an integrated model capable of reproducing the processes of snow accumulation and the processes of evapotranspiration and runoff production and propagation. The processes of snow accumulation and melt are modelled by implementing an adaptation of the UEB - Utah Energy Balance Model – adopting a distributed scale, while the processes of runoff generation are summarized according to a lumped and physically based conceptual approach, taking into account the vegetation cover, the soil texture and its slope. For the surface runoff a geomorphoclimatic approach was adopted, i.e. the surface runoff characteristic velocity is dependent on meteorological event entity, and therefore on the intensity of precipitation. A particular tool has been developed to calculate the karstic contribute to river discharges. The model captures the essential physics of the relevant processes, rather than merely reproducing a correspondence between inputs and outputs within a finite set of observations. Predictive capabilities and robustness of the model were tested comparing simulation results with 9 years (2000-2011) of quality-controlled hourly data.
AMICO also provides an automatic parameters optimization by a comparison between simulated and observed flow in the available measuring points. A section, designed specifically for the purpose of a communication tool, allows to display the results.

A risk-based methodology for assessing water-related hazards at the regional scale.

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Natural hazards have been one of the most serious causes of natural and socio-economic disasters in Europe in the last decade. Specifically, water-related hazards (e.g. floods, landslides, storm surges) are issues of major concern for Europe and they are expected to increase in frequency and magnitude due to natural and human-induced sources. Climate change and variability could increase the frequency of heavy precipitations, storm patterns and sea level causing runoff, overtopping, changes in river flow and extreme water levels. Moreover, anthropogenic development could exacerbate water-related hazards by means of land-use changes (e.g. urbanization, land cover changes, population density) leading to changes in ground permeability and slope stability. Within the KULTURisk project (FP7) a Regional Risk Assessment (RRA) methodology is proposed to evaluate the benefits of risk prevention in terms of reduced environmental risk. The method allows the identification and prioritization of targets and areas at risk from water-related natural hazards in the considered region by comparing the baseline scenario (i.e. current state) with alternative scenarios (i.e. where different structural and/or non-structural measures are planned). The RRA methodology is flexible and can be adapted to different case studies (i.e. large rivers, alpine/mountain catchments, urban areas and coastal areas) and spatial scales (i.e. from the large river to the urban scale). The final aim of RRA is to help decision-makers in examining the possible environmental risks associated with uncertain future hazards and in identifying which prevention scenario could be the most suitable one. In order to integrate stakeholders preferences and experts judgments into the analysis, the RRA methodology employs Multi-Criteria Decision Analysis (MCDA functions). Moreover, Geographic Information Systems (GISs) are used to manage, process, analyze, and map data to facilitate the analysis and the information sharing with different experts and stakeholders. In order to characterize water-related hazards, the proposed methodology integrates the output of hydrodynamic models with the analysis of site-specific bio-geophysical and socio-economic indicators (e.g. slope of the territory, land cover, population density, economic activities) of several case studies in order to develop exposure, susceptibility and risk maps that identify and prioritize relative hot-spot areas and targets at risk at the regional scale. The final outputs are GIS-based raster maps which allow communicating to politicians and stakeholders the potential implications of water-related hazards in non-monetary terms, with the ultimate aim to underpin risk prevention measures for maintaining environmental and socio-economic resources. These maps allow to establish relative priorities for intervention, to identify suitable areas for human settlements, infrastructures and economic activities, and to provide a basis for land use planning. Finally, the outputs of the RRA methodology are used as data input for the economic evaluation of different damages (e.g. tangible costs, intangible costs). Within the KULTURisk project, the methodology will be applied and validated in several European case studies. Moreover, its generalization to address other types of natural hazards (e.g. earthquakes, forest fires) will be evaluated. The main objectives and phases of the method and some preliminary results are here presented and discussed.

IMPACT OF URBANIZATION ON FLOOD MAGNITUDE IN IBADAN CITY, NIGERIA

M. Garba

Floods are natural phenomena that play an important role in shaping the environment. Increasing imperviousness and encroachment in to areas liable to flooding have continued to increase frequencies and risk to floods in our ever growing cities. Drainage system capacities in these urban areas are often exceeded by increasing surface runoff, indiscriminate dumping of refuse and siltation in waterways, the consequences is an unprecedented increase in flood water resulting in rise in associated damages and lost of lives. Ona river and its tributaries in Ibadan city, Nigeria was hit by floods in 2011, the University of Ibadan, the Oyeleye and IITA dams were at the receiving end. Many communities downstream suffer serious damages and over 100 lives were lost. This paper reviews the immediate causes and possible measures to prevent further occurrence.

Keywords: impervious, urbanization, floods

On evaluating the benefits of risk prevention: the KULTURisk framework

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Within the objectives of the KULTURisk Project are (a) contributing to consolidate and disseminate a culture of risk prevention with regard to hydrological and geological hazards, and (b) developing innovative approaches for the evaluation of the benefits deriving from risk prevention measures. Part of such innovative culture comes from the consideration of expected changes in future climate, within the well-established approaches of risk assessment. In order to allow for the integration of diverse disciplinary knowledge, the development of a comprehensive conceptual framework to support the evaluation of benefits of plausible preventive measures is a necessary preliminary step. From a methodological viewpoint the above raises the issue – amongst others – of including climate change science within the disaster risk reduction (DRR) framework. Unfortunately, the two research stream - DRR and climate change adaptation (CCA) – have developed in the recent past without any remarkable efforts for integration, adopting incompatible languages and inconsistent approaches, at least until the two international research communities joined forces to develop the IPCC Special Report on extreme events and disasters (IPCC-SREX). The IPCC-SREX indeed has significantly contributed to find common language and methodological approaches, but not much is provided in terms of operational solutions. The KULTURisk research team has worked in parallel to the development of the IPCC Report and developed upon its outcomes, to provide an operational framework to support integrated assessment and decision support. A conceptual framework integrating different disciplines has thus been developed to comprehensively evaluate the benefits of risk prevention. Three main innovations are proposed with regards to the state of the art: (1) to include the social capacities of reducing risk, (2) to go beyond the estimation direct tangible costs, and (3) to provide an operational solution to assess risks, impacts and the benefits of plausible risk reduction measures, compatible with both the DRR and the CCA literatures. The traditional risk metric in the physical sciences is the expected damage (direct tangible costs), which is defined as a function of hazard, vulnerability (physical) and exposure. The first two elements are characterized by probability distributions and the last element, exposure, provides the information to convert results into monetary terms. This framework is straightforward, but – when brought into practical implementation – it does not provide solutions to deal with the complexity of the social components of risk and vulnerability. In the development of the KULTURisk Framework (KR-FWK), we considered several different pre-existing proposals, and we designed a new one as a graphical scheme representing the concept map of the concepts and also the flow-chart for the elaboration of information. As stated above, one of the main innovations of the proposed framework is the inclusion of social capacities (adaptive and coping capacities) in the process of translating risk into a comprehensive cost matrix considering not only direct tangible costs (damages), as usually done, but also the three other components deriving from the combination of tangible/intangible and direct/indirect costs. The proposed KR-FWK is thus expected to provide: 1) an operational basis for multidisciplinary integration; 2) a flexible reference to deal with heterogeneous case studies and potentially various types of hazards; and 3) a means to support the assessment of alternative risk prevention measures including consideration of social and cultural dimensions. The KR-FWK indeed needs to be tailored to deal with different contexts of analysis. The project case studies of the process will provide a quite diversified set of situations, allowing to consolidate the framework itself and to develop ad hoc tailored solutions for most common implementation cases.

Modelling Imbalanced Economy Recovery in Post-disaster using Input-Output Analysis

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Input-output table is frequently used in the studies of large scale weather-related (e.g., hurricanes and flooding) disruption of a regional economy. The economy after a sudden catastrophe shows a multitude of imbalances in terms of demand and production and may take months or years to recover. However, there is no consensus about how the economy recovers. This paper presents a theoretical imbalance recovery route called dynamic inequalities, based on which a hypothetical post-disaster economic scenario of London 2018 is developed to assess the influence of future shocks to a regional economy. A macro econometric model is adjusted to project the baseline conditions at the time. The modelling results show that the London economy recovers, i.e. the reconstruction is completed, in seventy months by applying a proportion rationing scheme under the assumption of 50% labour loss with full recovery in six months, 40% loss to service sector and 10% - 30% loss to other sectors. The results also suggest that the imbalance will be norm during the economy recovery of a post-disaster even though the balance may, sometimes occur. The sensitivity analysis suggests that the proportion scheme may be an effective strategy to apply to a post-disaster economic reconstruction.
KEY WORDS: Disaster, input-output analysis, basic dynamic inequalities, imbalanced economy recovery, rationing schemes.

Why is it so difficult to measure water stress? A review of data and knowledge on water needs, use and availability.

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Access to sufficient water has been recognized as a human right. It is an essential resource in itself, but also to produce food, energy and other industrial products. Competing uses of the resource changes in resource availability due to rainfall variability may lead to physical water stress, requiring informed management decisions to ensure all needs are being met in a sustainable manner. Additional pressures derive from processes of global change, such as growing populations as well as climate change. Beside actual physical water stress, where the resource itself is limited, economic and social water stress can be experienced if access to resource is limited by inadequate infrastructure or monetary constraints.
Much work has been done on findings thresholds and definitions to measure water scarcity. This includes some work on defining basic water needs of different sectors. A range of data and approaches has been made available however all these approaches and data differ in their assumptions and consequently in their results.
We review and compare approaches, methods and data sources on human water use and human water needs. The data review allows identifying levels of consumption in different countries and relating the consumption patterns (i.e. water allocation to different sectors) to identified levels of water needs.
The results of our review highlight the differences between different accounts of water use and needs and reflect the need for mainstreamed accounting to make studies comparable across space and time. The comparison of different use and allocation patterns in countries allows identifying levels of water use which allow for a high standard of living while keeping water use at adequate levels. The findings can points towards sustainable levels of water use, which can increase human wellbeing and reduce the risk of water shortage.

Estimating flood damage costs and the impact of risk mitigation policies

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Our study aligned with the KultuRisk project, aims at estimating the comprehensive costs of damages due to hydrological disasters. This estimation benefits us by enhancing our understanding about the costs and benefits of risk prevention measures.
The conventional damage estimations only include the physical, direct tangible costs without taking into consideration the social capacity of the affected communities in dealing with risk. As proposed in the KultuRisk framework (described by Giupponi et al. in this same conference), there is an urge for introducing a risk measure, which goes beyond the direct tangible costs. On the one hand intangible costs (e.g. fatalities, loss of cultural heritage, etc.) might be more relevant than tangible costs for the affected communities and therefore for policy makers and insurance companies for setting risk premium. On the other hand, the economic ties of flooded region with other sectors or territories emphasize the importance of estimating indirect cost of a hazardous event.
The social capacity to cope with risks can be subdivided into adaptive (ex-ante) and coping (ex-post) capacity. Coping capacity refers to the ability to react to and reduce the adverse effects of experienced hazards, whereas adaptive capacity refers to the ability of a system to anticipate and transform its structure, functioning, or organization to better survive hazards. In order to provide a quantitative metric for the capacities mentioned above, we scrutinize the significance of a list of possible indicators/proxies such as age, gender, economic diversification, etc. that make up the variables of an adaptive and coping capacity matrix. We identify the role and weight that each factor plays in each of our four types of costs composing the total cost matrix: direct tangible, direct intangible, indirect tangible, and indirect intangibles. The outcomes of the above mentioned valuations are risk functions for each quadrant of the total cost matrix. A Bayesian Network approach is utilized to support empirical econometrics methods, for the purpose of inferring about those costs that cannot be directly valuated, because of time and human resources constraints
Our research works toward estimating, given all the constraints in the data gathering, the cost components whether be tangible/intangible or direct/indirect in a set of possible case studies provided in the project. We demonstrate how considering total costs and social capacities can lead to different results with regards to the traditional cost-benefit analysis. The consequence of our study is an interest to policy makers who will employ appropriate and cost-effective risk mitigation measures, based on the characteristics of each community at stake, for adaptation planning to climate change. Given our result, policy makers might need to shift their attention from structural defences to a combination of structural and non-structural defence measures as proposed in the KultuRisk framework. Further, once the total cost is estimated, it might change the allocation of resources and the social willingness to pay for risk prevention in the future.

Uncertain flood maps as an aid to stakeholder participation in flood modelling.

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Flood disaster worldwide causes damage to infrastructure and loss of life. In attempt to mitigate this damage, flood mapping is used to delineate the extent of forecasted flood hazard (e.g. Loat and Petrachech, 1997, Merz et. al., 2007). However, the scientific community acknowledges the "lack of certitude" in the model input data and the model components (Papenberger and Beven, 2006). Consequently, methodology has been developed to generate empirical probabilistic maps using reduced complexity methods, further aided by remote sensing data (Di Baldassarre et al 2010, Horrit, 2006). The challenge therefore, given the need and importance of the flood maps (see EU Flood Directive, 2007), is to communicate this uncertainty to the stakeholders and decision makers. It has been argued that uncertainty information is suppressed due to the fact that the inclusion may not be easily understood (Joslyn and LeClerc, 2012, Ramos et al., 2010). However, the suppression of this information is potentially dangerous given that the modeller chooses what information to hide, thus prematurely skewing the output and making a subjective, arbitrary and non-trasparent decision. This study shows part of the outcomes of an ongoing study in Barcelonnette, France, on the communication of probabilistic maps to stakeholders involved in flood risk management. The maps were created by taking into account the parametric and upstream boundary condition in accuracy. Flood propagation was carried out using the LISFLOOD-FP model (Bates et al., 2010). Preliminary interaction with stakeholders using uncertainty flood maps and dynamic uncertainty videos has shown the willingness for active stakeholder participation in the modelling process.

Building the HYMEX database on societal impact of floods: first results and difficulties related to the concept of "event severity"

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Introduction

Mediterranean countries, due to their climatic and morphological features, are yearly affected by several flash-floods involving the ephemeral streams typical of this environment. At a first glance, the severity level of these events could be assessed as low, especially if it is compared to the impact of floods affecting wide transnational river basins. In general, the severity level of a single flash flood depends on the framework in which it develops, even if, affecting small areas, it can cause less severe damage than in the case of wide basins. Nevertheless, in the case of flash floods, the high frequency of events increases damage: actually, small basins can suffer damaging floods more than once a year and in general more frequently than big river basins do. Then, to correctly appreciate the impact of flash floods in small Mediterranean basins, a dedicated database was to be built.

Actually, despite some international databases are available and frequently consulted, they are mainly focused on major catastrophic events, characterized by a minimum severity threshold changing from database to database. This is the case of the Emergency Events Database (EM-DAT) from the Centre for Research on the Epidemiology of Disasters of the Université Catholique de Louvain, and the Natural Hazards Assessment Network (NATHAN) of the reinsurance firm Munich Re. Both databases only consider those events that fulfil several criteria to be considered "major disasters", while "minor" frequent flash floods are rarely included.

Methodology

The present work has been realised in the framework of the HYMEX project, by Working Group 5, a transversal group of HYMEX dealing with all the aspects related to societal and ecological impacts of hydro meteorological extremes, as well as their perception and communication processes. We started from four previously existing Local Databases realized in the following Mediterranean study areas: Catalonia (Spain), Balearic Islands (Spain), SE of France, Calabria (Italy). All these databases were characterized by different length and they were built using different information sources, even including pre-existing databases which were improved by introducing data coming from further historical research.

In order to have a continuous climatic series of 30 years, we focused our attention on the period 1981-2010: for this period, a common flood database has been realized. We set a series of criteria in order to homogenize the records included in the preexisting Local Databases. Actually, each record must include fields describing the data of the event, main affected zones, casualties, a short description of damages, and, when available, the economic losses and rainfall values. After this review, all the records included in the Local Database and concerning the study period were reorganized in the *HYMEX database on societal impact of floods*.

The contribution shows the first results coming from the analysis of the available data. The paper mainly discuss the following key points: the difficulties coming from the heterogeneity of data sources, the implications of the criteria used to define the impact of flood events, the difficulties in selecting rainfall representative values and the comparison of our dataset to international databases.

Results

385 flood events have been classified, being the maximum contribution this one from Catalonia which includes also minor floods. Particularly, in this region, less than 5% of the flood events can be considered as catastrophic ones, 52% can be classified as extraordinary flood events, while 40% are only ordinary floods (only little damages). 17% of the events have produced one or more casualties. Catalonia and SE of France have experienced the greatest number of casualties, and it is important to remark the fatal impact of some extraordinary floods produced in August, but also in other months, as a consequence of imprudent behaviors, when people is dragged by water when they are crossing a water path.

Flood damage, protection works and population amount: a 150-year case history concerning the Sibari coastal plain (southern Italy)

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Introduction
Several Mediterranean countries, due to their climatic and morphological characteristic, show a hydrological network made of short and steep ephemeral streams, showing low or absent flow during dry months and sudden flash floods during rainy periods.
In southern Italy, to cope with the pronounced variability of these rivers, and the damage caused by their huge bed load, the national government realised a series of works, starting from the XIX century but mainly realised in the fifties of XX century. Different types of works and reforestation practices were carried out, both on the high basins and along the low sectors of the river courses. Works aimed to minimize the impact of floods, even in order to eliminate the formation of swampy areas on the flood plains, where the Anopheles mosquito, responsible for the spread of malaria, used to proliferate.
As a whole, these works reached their main goals: even thanks to DDT (Dichloro-Diphenyl-Trichloroethane) and the vaccination of the population, the river plains become sane places, free from malaria, and they were progressively populated. By the time, anthropic pressure increased: road networks and different types of settlements, according to the analysed region, were built.
In this study, we reconstruct the evolution of a river plain of Calabria, the Sibari plain, which experienced all the previously described steps: the aim of the analysis is to assess whether the frequency of damaging floods is changing and, if so, whether these changes can be attributed to either anthropogenic modifications occurred through the years and/or climatic modifications eventually related to climate change.
Calabria has a quite rugged morphology: the few flat areas are river plains. Owing to this shape, the drainage network consists of ephemeral streams, known as fiumara and widely observed in southern Italy. Fiumaras show steep and narrow beds in the mountain sectors which abruptly enlarge on coastal plains, becoming anastomosed and often wider than one kilometre. Both erosion and landslides supply the debris carried during floods. The irregular water flow can abruptly change from low or null, to impulsive flash floods.
The Sibari plain, located in the north-east sector of Calabria, is 450 km^2 wide and comprises 24 hydrographical basins: it represents the widest lowland of the region, created by sedimentation of the Crati River and of adjacent fiumaras.
Methods
The study method is based on the creation and analysis of four databases: 1) a historical series of geo-coded flood damage, concerning damaging floods which occurred over the past few centuries in the study area; 2) a geocoded series of protection works for land reclamation, protection from floods and improvement of soil stability in steep areas, gathered from the archives of the agencies that carried out the works, organized in a GIS-format; 3) a historical series of maximum flood discharges and extreme rainy events, aimed at defining the trends of occurrence and the intensity of flooding; 4) a coastal line position and migration over time, created using mainly literature data based on discontinuous data such as historical maps and images; 5) the municipality population number, to discuss the role on flood damage and the effect of protection works.

Results
The work describes the complex succession of floods, protection and reclamation works, human transformation of the plain and major land use changes over the last two centuries in the study area. The new characteristics of the plain and its modifications, including major engineering works, land-use transformation and urbanisation, are illustrated. The damaging floods of the last 200 years, the modifications of runoff and flooding due to works built over the basins, hydrological data and the records concerning coastal modifications were used to create specific databases and a GIS in which these data can be analysed by typology, location and extension. The proposed approach highlights the high degree of correlation between drainage basin management, mainly in terms of increasing protection from natural hazards, and anthropogenic development in a broad coastal plain.

Mapping overland flow hazard in order to enhance citizens' awareness of head catchment hydrology

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Between 1998 and 2004, Europe suffered from more than hundred major inundations, responsible for some 700 deaths, for the moving of about half a million of people and the economic losses of at least 25 billions Euros covered by the insurance policies. Within this context, EU launched the 2007/60/CE directive. This directive aims at a better evaluation of the risks and a better coordination of prevention, protection and crisis management.

In most countries, inundation maps only include rivers' overflowing. In Wallonia (southern part of Belgium), it was decided to include overland flows and mudflows in the flood hazard map. Indeed, the cleaning operations for a village after a storm can lead to an estimated cost of 11 000 €. Average construction cost of retention dams to control off-site damage caused by floods and muddy flows was valued at 380 000€, and yearly dredging costs associated with these retention ponds at 15 000€. A specific study in Gembloux (25 000 inhabitants) estimated the mean annual cost for the runoff damages to 20 000€. This cost only consists of the physical damages caused to the settlements and movable properties of the residents as well as the emergency operations of the firemen and the city. On top of damages to public infrastructure (clogging of trenches, silting up of retention ponds) and to private property, runoff and mud flows generate a significant loss of arable land. Yet, the soil is not an unlimited resource. Moreover, sediments' transfer to watercourses alters their physical and chemical quality. And that is not to mention the increased psychological stress for people.

But head catchment hydrology is not well known. Mapping the overland flood and mud flow hazard over a 17000 km² region is a real challenge. This contribution will present the pragmatic methodology used in Wallonia. In accordance with the Directive, different maps are produced (25, 50 and 100 years of return period and an extreme scenario). Local characteristics are taken into account: rainfall statistics, soil data, land use and relief. They are used to assess runoff production and transfer to an outlet identified as the point where runoff enters the permanent river network. Peak discharge values are used as basis for the mapping. The maps locate the water paths using a colour chart based on the peak discharge. Summer 2011 and spring 2012 storm events as well as a survey made at the municipalities' level allowed us to validate in some ways the maps produced.

Whereas this first approach at regional scale includes uncertainties, the aim of these maps is currently to prompt recognition of the runoff inundation hazard. It is of major importance for soil conservation and citizens' protection. Above all, it should contribute to lower the damages by early prevention during the design of town-planning projects.

Recurrence of damaging floods and role of population number in a karstic area (Bari, southern Italy)

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In karstic areas cases floods are rare, short, and sudden but the effects are often very dramatic. Flash floods (local floods of great volume and short duration, defined by the USA National Weather Service as floods caused by heavy rainfall in a short period of time, generally less than 6 hours) are extremely dangerous. Recent years have seen several flood-related casualties in Italy, in 2003, 2005 (when the last catastrophic flood happened in the karstic area of Bari), and 2007. Flash flood warnings are intrinsically difficult due to the short time available to warn people living next to the river. Our goal in this study was to contribute to the understanding of the relationship between flood events in karstic areas, in terms of recurrence, exceptionality and/or intensity, anthropogenic effects, mainly in terms of population number variations, and damages. Some authors have shown that urbanisation, land use changes, and hydraulics works must be taken into account to really understand the effects of past flood events. A comparative analysis of these data can thus allow us to understand if the trend of flood damage is steady or increasing and to determine whether it is affected by the growing density of population and facilities in flood-prone areas.The approach was based on three types of analyses: the historical analysis, based on historical data, the hydrological and the geomorphological analysis, both based on recent monitored or measured data. The historical analysis was focused on identifying and comparing two kinds of data: the series of past flood events over a period sufficiently wide to define the flood recurrence period and the main steps of anthropogenic development, called the anthropogenic role. This role was expressed using the population number and needs and considering the facilities in flood-prone areas. The hydro-geomorphological analyses were based on two types of data. Long time series of the annual maximum rainfalls of short duration were used to assess the return period of high intensity rainfall that caused studied flood event(s) for which rainfall measurements were available. The geomorphological analysis considered rainfall, hydrogeological characteristics of outcropping rocks and soils, and geomorphological data on the drainage basin to calculate net rainfall and peak flow characteristics. The historical analysis of floods and damages highlighted four flood periods, distinguished on the basis of the recurrence period and the level of damages. The hydro-geomorphological analyses showed the peculiarities of the 2005 flood event. The maximum rainfall return period for the 2005 event was due to exceptional three-hour cumulative rainfall. The study case was a sub-catchment where very high rainfall intensities were observed. The rainfall return period was found to be roughly in the range of 50–100 years, considering a cumulative rainfall duration (3-hour) about equal to the concentration time. This study shows that main modifications of flood recurrence and level of damages can be justified considering the variation of population number.

Levee breaches statistics and "geotechnical uncertainty" in flood risk mapping

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In flood hazard mapping different sources of uncertainty including the hydrological, climatic, geotechnical and hydraulic ones need to be taken into account. In a recent interview to experts in flood hazard assessment and management, "geotechnical" uncertainty related to the possibility of levees' collapse because of piping or erosion was identified as the third factor in order of importance, before the effect of hydraulic modelling of flooding processes in determining uncertainties in flood hazard mapping. Hydrological forcing was indicted as the most important factor. The aim of this study is to implement a stochastic approach to model the position, length and depth of the levee breaches in order to assess the flooding volume and area. Extending previous analyses on statistics of levee failure type and breach size on a 98 km-reach of the Po River, here we analyze flood events occurred in the Piave, Tagliamento and Adige rivers providing statistics of some hundreds of historical breaches occurred in the last two centuries. Levee failure spatial density, temporal frequency and, partially, size are presented as a function of the geomorphology of the river (i.e. braided, sinuous and meandering) of levees geometry and flood intensity. A stochastic framework for probabilistic flood mapping is discussed, taking into account in a Monte Carlo approach the effect of position, size, density of levees failures on the statistics of depth and velocity of inundated areas. An example is shown of the resulting probabilistic map for a 98km-reach within the middle-lower portion of the Po River catchment between the gauging station of Cremona (upstream) and Borgoforte (downstream), in particular in a floodprone area of 100 km2 within the left and right levees of the Taro and Parma rivers.

It all depends what you ~~mean~~ median

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The estimation of rare extremes such as the so-called 100-year event typically requires the pooling of data from a group of stations judged similar to the subject site. There is *dependence* between annual maximum (AM) 1-day rainfalls across a network of stations. If the stations are closely grouped, the dependence is likely to be strong. More often, the network of stations is sparse and the dependence is quite weak. Partial dependence is a good thing! If you pool data from stations that are so widely scattered that their extremes are independent, it is unlikely that the information pooled is relevant to estimating extreme behaviour at the subject site.

A second problem arises in rainfall frequency estimation in arid areas: not all AMs represent extreme events. Occasionally, the AM 1-day rainfall is zero because the year is entirely dry! It is helpful to standardise the AMs by the median rather than by the mean. The median is a more robust estimator when the data series includes exceptionally large or small values.

Pentad maximum (PM) analysis provides an alternative to AM analysis. Pentads are 5-year periods. The poster motivates the PM method by a *single-site frequency analysis of floods on a highly permeable catchment*. It then illustrates the outcome of a pooled analysis of maximum 1-day rainfalls across a network of *N* stations in an arid zone. The method exploits the Dales and Reed concept of an effective number of independent sites, N_e.

The rainfall growth curve derived from the PM analysis is transformed to the AM frequency domain by shifting the curve ln*5* units to the right in a Gumbel plot. This reflects that, in the absence of pronounced serial correlation, the effective number of independent years in a pentad is of course five.

Reference: Dales, M.Y. and Reed, D.W. 1989. Regional flood and storm hazard assessment. Report 102, Institute of Hydrology, Wallingford, UK, 159pp. See http://www.ceh.ac.uk/products/publications/Regionalfloodandstormhazardassessment.html.

Comparative assessment of predictions in ungauged basins: Runoff hydrograph studies

M. Rogger, J. Parajka, A. Viglione, J. Salinas, M. Sivapalan, G. Blösch

Prediction of the runoff hydrograph in ungauged basins is at the basis for a wide range of hydrologic investigations and water resources management tasks. Scientific applications focus on understanding of catchment function and how the individual processes combine to produce catchment response. Operational utilizations include estimation of design variables (for spillways, culverts, and embankments design), water allocation for irrigation, industry and humans, hydropower operation, environmental flow estimation, flood and drought forecasting. Hydrologists have been interested in being able to provide continuous hydrograph predictions also because problems of water development have evolved from water quantity to water quality and because of the effects of environmental change. In this work we perform a comparative assessment of the performance of methods proposed in the literature to estimate runoff hydrographs in ungauged basins. The aim of this assessment is to understand where particular methods work best and what factors control their performance, and to provide a benchmark to guide future progress on prediction of runoff hydrographs in ungauged basins.

Perception and communication of drought risk for mitigation measures development

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Drought has a slow evolution in time. The consequences of a drought take, therefore, a significant amount of time, with respect to its inception, in order to be perceived by the socioeconomic systems and moreover in order to observe their worst effects on environmental and anthropogenic systems. Taking advantage of this feature, an effective mitigation of the most adverse impacts of drought is possible, developing a monitoring system to promptly warn about the drought onset and to follow drought space and time evolution. Drought may become a natural disaster depending on its impacts on population, on economic systems, on environment, and on water supply systems. All the mentioned contexts are influenced mainly by the hydrological drought that can be characterized with some indices related to hydrological time series. Particularly, water shortages on water supply systems depend on the hydrological drought as it affects water storage, as well as on demand fluctuation and on the actions carried out in order to reduce drought impacts. For that reason a dynamic indicator relating supply and demand, related to some threshold levels that describe the hydrological state of the system, is here defined. Threshold values, considering the probability to assure a given fraction of the demand in a certain time horizon, are identified. Normal, pre-alarm, alarm, and emergency states are individuated and some mitigation measures are related to each state. Moreover, since drought is a slow onset risk, the promotion of perception of natural hazards and the communication of alarms can assume paramount importance in the development of effective mitigation measures. People, in fact, do not react to certain hazards or risks because the inability to perceive the considered "long term" disasters, i.e. that they not necessarily occur within a short time. In other words if the environmental disaster takes place on a long time span, the people predisposition is not to perceive it and then not to react. An adequate assessment of exposure and perception of the population to risk, becomes fundamental, also to reduce economic losses. The procedure for mitigation can be applied to all the water supply systems with the resource coming from water bodies regulated with a reservoir or a system of reservoirs. Once proper values for the three threshold levels are defined and the related demand reduction is accepted by the stakeholders, the proposed mitigation rules are able to reduce the effects of most severe droughts. In the same framework, suitable communication procedures can be activated in order to promote people perception to drought risk.

Risk Cumulus Analysis for the Flood Hazard

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One of the main consequences of the demographic and economic development and of markets and trades globalization is represented by risks cumulus. Risks are cumulated whenever a single realization of an event can lead, directly or indirectly, to a number of severe negative effects. In most cases, the cumulus of risks intuitively arises from the geographic concentration of a number of vulnerable elements in a single place, e.g., an urban, commercial or industrial district. Nevertheless, in many cases the cumulus of risks may be associated to financial or economic relations induced by the globalization process. By following those links, event's effects can be emphasized and spread around the entire global society, hitting communities that are located far away from the area originally stroked. Finally, and primarily for natural events, risks cumulus can be associated, in addition to intensity, also to event's extension. In this case, the magnitude can be such that large areas, that may include many regions or even large portions of different countries, are stroked by single, catastrophic, events (*Ghizzoni et al., Adv. Wat. Res., 33, 1243-1255, 2010*). To cope with natural risks a variety of mitigation actions can be put in place: from the improvement of monitoring and alert systems to the development of hydraulic structures, throughout land use restrictions, civil protection, financial and insurance plans. All of those viable options present social and economic impacts, either positive or negative, whose proper estimate should rely on the assumption of appropriate – present and future – risk scenarios: a quantitative event description in terms of *i)* the hazard, with its probability of occurrence, extension, intensity, and duration, *ii)* the value of the exposed elements and *iii)* their vulnerability. In this framework, the present contribution is intended to highlight the overall structure of a proper risk cumulus analysis for the flood hazard and to focus on two elements: the distribution of flood events in a multi-site multi-basin fashion and the identification of flood prone areas.

Predictions in ungauged basins: comparative assessment of floods and low flows studies

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Quantitative prediction of runoff in ungauged basins is of vital importance for a variety of water resources management purposes, e.g. water supply, irrigation, ecology... More precisely, prediction of runoff signatures related with hydrological extremes, such as flood peak discharges and low flows, are needed, among others, for a signicant number of applications in hydraulic and river engineering that are aimed to protect against or mitigate the impacts of floods and periods of water scarcity. Because of the societal relevance of these predictions, the hydrological comunity has been very active during the PUB decade (Sivapalan M. et al., 2003) in developing and improving methods and estrategies for predicting flood quantiles and low flows estimtes in ungauged catchments. The present study shows, on the first level, a compilation and intercomparison of dozen of studies from the last 20 years in terms of predictive acuracy and an assessment of the various methodologies across climates, places, and scales. On the second level, catchment-by-catchment data for a selection of studies was analysed in order to find the climatic and catchment controls (aridity, precipitation, catchment area and elevation) influecing on the predictive performance of the different methods.
Sivapalan M. et al.(2003), IAHS Decade on Predictions in Ungauged Basins (PUB), 2003?2012: Shaping an exciting future for the hydrological sciences, Hydrological Sciences Journal, 48:6, 857-880

What we could learn from practice of implementation of structure measures for flood protection

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The contribution discusses recent developments in construction technology give significant new value to the implementation of structural measures or flood protection. Societies have become more dynamic and are changing more rapidly, demanding for more and more efficient flood protection measures. Climate variability has recently highlighted uncertainty in hydrological estimates. Flood protection solutions adopted in the past are, with the current societal development, showing their inadequacy and tragic experiences leading to damage or collapse of structures. Urban development produces changes on surface runoff regime that increases discharges and tends to increase flood risk. Structures designed a few decades ago based on the estimated 1-in-100 year flood event seem now to be underdesigned. The planning and implementation of structural flood protection schemes is usually a long process. Once that the protection structures have been built, they are expected to work for quite some time. Thus, their presence, on the long term, can have an influence on the landscape development and morphology of rivers and floodplains. In turn, morphological changes induced by the presence of structures, might require additional measures or heavy maintenance for ensuring the efficiency of the planned flood protection scheme.

Structural measures have long history from ancient time. Some measures have been in service several hundred years such as the Grubar channel in Ljubljana. They are part of landscape and might also create opportunities for development (Vienna, New Belgrade, and Ljubljana). The small structures for torrent contrrol spread over the head part of watershed enable to sattle in hard mountanious condition (Soča-Isonzo) . Design return periods and freeboards tend to increase over time as a result of economic development in floodplain areas and the aforementioned "levee effect".

Any intervention has a strong impact on the hydrological regime and sediment transport, including changes in stream morphology that could increase flood hazard downstream or upstream. That asks for maintenance and additional structural measures or very intensive non structural measures. An example is the Po river for structural measures and Mali Graben in Ljubljana municipal area where overgrown of vegetation on the river bank increased flood hazard and flood risk upstream.

The development of structural measures including decision making process is a long process that takes decades (e.g. Vienna and Belgrade). To make these long term plans, a strong political support over a long period of time is essential.Urban areas are in development and ask for better protection in future. Than adaptability of structural measures and development of nvironmental friendly, integrated with social development, flood protection measures are essential for sustainable development (Ljubljana).

Governance of Water-related Risks: Case study of Nyong River, Cameroon

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Nyong river as many African water resources is highly vulnerable to impacts of climate change, manifested through increased drought and flood severity, more intense storms, shifts in the timing and distribution of rainfall, warmer temperatures, and secondary effects such as poor water quality and disease pressure affecting the local population. The water quality of this river is profoundly affected by climate change, which is occurring on top of rapid population growth, fast-paced urbanization, land-use change, and degradation of critical environmental services that underpin food, fish farming and livelihood security.
Effectively managing risks to flooding in Cameroon and making the river systems more resilient in the face of climate change, and global environmental change more broadly, requires strengthening the knowledge base about current and future vulnerabilities and impacts and about appropriate responses across time and space. As a response to the mitigation of water-related risks ,this paper focuses on multi-disciplinary approach that is issue-based and solution-focused, combined with actions that foster communication across research, policy and practice are essential to this effort.

Key words: River; risks; vulnerability; flooding; mitigation

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Predictions of runoff signatures in ungauged basins: Austrian case

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Runoff variability can be broken up into several components, each of them meaningful of a certain class of applications of societal relevance: annual runoff, seasonal runoff, flow duration curve, low flows, floods and hydrographs. We call them runoff signatures and we view them as a manifestation of catchment functioning at different time scales, as emergent properties of the complex systems that catchments are. Just as a medical doctor has many different options for studying the state and functioning of a patient, we can infer the state and functioning of a catchment observing its runoff signatures. But what can we do in the absence of runoff data? This study aims to understand how well one can predict runoff signatures in ungauged catchments. The comparison across signatures is based on one consistent data set (Austria) and one regionalisation method (Top-Kriging) in order to explore the relative performance of the predictions of each of the signatures. Results indicate that the performance, assessed by cross-validation, is best for annual and seasonal runoff, it degrades as one moves to low flows and floods and goes up again to high values for runoff hydrographs. Also, dedicated regionalisation methods, i.e. focusing on particular signatures and their characteristics, provide better predictions of the signatures than regionalisation of the entire hydrograph. These results suggest that the use of signatures in the calibration or assessment of process models can be valuable, in that this can lead to models predicting runoff correctly for the right reasons.

Deriving global flood hazard maps of fluvial floods through a physical model cascade

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Global flood hazard maps can be used in the assessment of flood risk in a number of different applications, including (re)insurance and large scale flood preparedness. Such global hazard maps can be generated using large scale physically based models of 5 rainfall-runoff and river routing, when used in conjunction with a number of post-processing methods. In this study, the European Centre for Medium Range Weather Forecasts (ECMWF) land surface model is coupled to ERA-Interim reanalysis meteorological forcing data, and resultant runoff is passed to a river routing algorithm which simulates floodplains and flood flow across the global land area. The global hazard 10 map is based on a 30 yr (1979–2010) simulation period. A Gumbel distribution is fitted to the annual maxima flows to derive a number of flood return periods. The return periods are calculated initially for a 25×25 km grid, which is then re-projected onto a 1×1 km grid to derive maps of higher resolution and estimate flooded fractional area for the individual 25×25 km cells. Several global and regional maps of flood return 15 periods ranging from 2 to 500 yr are presented. The results compare reasonably to a benchmark data set of global flood hazard. The developed methodology can be applied to other datasets on a global or regional scale.

Exploring the usefulness of global topography to support flood management under uncertainty

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The extreme consequences of recent catastrophic events have highlighted that flood risk prevention still needs to be improved to reduce human losses and economic damages, which have considerably increased worldwide. Flood models were proven to be useful tools to support the decision making process in flood risk management. However, in many rivers and floodplains the desirable input data are not sufficient or unavailable. A potential opportunity to fill this gap might be offered nowadays by the global remote sensing data, which can be freely (or at low cost) obtained from internet, such as the Shuttle Radar Topography Mission (SRTM) and the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) topographies. However, it is not clear to what extent exactly people can trust or make use of these topographic data. The challenge therefore, is to explore the actual value of SRTM and ASTER topographies for supporting floodplain mapping given rivers in the world characterized by various space scales. Previous studies showed the value of SRTM topography in supporting the prediction of design flood profiles in River Po, Italy and reproducing flood extent in River Dee, UK. This study analyzed the modelling performance gaps under uncertainty using high quality and global topographic data quantitatively by focusing on Barcelonnette in France, a small urban catchment (www.kulturisk.eu). Lastly, the limitations of using global topography data for supporting floodplain mapping in small rivers is discussed.

Numerical simulation of groundwater model of continental island and environment management

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Abstract : Donghai Island is a continental island with special hydrogeological conditions, where shallow aquifer is separated from the mainland aquifer by the gulf, but the middle/deep confined aquifers in the island and continent are closely linked and keeping consanguineous hydraulic connection. Consanguineous hydraulic connection can leads to water quality exchange between middle/deep confined aquifers in the island and continent. There is a national oil base which is a latent contaminant source to the groundwater in this island. To research the impact of groundwater exploitation and oil leaking on the groundwater flow and groundwater quality, the three-dimensional groundwater flow and groundwater quality models were built using the MODFLOW and MT3D. Using the validated models, two scenarios are simulated to analyze the variation of the groundwater flow and quality. The simulation results show that the groundwater in the middle/deep aquifers of the island flow from south to north and supply the groundwater in the middle/deep aquifers of the continent. The leakage from shallow aquifer to the middle aquifer is $893.9\times10^4 m^3/a$, meanwhile the leaked oil infiltrate the middle aquifer from shallow aquifer with groundwater leakage. The middle/deep aquifers in the continent are subjected to the pollution of the leaked oil in the island under the present groundwater pumping condition. Under the condition of largely pumping in the island, the island change to the discharge area from the recharge area. Meanwhile the influence of the leaked oil is limited into a small a range in the middle/deep aquifers of island. The groundwater in the middle/deep aquifers can't affected by the leaked oil in the island.

Keywords : continental island, numerical simulation, groundwater flow, groundwater quality

Water and Food Security: the Role of Water Resources and the Global Political Economy

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The purpose of the presentation will be to highlight the main driving forces that cause water users, mainly farmers, to use water resources beyond sustainable levels. These forces are demography, socio-economic development including the returns to water achieved on the world's farms, the imperatives of rural livelihoods, consumer behaviour and climate related uncertainties. These driving forces determine water availability and water demand in the local and global food supply chains. Because food consumption accounts for about 90% of the water demand of society water security is very closely linked with†those who operate in food supply chains.
The analysis will focus on food water. Food water is the 90% of water needed by an individual or an economy to provide its food needs. About 70% of this water is green water and about 30% is blue water. Farmers are the major agents who allocate and manage these water resources. They manage all the green water and with the assistance of engineers, other professionals and ag-corporates they are the main allocators and managers of the vast volumes of blue water used for irrigation. Agricultural history shows that green water mainly looks after itself as it is not possible to use last year's water. More important it is not possible to use next year's water nor that of the years beyond. Blue water, unlike green water, is always over-allocated. Because when there is a drought farm-livelihood imperatives ensure that water is diverted and pumped from existing, and if necessary from potential future blue water storage.
The analysis will show that it will be the behaviour of agents in the food supply chain that will determine whether future global populations will be water and food secure and whether water ecosystems will be restored to health.
Four key supply chain conditions will be identified. They must be addressed if we are to achieve food water security and water ecosystem security. The food supply chain is all in the private sector and it looks like a market. But it has very dangerous power asymmetries. Farmers and water ecosystems are relatively weak. Corporate traders and brands are strong. Food supply chains are dangerous juggernauts because they operate accounting rules that are blind to the cost of water inputs and they do not capture negative ecosystem externalities.
First, farmers in industrialised and BRICS economies must be incentivised to sustainably intensivise their food production from both green and blue water and return some blue water to the water environment. Farmers in the many developing economies where farmers currently achieve very low returns to green and blue water must be assisted to increase crop and livestock productivity. In many economies yields can be more than doubled. The role of socially appropriate inward investment in water and land will be discussed.
Secondly, the powerful corporations - non-brand (ABCD & Glencore) and brands (Unilever, NestlÈ, Pepsi etc) - that trade, process and retail food must be encouraged to go even further than promoting 'Creating Shared Values' (CSV) campaigns that link farmers, ag-industry science and ag-industry corporations, supermarkets and consumers.

Thirdly, major corporates in private sector global food supply chains must be steered to engage with international and national accounting standards boards – for example the US Federal Accounting Standards Board, and with the big four audit corporations (PwC, KPMG etc) as well as with farming and ecosystem interests to develop workable accounting standards for food water.

Fourthly, there is a suite of conditions that result from the food choices of consumers that are problematic. In OECD countries consumers throw away 30% of the food purchased. Many consumers in these economies also consume too much food and impair their health. Both food waste and excessive food consumption are seriously negative vis-‡-vis scarce renewable water resources and (mainly) non-renewable energy resources. In poor countries 30% of food is wasted between the farm-gate and the market with equivalent impacts on scarce natural resources.

The presentation will conclude with a brief discussion of climate uncertainties and a review of the role of the political economies beyond water resources and water science that will enable society to water, food and ecosystem secure.

Political economy of water-for-food security in the Middle East and North African region

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The purpose of this study is to increase understanding of the political economy processes that have determined, and will determine in the future, water and food security in the arid and semi-arid Middle East and North African (MENA) region. The region is the most water scarce in the world. The insecurity of the MENA is not only rooted in its poor water resource endowments, but also in the very limited capacities of the region's agricultural sectors and governments to adapt and make the most of its water resources scarcity. The socio-economic 'adaptiveness' of the region's political economies is argued to be the main explanatory factor of how available water is used.

Due to the very high volumes of water required to grow crops, water and food security in the region are closely linked. Almost any society can meet its municipal and industrial water requirements but the same statement does not hold true for food production. The term water-for-food security is used throughout the study to capture this link between these two securities, and for the purpose of drawing attention on the political economy process that underpin water and food security in water-deficit countries. The term food-water (Allan 2012) will be used to capture the water associated with crop and livestock production.

The water demands of the MENA economies have exceeded the capacity of their own resource base to underpin food self-sufficiency and entered water stress by the second half of the twentieth century. Current and future tensions in the region will arise from how the political economies of the region will manage the water-deficit for food production and secure the water needs of their populations. The study will situate the water and food-related challenges faced by the region in the wider context of international trade, showing that economic systems have enabled the MENA countries to access water in the global hydrological systems via trade and effectively to alleviate the local water resource deficit. The region's water and food security currently depend more on water from outside the region, 'embedded' in food imports and accessed through trade, than on its local water endowments. This market-mediated 'import' of water in virtual form has effectively and invisibly provided the region's economies with food-water security over the past half century.

The existing literature on the MENA region has thus far lacked a comprehensive investigation of the nexus between water, food, and trade in the region. This study will draw attention on the political economy processes that determine, and will always determine, the region's water-for-food security, and that go beyond the traditional concerns of water professionals and scientists. These perspectives would effectively inform both water users and policy-makers on the available options to current water management ad offer new avenues for a more sustainable use of water resources. The present study aims to fill this gap by seeking to answer a number of interrelated questions. How do the region's endowments contribute to the water and food security of their populations? What is the role of trade in underpinning water and food security, and what enables the region's economies to cope with the water deficit?

This study seeks to answer these questions by investigating the very dynamic relationship between water, food and trade in the region. The aim is to reveal the political economy processes underlying water and food security in the region and to show the avenues through which the sustainable intensification of agricultural production can progress. For this purposes, the study will, first, provide estimates of the water resources that contribute to water and food security in the region's economies. Both blue water, i.e. surface and groundwater sources sustaining irrigated agriculture, and soil water (also referred to as green water), which underpins rainfed agriculture and is usually ignored by conventional water scarcity assessments, will be considered. Secondly, it will unveil the extent to which the MENA water-deficit economies depend on water accessed in the global system through international trade to meet their food requirements. Third, it will be shown that water security is less dependent on a country's water endowments than it is on its socio-economic strength and diversification, which are the main determinant of how available water is used.

Toward A Framework for Modeling Dynamic Human Hydrologic Systems

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In view of the water challenges related to global change over the next century, including socioeconomic changes as well as climate change, a fundamentally new approach to modeling the interactions between water and society is needed to advance the sustainability science of water resources management. Given current computing power and unprecedented ability to observe the physical and societal aspects of water resources, there is a significant and important opportunity to create a modeling environment that links the physical understanding of the hydrological cycle with the socioeconomic understanding of water and societal interactions. The result will allow us to better project the dynamic response of these complex systems, better assess the relative effects of demographic and climate changes and better evaluate various hypotheses for addressing future water resources challenges. A human-hydrologic systems approach is needed to address some of the major challenges of water sustainability, such as the direct and indirect connections between water and energy policy, water management implications of food and fiber production and the preservation or enhancement of ecosystem services in the context of managed rivers. This paper explores the developments needed to conceptual structure necessary to characterize, model and understand the dynamic responses of human hydrologic systems. Analysis methods such as empirical approaches, optimization and simulation, and agent-based modeling will be demonstrated in applications to water resource systems in North America and Asia. The findings reveal that simple, one way and linear representations of human-hydrologic systems are inadequate for representing the dynamic responses that characterize them.

Impact of deforestation upon the soil loss level in Sidi el Barrak dam and water resources availability in the governorate of Beja

W. Chouaieb

The water resources availability versus the increase of population is one of the main challenges in hydrological research. The current water shortage in Tunisia and the neighboring countries, where average water availability is about 400 m 3/capita/ year, is a consequence of the anthropogenic impact and the climatic change. Beja governorate famous for its dense forests Bellife 1 and Bellife 2, is an area that had witnessed a lot of changes during the last decades caused mainly by the industrialization and urbanization of different areas. The extent of these forests and the biodiversity is altered by the extreme hydrological regime and the human pressure. Both forests help to fix soil and protect, downstream Sidi el Barrak dam against siltation. Consequently, vulnerability of water resources to human pressure is a fact that we need to monitor. The deterioration of water quality is one implementation of the anthropogenic and climate change impacts in the area. The latter factors lead to soil erosion as well as dam's siltation which have negative, economic and environmental consequences on society. In fact, less siltation in Sidi el Barrak dam means more water for irrigation, water supply, and better flood control in a country where the available water is fairly responding to the current water demand. Beja Governorate including the attributed Bellife forests was chosen to analyze the human impact on the water availability in the area. Trend and variation analysis as well as the use of GIS (Geographic Information Systems) tools were performed to monitor the deforestation sequences, the hydrological variability and the degradation of the landscape. The current research work is based on 30-year hydrological and mapping data bases. The rainfall trend analysis coupled with the deforestation sequences had allowed to better explain the runoff yield and consequently the storage capacity decrease for Sidi el Barrak reservoir. In fact, the spatial database built using multiple layers could display the soil loss distribution all over the studied area. The latter analysis, come out with specific results related to the vulnerability level of the catchment. Moreover, the findings have identified the current trend of water resources shortage constrained by human pressure and climate change predicted the mitigation measures to overcome the deficit for the next decades.

Keywords: deforestation, human pressure, climate change, water resources, deficit, mitigation

A complete review of the breadth of quality Geospatial Open Source Software available to Hydrologists, using OSGeo-Live

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In this presentation, we will describe the features and uses of the best Open Source GIS Software being used by hydrologists and others in the Geospatial field.
In recent years the accessibility of new technologies have changed dramatically the methodologies and techniques used in hydrology. Particularly, nowadays it is impossible not to take into account Geographical Information Science (GIS). Such cross-discipline has grown in recent years, particularly in the field of hydrology, because of the growing use of GPS devices in the field, the speedup of computer analysis, the relative accessibility of geographic data. GIS has become crucial in all phases of the transformation of raw data into information suitable for end users, from data collecting with Global Positioning System, to pre-processing, elaboration and analysis, visualization and data publishing via web GIS services.
OSGeo-Live is a ready to use suite of quality geospatial open source applications, available for the full range of geospatial use cases, including storage, publishing, viewing, analysing and manipulating data. It is available as self-contained DVD, USB thumb drive and Virtual Machine, based on Xubuntu, which includes close to 50 of the best geospatial, open source applications, pre-configured with data, project overviews and quick-starts, translated into multiple languages. It is an excellent tool for demonstrating GeoSpatial Open Source, practising with tutorials and workshops, or providing to potential new users.
Open source software gives you the best quality products at lower cost. It moves the source of the profits from the software's sale to the related services. Among the advantages of free software, we include the lower initial costs, the collaborative development typical of open source communities, adherence to standards and superior quality.
The Open Source Geospatial Foundation (OSGeo) is a not-for-profit organization, created in early 2006 to the aim of supporting the collaborative development of geospatial open source software, and promote its widespread use. The foundation provides financial, organizational and legal support to the broader open source geospatial community. It also serves as an independent legal entity to which community members can contribute code, funding and other resources, secure in the knowledge that their contributions will be maintained for public benefit. OSGeo also serves as an outreach and advocacy organization for the open source geospatial community, and provides a common forum and shared infrastructure for improving cross-project collaboration. The foundation's projects are all freely available and useable under an OSI-certified open source license.

Contribution to improvement of knowledge on the climate variability in the valley of Senegal River basin in Mauritania

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Our study area is located in the southern part of Mauritania and has been characterized by persistent rainfall deficits since the end of the seventies. The seven rainfall stations on which our study is mainly based on are those having reliable data. The observation from these measurement stations is sufficient enough to indicate a break in the rainfall and temperature time series (1950-2007) which allow an interesting comparative at regional level. The use of rainfall anomalies and other statistical tests show the alternation of wet periods from 1950-1969 and dry periods from the beginning of the seventies until the end of the nineties and a succession of wet and dry years until the end of 2007. The Regional pluviometric index shows an important rainfall decrease of about 33, 5 % during the period 1970-2007 compared to the period 1950-1969. The isohyets have generally moved from north to south during the period 1950 – 2007; meanwhile a north wards movement of the isohyets is noticed when the period 1990 to 2007 is compared to the period 1970-1989. The start and the end of the dry and wet seasons of the period 1950-1993 are over all characterized by a reduction of the mean daily rainfall. On the other hand; this reduction of the mean daily rainfall is not very significant for the start and end of the dry and wet seasons for the period beyond 1993. This pluviometric variability is also linked to the change in the rainfall frequency. The analysis of temperatures confirms the increasing of mean and values during all period of observation considered by this study. The analysis of rainfall extremes of two following periods, 1980-2007 and 1950 - 1979 show that extreme pluviometric events were higher during the actual (1980-2007). It also appears that the risk of having more frequency of floods is higher during the present period.

Networks of virtual water trade

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Most food production relies, directly or indirectly, on freshwater resources. Thus, water resources available in a certain region contribute to determine the maximum amount of food that the region can produce. Human societies often cope with water scarcity by importing food products from other areas and global food security increasingly relies on this trade. We analyze the virtual transfer of water resources associated with the trade of food commodities and their transport from production to consumption regions . We show how these patterns are changing over time, and at what rate the globalization of water resources is occurring. Using a rich database of international trade we reconstruct the virtual water network for the past few decades. Recent changes in virtual water trade are discussed in the context of global equity, societal resilience, and water solidarity.

Application of Cosmic-ray Neutron Sensors to Long-term Monitoring of Soil Moisture: A New Tool for Assessing Sustainable Agropastoralism in Drylands

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An estimated 200 million rural smallholders in arid, semi-arid and subhumid regions in Sub-Saharan Africa practice livestock-based or mixed livestock-crop-based agriculture. Approximately 2/3 of these regions are drylands, where annual potential evapotranspiration is 200% more than rainfall. These regions have some of the highest levels of poverty and food insecurity in the world and they are exceptionally vulnerable to climate change. Production of these lands is a critical source of protein, nutrition, and commerce for both rural and urban populations. For example, in Kenya, livestock contributed 50% to the national agricultural gross domestic production in 2004, with proportional contributions continuing to increase. Here, we investigate the issues of dryland productivity and food security in central Kenya. Beginning in late 2011, local communities in central Kenya began converting historical pastoralist areas into agricultural sites by abstracting more river water to support the increased demand. This natural experiment is a unique opportunity to study both the pastoral and agricultural systems together from an ecohydrological perspective, given that water is the limiting resource. In this work and as a first step in the study, we aim to understand the existing natural system water balance by comparing measurements from a cosmic-ray neutron soil moisture sensor and eddy-covariance tower. We are particularly interested in assessing the water balance fluxes of landscape average evapotranspiration (ET) and deep vertical leakage (L) as a means of understanding how the ecosystem functions. Cosmic-ray neutron sensors provide areal average measurements of soil moisture over a several hundred-meter radius circle and tens of centimeters by quantifying the well-mixed layer of low-energy neutrons present. Preliminary analysis of 1 year of data indicates that cosmic-ray neutron derived daily ET compares well with the estimate from latent energy flux. In addition, the time series of soil moisture allows us to quantify the potential for vertical leakage and recharge to be significantly taking place over the landscape. The use of cosmic-ray neutron sensors to assess ecosystem function is preferable in these remote areas given their relatively low cost, size, power requirements, and data robustness as compared to eddy-covariance methods. With the viability of this method, there is potential to more easily monitor dryland ecosystems and assess their health through simple water use metrics with the long-term goal of manipulating landscapes to be more productive and climate resilient systems.

Variability in rainfall patterns in West Africa and societal impacts

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Mesoscale convective storms provide most of the rainfall in West Africa. Such storms exhibit different attributes as they traverse strong thermodynamic gradients in their westward movement from land to ocean. Precipitating storms tend to be deeper and more intense over continental than coastal and maritime regions of West Africa. Many incipient storms in continental West Africa evolve to become convective systems with frequent lightning in their developing stages and eventually attain more stratiform conditions as they dissipate. In spite of mesoscale convective storms providing most of the rainfall in West Africa, no comprehensive assessments exist to learn how precipitation yield from such storms is changing in response to regional and global environmental changes. Assessments are needed to develop societal adaptation strategies in response to changes associated with atmospheric warming. Such assessments are urgently required in West Africa where communities are directly susceptible to climate change impacts, for example, in the areas of human health and agriculture. Timely hydrometeorological information is of great importance to advise communities on the potential of shifts in agriculture, and limits of adaptive capacity in rain-fed agriculture. There are also close connections between onset of storm formation and rainfall amounts, and outbreaks of malaria and cholera. Therefore, in this presentation, using satellite-based rainfall data we will present and discuss results on the changes of precipitation yields from mesoscale convective storms during the last decade. We will also report on the variations of hydrometeorological conditions influencing the onset of and the rainfall yield from mesoscale convective storms. Historical rainfall variability will be related to agricultural activities and outbreaks of disease (e.g., malaria and cholera) in West. Disease epidemics and rain-fed crop failures are some of the realities of societal vulnerability to rainfall in West Africa.

Forecasted estimations of runoff change in the Dniester Basin under conditions of climate change

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River runoff is an important natural resource for economic and social development of countries worldwide. Climate change directly affects the quantitative and qualitative characteristics of rivers hydrological regime. In the last decades in many parts of the world disastrous floods are observed resulting in losses of property or even casualties. Therefore one of the major issues is to assess changes of hydrological regime of rivers in flood vulnerable regions and under conditions of climate modifications. The Dniester Basin is characterized by formation devastating rain floods which are detrimental to the economies of two countries: Ukraine and Republic of Moldova.

The goal of presented study was modeling and assessment of projected changes in annual mean, maximum and minimum flow in the Dniester Basin by the mid 21st century, according to calculated data derived by Global Circulation Model ECHAM5 and the regional climate model REMO using the IPCC A1B scenario.

Selections of reference period for this study (1971-2000) as well as appropriateness of data calculated with REMO/ ECHAM5 climate model (A1B scenario) for the Dniester Basin have been discussed by Krakovskaya et al., 2012.

For water flow simulation modeling hydrological complex MIKE 11 with Rainfall-Runoff model was applied. Modeling has been performed for selected representative catchments which reflect peculiarities of water discharge formation for three parts of entire basin namely Carpathian, Volyno-Podolskaya and Lower Part. Calibration of NAM module of Rainfall-Runoff model is performed using historical annual observation data on water discharge, evaporation, precipitation and air temperature for period 1998-2000 for selected representative catchments. Ratio of mean square error of testing prognosis ($\overline{S}$) to the mean square deviation of predicted value ($\overline{\sigma}$), i.e. $\overline{S}/\overline{\sigma}$ was adopted as a quality criteria for module NAM calibration. Calculations of quality parameters for module NAM calibration has shown that for mean monthly and maximal monthly water discharges calibration can be considered as having good category while for the minimal water discharges calibration is characterised as having moderate category. Therefore obtained parameters of calibration quality allowed NAM module using for modelling of water discharge in Dniester Basin.

Forecasted modelling has been performed on the basis of climatic parameters (air temperature, precipitation, evaporation from the surface) for the periods of 1971-2000 and 2021-2050 using data of REMO/ ECHAM5 model according to A1B scenario. Correlation coefficients between historical and modelled mean monthly values of water discharge for the period of 1971-2000 allowed stating that climate model REMO/ ECHAM5 quite adequately reconstructed climatic conditions of water flow forming for representative catchments in the Dniester Basin.

Obtained projections of the Dniester water flow changes showed that the most significant changes could be expected for the Lower Part of the Dniester Basin: decreasing of mean annual water discharge down to 24%; maximal water discharge down to 5.7%; minimal water discharge down to 24%. For Carpathian and Volyno-Podolskaya parts of the Dniester Basin expected changes of mean annual water discharge will be within the limits of natural variability. Changes of annual water discharge distribution also could be expected i.e. increasing of water flow during the cold season, shift of the spring flood beginning and peaks toward to more early dates, increasing of floods frequency. Annual distribution of water flow of rivers in the Lower Part of the Dniester Basin will be characterized with more sharply visible flooding regime with possible decrease of spring flood flow. These phenomena could be explained by changes in precipitations structure in studied region for example by increasing share of heavy rains. Essential changes of maximal water discharge values in the Dniester Basin are not expected. Some decrease of maximal water discharge values up to 13% for Volyno-Podolskaya part could be supposed. In Carpathian and Volyno-Podolskaya parts minor increase of minimal water discharge is foreseen. Results obtained could be used for development of recommendations on adaptation measures for population and different industry branches in the Dniester Basin.

Introducing an historical perspective to virtual water flows: how hydrometabolism explains the "bad" virtual water flows from non renewable/overexploited groundwater

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Introduction
Virtual water concept has now become a mainstream topic in global water policy discourse. We can find it mentioned in major United Nations reports and current literature on the water-food-energy nexus, as well as in major environmental policy publications (Tony Allan). However, still more need to be done in order to get a bigger picture of what this concept is capable of showing us if we deepen our analysis and extend it to virtual water typologies, for example (virtual blu water, virtual green water, virtual grey water) related to food pattern consumption, or if we explore even other typologies of virtual water (coming from arid countries, coming from water-rich countries) : these and other categories can be useful to understand the real value of food and products we usually consume on a daily basis (Antonelli and Greco 2012, Hoeckstra 2012).
Method The method proposed here will be based on data gathering in Italy and on current literature on virtual water, with inputs from historical research on food and crop trade in ancient times.
Discussion Not all virtual water is good. Not all drops are equal (Antonelli and Greco 2012) . In order to show precisely where "bad virtual water is", this paper will guide us through an historical perspective and then comes back to current times in order to gain a wider picture of it all.
At first, we will aim at simply introducing yet another component of the current virtual water analysis in the current literature: the historical perspective, as mentioned above.
Thanks to this perspective, the virtual water rivers in history will be easily identifiable and another terminology will be then introduced: hydrometabolism, drawing back to economic metabolism concept. Proceeding with our analysis, the human-nature of these water flows and the fact that, in history, these virtual water flows (or , virtual rivers) have always been existed, will , at the beginning , downplay the imporance of virtual water in past times. After this first finding, we will see how, with time, some of these flows have been inverting their routes for some reason, and we will explain the motivation of this "inverted virtual water flows" through an historical perspective.
Finally, the paper will guide us through our research goal , wich is to identify some hot-spots where some particular virtual water rivers are currently flowing , abd causing the highest impact on the environment and to the local population residing around the abstraction plants: the "bad virtual water" will be therefore identified in terms of blue water being pumped from non renewable and overexploited groundwater sources and exported under the form of virtual water by major agro-business companies, for the benefit of global consumers.Consumers do not know the origin of the water embedded in their food, and consider a tomato coming from the Maghreb exaclty like a tomato coming from the Netherland. Consumers are not able to give value to different types of virtual water embedded in food. These cases of "bad virtual water" are just a symbol of the extreme consequences of unregulated hydro-metabolism, in time of global markets and land&water grabbing.
Conclusions
Virtual water flows in the past have been of minor impact on both the environment and the local population because of the small numbers of human population on the globe, the sustainability of agricultural methods and the small impact of trade in the food market. In current times, with seven billion people living in our planet, globalization of food and crop trade and overexploitation of water resources, virtual water trade has become "extreme" in certain areas: the hot-spots identified in this paper have shown how virtual water export are detrimental if water is being pumped from non -renewable and overexploited groundwater, and our main aim is just to show, once again using "virtual water lenses" , where a change must start from, and where the risks with virtual water export are currently becoming bigger.

Stepping into Water Crisis: analysing the driving forces of China's water resources exhaustion

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China is a country with abundant water resources, but these are unevenly distributed. The statement that all rivers run dry in the North, and all water is polluted in the South sketches a realistic picture about China's current water challenges. . Alongside the South-to-North Water Transfer Project, China sees technology as a rescue from the water crisis without harming its economic development. China announced its ambitious plan to cut "water consumption per unit of GDP to 125 m3 by 2020, down by 60% from today" with special focus on more efficient irrigation, in order to cope with the projected economic growth of 60% by 2020 (Ministry of Water Resources, 2007). In this paper, we employ three indicators to assess water issues in China: freshwater consumption discharged COD in wastewater, and unavailable water (amount of freshwater bodies contaminated and thus unavailable for any purpose of usage). For this we use the latest available datasets and adopt structural decomposition analysis to investigate the driving forces of China's water crisis from 1992 to 2007. We find that 1) agriculture is not the major contributor to China's water crisis, although it remains the largest freshwater consumer in China. 2) technology improvements can effectively offset some freshwater consumption and COD discharge but it fails to eliminate cumulative pollution which can be seen as a key contributor to the water crisis. Finally, China's water-intensive export production pattern is responsible for 1/4 of total consumed freshwater to be used (virtual or embodied water) for export production and about 1/3 of freshwater resources is too polluted to serve for any other production purposes.
KEYWORDS: China, water crisis, water scarcity, water pollution, input-output analysis, structural decomposition analysis.

Time Domain Reflectometry Coaxial Probe for Water Content Measurements of Soil

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Water resources are utilized for many human activities. However, there is often a mismatch between the water requirements and the withdrawal actually available and sustainable. This mismatch may become even worst as a consequence of climate change. In fact, climate change affect both water demand and water resources and it is highly probable that society will suffer increased water requirements without having a proportional increase of available water resources.

Irrigation is demanding huge withdrawals of water. One region where these problems are self evident is North-Western Italy, where the water requirements for agriculture are important in large parts of the territory. Such water demands strongly depend on meteorological variables. In addition in the whole Alps, glaciers are retreating their volume, leading in the long term to a decrease of water for irrigation. Such water requirements are strictly derived from the durations of periods with low soil moisture values. Its deficit has to be replenished by irrigation, and reliable techniques has to be utilized for precisely and reliably measuring soil moisture in soils ranging from sandy to clayey ones.

Knowledge of water content is thus important for water resources management and risk prevention. Volumetric water content of soil may be measured in situ using Time Domain Reflectometry (TDR). The TDR measurement setup is mainly formed by a cable tester connected to a probe by means of a flexible coaxial cable. The probe, generally a three-rod, can be easily inserted in the soil. This technique is noninvasive and does not require sample collection and time-consuming laboratory measurements.

The aim of this work was to develop a TDR probe that can be used for loose materials while ensuring optimum working conditions in terms of ease of insertion into and contact with the surrounding porous medium, and homogeneity and confinement of electrical energy storage. The designed probe uses eight brass blades 15 mm wide and 165 mm long disposed along a cylinder and a stainless steel rod in the center. The characteristics of the new designed probe with respect to the standard three-rod probes, represent a compromise in terms of ease of insertion into the porous medium, good contact with the surrounding, and homogeneity and confinement of electrical energy storage. Signals from the new probe permits more reliable and accurate volumetric water content measurements. Once calibrated, the new probe allows measuring volumetric water content within a small error range. The performance of the new probe was tested on various porous media. A standard three-rod TDR probe and a coaxial probe were used for comparison. The criterion of mean absolute error and the associated standard deviation, calculated on the difference between the water content values measured by the TDR probes and those determined by gravimetric observations were used to determine its performances.

Water supply and demand for rainfed agriculture in Africa

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Water balance calculations, based on CRU gridded monthly climate data, provide a tool for partitioning available precipitation between surface runoff, soil water storage, evapotranspiration and recharge to groundwater. Using a dynamic hydrological model in which vegetation biomass and soil organic matter also respond to and modify the availability of water, we can distinguish regional patterns of hydrological regimes along the spectrum from humid to arid conditions.

These models have primarily been applied to estimate available local runoff at a regional scale across Africa, and estimating how much concentration of runoff is required to support rainfed agriculture, in combination with water harvesting technologies. The benefits of water harvesting are most achievable where rainfall is marginally inadequate for rainfed agriculture, allowing supplementation by harvesting of surface runoff or groundwater, preferably from renewable sources. As the climate becomes more arid, the required ratio of collecting area to cultivated area increases, until it is only feasible in areas adjacent to superior water supplies. The reliability of harvesting methods also depends strongly on the inter-annual variability of rainfall, which generally increases towards more arid regions, providing an additional constraint on the sustainability of harvesting systems.

An analysis of local climates and their variability allows a preliminary classification of suitability for different styles of water harvesting. Where rainfall is almost adequate for rainfed agriculture, simple local collecting systems are appropriate, creating microcatchments. Where rainfall is less, then additional factors come into play, for example enabling water from adjacent higher rainfall areas to be collected by natural catchments that flow towards a target agricultural area, so that topographic and climate gradients become increasingly important.

Demand for water harvesting and other mechanisms to mitigate water scarcity is in relation to the local population, particularly in near-subsistence economies. The tools developed allow some assessment of the extent to which current resources are fully utilised, and indicates the potential to meet future needs as rural populations continue to increase, and in the face of expected climate change.

These principles and tools are exemplified by maps for Africa, generated by the model from the climatic data and showing the broad regional patterns of recharge and water harvesting potential.

The drivers of the virtual water trade: a preliminary analysis based on gravity-law models

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The global trade of food products is associated with the transfer of large volumes of virtual water, namely the water used for the production of such goods. As an effect of globalization, the intensity of virtual water trade has strongly increased in the last few decades. This complex network links all the world countries and territories (about 270) with several thousands of links, through which virtual water is exchanged in both directions. Starting from the FAOSTAT data set on the production and exchange of 310 crop and animal products, we have reconstructed the global virtual water network from 1986 to 2008. On each link between two countries i and j, the virtual water fluxes, s_{ij} and s_{ji}, are calculated for each year in this time interval.

Virtual water fluxes depend on many economical, political, social, environmental, and cultural variables. Here we investigate the dependence of virtual water fluxes, s_{ij}, on population, gross domestic product, surplus and deficit of virtual water, and geographical distance between countries. The conceptual framework of gravity laws, which is often used to explain fluxes occurring in networks, is adopted here. Gravity-law models have the simple structure of a monomial formula $f_{ij}=v1_i^{\alpha} \cdot v2_i^{\beta} \cdot \ldots \cdot v1_j^{\gamma} \cdot v2_j^{\delta} \cdot \ldots$, where v1, v2, etc. are the possible explanatory variables. In particular, we have considered extended gravity laws, where variables are raised to exponents possibly different from one. Moreover, statistical tests have been used to evaluate the significance of specific explanatory variables. Using a "gravity" model approach and other empirical relations we identify the most relevant drivers of virtual water trade. We find that standard application of gravity-law models does not provide a good fit to the data, while a more refined approach based on the combined use of regression and an analysis of the virtual water network provides a better explanation of virtual water fluxes.

Dependency of hydrodynamic dispersion coefficient to the soil water flow rate in the disturbed homogeneous soil columns.

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Predicting solute transport processes in porous media are essential to sustainable manage soils and subsurface aquifers and to address chemical pollution in these resources. In first step 30 soils were sampled from different region of Zanjan, Iran. The soil moisture characteristics curve, particle distribution and hydraulic conductivity were measured and then 9 representative soils with wide range of physical properties were selected. To identify the mixing regime of solute in the unsaturated soils, series of solute transport experiments were conducted on 9 soil columns (20 id× 50 cm ih) at steady-state unsaturated condition. Two well know solute transport models, CDE and CLT were fitted to all experimental breakthrough curves (BTC's). This study showed that for homogeneous and undisturbed soils, the CDE model can explain the BTCs more reliably than the CLT model . Our results showed that the soil physical properties as well the conditions of experiment are critically determining the appropriate model which can characterize the BTCs. Since most BTC's were obtained in unsaturated conditions with assuming the entire solute mixing regime , we concluded that is more rather reliable in unsaturated conditions. Through interpreting the trend of CDE and CLT parameters obtained for all experiments we further concluded that the hydrodynamic mixing regime is determined with two antagonist mechanisms ,the effect of solute flow tortuousity and contribution of bigger pore in high flow rates. Because the relative contribution of each mechanism completely depends on water flow rate and type of soil, the complete predicting of solute transport in unsaturated soils may contaminated with large errors. We also further observed that the variance of solute molecule velocities varies with flow rate. This variation may be used as an index of mechanisms (and their relative contributions) determining the solute mixing regime.

Effect of human induced land use changes on water runoff from the small catchment

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The aim of this study was to model and assess the impact of human induced land changes on runoff from small catchments. The study was carried out at Kopaninský stream catchment in the environment of Bohemian-Moravian Highland in the Czech Republic. The mean for model validation of changes in runoff was continuous model SWAT (Soil and Water Assessment Tool). In a small catchment there were simulated various scenarios of changes in land use caused by human activity. It can be said that more than the change of land use itself, changed management of these areas affects the water runoff more. The only exception is the hypothetical transfer of a radical change in the whole catchment area into urbanized paved space. This study was supported by grant QI111C034 of Ministry of Agriculture of the Czech Republic.

On statistical investigation of the virtual water trade network

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If one country (one region, company, individual, etc.) exports a water intensive product to another country, it exports water in virtual form. In a context of growing attention on water resource, in many parts of the world, also the trade of virtual water has received a larger attention in recent years. The applications of statistical methods to the virtual water trade are carried out through a descriptive analysis of the structural characteristics of networks, while statistical methods and models for network data have been used only marginally. A modeling approach for studying the networks of virtual water flows is proposed here. The goal of networks data models is the quantitative examination of the stochastic properties of the relations and the actors of a particular network. Different types of models for social network structure have been suggested in literature. They may be organized along several major axes as well as they may be classified into static and dynamic models. Some preliminary analyses have suggested considering only the static models. Furthermore, since in the context of virtual water trade, exports from one country to another may be determined by factors/circumstances beyond a country's control such as environmental effects, socio-demographic evolution, economic and politic scenarios the random effects models are preferred. Particularly, the mixed effects model (i.e. random effects models and their generalization) approach has been chosen, also for its advantage concerning availability of good estimation methods. In the network of virtual water trade each country participating in trade is represented by a node. Links among nodes are the volume of virtual water embodied in the traded commodities and are directed on the base of direction of trade flow. Mixed effects models for network data are practical to implement also in the case of valued networks, such as those where counts, measurements, or ranks are observed. In the application, detailed international trade data from FAOSTAT, to reconstruct the global trade patterns of each food product reported by the FAOSTAT data base, including crops, crop-derived food commodities, and animal products, are used. Then, the country specific average water footprint of each product by crop FAOSTAT code, for the conversion of the crop trade matrices to virtual water trade matrices, is used. The results of the preliminary analysis are not presented here for the sake of brevity but more investigations are encouraged. Above all, as in the mentioned database, the virtual water content of many products is available also at sub-national scale, investigation on the domestic virtual water trades and its management are also foreseen. Understanding the virtual water trade concept and strategy may be important for formulating informed policies and improving water use efficiency at different levels, i.e. for those countries relatively dry in some areas and relatively wet in other areas, domestic virtual water trade may be a relevant issue.

Water quality modelling as a tool of sustainable development

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Growth of anthropogenesis load on a coastal zone of the sea in the last years in connection with increase in number of tourists and building of coastal structures has led to an aggravation of many environmental problems. The majority of them are connected with the sea water quality control. Possible prospects of their solution are connected with realization of the concept of "sustainable development" - sustainable coexistence of mankind and the nature, and the basic method of that is the water quality modelling.

A plenty of parameters is used to provide the fullness and objectivity of the estimation of quality of superficial waters now. The choice of important for application of 10 parameters from 40-45 proves in the presented model. To increase the accuracy and informative of forecasts for the coastal zone conditions the system-dynamic model has been developed, what allows to estimate the quality of the sea water, including that in the semi-enclosed coastal water areas with the limited water exchange. The model of water quality in the coastal zone includes the equations of deposit concentration changes and chemical substances evolution in the studied areas. The model incorporates joint description of cycles of two biogenic elements - nitrogen and phosphorus. The system is completely defined by the biogeochemical reactions. The sizes of such water areas allow the applying the full mixing and zero-dimensional models of water quality. The circulation of water inside the area is taken into account additionally. Water exchange in the semi-enclosed coastal water areas is defined by the discharge through the open parts of area border.

The novelty of the offered model is its adaptation to the specific conditions of semi-enclosed coastal water areas. The coastal engineering objects including the presence of partly closed structures and areas with limited water exchange and high intensity of pollution concern to the last. Water exchange is carried out due to currents, what are typical for the coastal zone (longshore, rip currents). At the same time, the model contains details of the biogeochemical processes included to complete models of water quality corresponding to the sustainable development.

The model also allows to receive integrated estimations of ecological damage from creation of the marina in the coastal zone to compare various engineering decisions on designing and constructing of yacht-ports and to choose from those variants which are correspond to the minimal ecological damage.

The developed system dynamics model is realized in the «PowerSim Studio» media. The data of natural measurements of water quality are applied for the model verification, and the correlated numerical results for the Russian Black Sea coast are presented.

The developed model allows estimating a change of sea water quality in connection with construction of coastal engineering objects and an integrated estimation of ecological damage from creation of engineering objects in the coastal zone.

Realization of dynamic model enables to carry out process of research quickly and effectively. Moreover it is possible to reveal dynamics of the processes proceeding in complex ecological system, to predict a condition of system in time, to take decision and analyze problem situations.

The results, received by means of described above model, can be used also in estimation of ecological risks. Estimating the ecological risk it is necessary to consider results of influence of any actions and events on the diversified environment components. And, hence, it is necessary to define the ecological importance of each of these influences and to lead a quantitative estimation of damage which they can cause.

The including of the coastal water quality model into the procedures of the integrated coastal area management is also discussed.

Hydrology and Society: River networks as ecological corridors for species, populations and pathogens of water-borne disease

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The Lecture proposes a synthesis of recent (and,in the lecturer's opinion, rather exciting) research developments, appeared in disparate fields at the interface of hydrology, geomorphology, epidemiology and ecology, seen through the integrated framework of analysis for riverine ecological corridors – a traceable conceptual thread whose origins and functions are presented and discussed in the Lecture. In the first part of the Lecture, I shall address a range of related topics, including the biodiversity of freshwater fish in river networks and vegetation along riparian systems, how river networks affected historic spreading of human populations, and how they influence the spreading of water-borne diseases. Metacommunity and individual-based theoretical models are studied specifically in the contexts of hydrochory, population and species migrations, and the spreading of infections of water-borne diseases along the ecological corridors of river basins. Laboratory studies on experimental metacommunities, a new frontier of hydrologic research in this Lecturer's view, are studied for understanding biodiversity under directional dispersal. Field studies are analyzed in the context of species persistence times. In the second part, I shall provide on specific example of real-life application with direct social and economic implications, modeling epidemic cholera in Haiti. The overarching claim is that mathematical models can indeed provide predictive insight into the course of an ongoing epidemic, potentially aiding real-time emergency management in allocating health care resources and by anticipating the impact of alternative interventions. To support the claim, I examine the ex-post reliability of published predictions of the 2010-2011 Haiti cholera outbreak from four independent modeling studies that appeared almost simultaneously during the unfolding epidemic. For each modeled epidemic trajectory, it is assessed how well predictions reproduced the observed spatial and temporal features of the outbreak to date. The impact of different approaches is considered to the modeling of the spatial spread of V. cholera, the mechanics of cholera transmission and in accounting for the dynamics of susceptible and infected individuals within different local human communities. A generalized model for Haitian epidemic cholera and the related uncertainty is thus constructed and applied to the year-long dataset of reported cases now available. Specific emphasis will be dedicated to models of human mobility, a fundamental infection mechanism. Lessons learned and open issues are discussed and placed in perspective, supporting the conclusion that, despite differences in methods that can be tested through model-guided field validation, mathematical modeling of large-scale outbreaks emerges as an essential component of future cholera epidemic control.
I conclude that a general theory emerges on the effects of hydrology on 'society' i.e. the ecological processes and dynamics operating on river basins that are establishing, in the lecturer's view, a new and significant scientific research field. Insights provided by such a theory will lend themselves to issues of great practical importance such as integration of riparian systems into large-scale water resource management, spatial strategies to minimize loss of freshwater biodiversity, and effective prevention campaigns against water-borne diseases.

Survey of Water Quality of Powai Lake in Mumbai, India

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This research carried out on Powai Lake in Mumbai, India investigated the physical, chemical and environmental characteristics of the lake water. Detailed survey was carried and eight samples were collected repeatedly from different areas of Powai Lake over a period of three months. The outcome of this work was a better understanding of what contributes to the deterioration and the eutrophication of the lake, which may lead to recommendations for more effective and sustainable planning and management of this wetland.
Key words: wetland; pollutant; eutrophication; planning; mitigation.

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Multifunctional soil conservation and land management through the development of a web based spatial decision supporting system.

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Here we report results concerning the LIFE+ SOILCONSWEB project which aims to produce, to test and to apply a tool to support (stakeholders) decision on landscape issues aiming to both the best soil conservation and land management and most importantly to an easy landscape implementation of some important but complex environmental related EU directives and regulations and NAP.
In fact, some of these EU directives/regulation have an intrinsic complexity because they apply to soils and landscapes which have the well recognized "multiple functions" as a fundamental feature. Then it is not surprising that this decision supporting tool requires, as fundamental feature, to include and mix many different high quality layers of information, engine and processing in order to be successfully applied.
Such tool will be developed in the framework of a "Web-based Spatial Decision Supporting System" (WS-DSS) and it will consider soil and landscape. Nowadays this tool can be conceived because developments in Internet technologies make it indeed possible for geographically dispersed groups to access and process spatial information that is distributed across the Internet on different platforms. Decision makers can then have real-time (or near real-time) access to critical, accurate, complete and up-to-date spatial data held in multiple data stores that may not be managed or maintained by them.
This decision supporting tool, during the lifetime of the project, will be adopted in a test area by the Regione Campania - Agriculture Division (Associate partner) which is the local public administration responsible for all the applications of the EU regulations and directives quoted in the project.
The tool will be available to individuals, groups of interests and public bodies and it will also allow to integrate classical top-down decision with bottom-up contributions to landscape planning and managing.
The objectives being that the WS-DSS tool will enable, through a web server system, to advice and to produce detailed spatial documents, report and maps on a series of questions including agriculture, environment and climate change enabling an easy implementation and an innovative spatial based adoption of the following EU rules and directives:

Runoff and Sediment Source Areas from the landscape of Debre Mawi Watershed in Blue Nile Basin, Ethiopia

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Land degradation by soil erosion is a challenge and a threat to Ethiopia's economy. Blue Nile Basin is a hotspot area where soil loss from the highland is very high and a threat to planned reservoirs in the basin. Identification of hotspots runoff and sediment source areas are therefore important to soil and water conservation practices.

Debre Mawi, a headwater watershed in Blue Nile basin, was instrumented with automatic rain gauge to measure rainfall and with five broad crested weirs to measure the amount of storm runoff and sediment concentration at five nested locations within the watershed in two summers (2010 and 2011). In addition, depth of perched water table and infiltration rate were measured in the summer of 2010. The storm runoff and sediment concentration at the outlet was simulated using saturation excess water balance and erosion model. In the hydrology model, the watershed was divided into two different runoff producing areas (saturated and degraded) and hillslope where baseflow and interflow is produced while the erosion model assumed that only runoff producing areas are involved in active erosive work.

The result showed that the median infiltration rate was only exceeded 3% of the time. And high intensities occurred mostly in June and July in which the runoff coefficients were higher in the upslope sub-watershed than at the outlet indicating that water infiltrates before reaching the outlet. With the progression of the rainy period, the runoff coefficient at the outlet was increasing and at the end of the rainy period 40 percent of the rainfall in the watershed becomes runoff. Mapping of saturated area from piezometer reading suggested that 10% of the runoff originates from saturated area and the remaining 30% might be from degraded shallow area on the hillside. The saturation excess water balance simulation with nine parameters was reasonable with Nash Sutcliffe of 0.7.

The sediment concentration and load measurement in June and July was greater than in August at all weirs because the soil in the watershed was loose after prolonged dry period and hence rill network and then rill erosion was higher. However, sediment contributions from upslope were less than at the outlet suggesting that sediment sources were located down slope. In Debre Mawi, saturated areas were found and confirmed by the piezometer readings and these areas had usually active gullies producing two times more sediments than upland erosion by rill. The erosion model with only two parameters that coupled with the hydrology model simulated the sediment concentration with a Nash Sutcliffe of 0.83.

The result suggested that sediment producing areas are only 40% of the total area and the higher sediment concentration in Debre Mawi is because of gullies located in saturated areas. These results have led to the reconsideration of the placement of soil and water conservation practices and modeling principles that need to be modified to include local saturated areas.

Estimation of water availability for the Ridracoli water supply reservoir: rainfall-runoff modelling of the gauged and ungauged drainage catchments

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The Ridracoli reservoir - an important public water supply reservoir in Northern Italy - provides the primary sources of drinking water for one million of resident customers, plus millions of tourists in the summer, supplying more than 60 millions of cubic meters per year to the whole Romagna coastal region.
In addition to the headwater catchment, closed at the dam, the reservoir receives water also from four diversion watersheds, linked to the reservoir through an underground water channel.
In the last decade the system experienced water shortage conditions thrice, in 2002, in 2007 and in autumn-winter 2011-2012, when the reservoir water storage fell below both the attention and the pre-emergency thresholds, thus prompting the implementation of a set of mitigation measures, including limitations to the population's water consumption. The demographic forecasts indicate, from 2007 to 2024, a growth of 8% to 19% (for different scenarios) in the number of resident costumers for the three Provinces of Ravenna, Forlì-Cesena and Rimini and an even larger growth is foreseen for the tourist population (more than 1% per year), thus further increasing the expected water supply demand.
In order to augment the inflows to the reservoir, other neighbouring catchments might be joined through new tunnels, thus enlarging the diversion drainage area, but a first – less demanding - step might consist in increasing the water currently abstracted from the existing diversion catchments. The withdrawals from the diversion watersheds are in fact currently undersized, abstracting only a part of the streamflow exceeding the approved minimum flows, due to the design of the water intake structures: the present study aims at estimating the total reservoir water availability obtainable if exploiting the full potential of the diversion streamflows.
The study first presents the reconstruction and reconciliation of the hydro-meteorological time series, at fine temporal time-step, for the headwater catchment (on the basis of water balance) and for the diversion drainage area.
The second step is the set up and parameterisation of a rainfall-runoff model for the three gauged diversion watersheds and for the headwater catchment: a regional parameterisation approach is then applied for modelling the streamflow originated in the fourth, ungauged, diversion watershed.
The potential reservoir water availability is finally estimated, hypothesising to take from the diversion watersheds all the streamflow exceeding the minimum flow requirements and simulating the reservoir storage volume during a long continuous time interval including water scarcity periods.

How different diets in the EU can influence global water management

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The water footprint (WF) and virtual water (VW) concepts provide the opportunity to link the use of water resources to the consumption of goods. They have been brought into water management science in order to show the importance of consumption patterns and global dimensions in good water governance. An important distinction needs to be made between the WF of production (WF_{prod}) and the WF of consumption (WF_{cons}). The first is the sum of direct and indirect water use of domestic water resources. The second is the sum of direct and indirect water use of domestic and foreign water resources through domestic consumption. Apart from intra-European virtual water flows between EU nations and regions, the EU28 (EU27 and Croatia) is an extra-European net virtual water importer. It imports more virtual water than it exports, especially due to the consumption of commodities like animal feed, coffee, cocoa and cotton. Its WF_{cons} (857 km^3 or 4815 l/cap/day) is larger than its WF_{prod} (609 km^3/yr or 3420 l/cap/day). Domestic water use only accounts for a small fraction of these values. The consumption of agricultural products accounts by far for the largest fraction (89%, 760 km3 or 4265 l/cap/day) of the WF_{cons}. This value is composed by a green WF_{cons} of 636 km^3, a blue WF_{cons} of 53 km^3 and a grey WF_{cons} of 70 km^3. In other words, if consumers consider reducing their WF_{cons}, they need to look at their diet rather than at their water use in the kitchen, bathroom and garden. Within the wake of climate change and global demographic changes, it is necessary to act on a reduction of the blue, green and grey WF of the EU, within a sustainability context. In order to provide a healthy diet to the 9.3 billion people projected for the mid of this century in a sustainable way, changes in current global agricultural production processes (e.g. closing the yield gap on existing agricultural lands by means of sustainable intensification) as well as consumption behaviour (especially in the western world) need to be made. Today, hunger and famine coexist with overconsumption and associated health problems. One major pathway is therefore to act on consumption behaviour adaptations by the citizens of the EU28. Currently the average EU diet consists of too many products from the groups sugar and meat and not enough products from the groups cereals, rice, potatoes, vegetables and fruit. Both the daily consumption of kcal and the proportion of animal proteins are considerably higher than recommended. Especially a reduced consumption of animal products (meat and milk) would have a large impact on the WF_{cons} of the EU28, where more than 50% of cereal production is used as feed and additional feed imported. This paper analyses the EU28 WF_{cons} for different diets: the current diet, a healthy diet, a vegetarian diet and a combined diet between both latter diets. It is shown that these diets result in a substantial reduction of the WF_{cons} for agricultural products, with consequent effects on virtual water flows. The paper also shows which products account for a WF in external-EU countries through trade imports. The WF provides the unique opportunity to link the use of water resources to the consumption of goods and shows where the internal and external WF_{cons} of EU citizens are located. Nevertheless it is a partial indicator. To evaluate the sustainability of the EU agricultural production system and consumption behaviour, an integrated approach including other factors is necessary: land resources, greenhouse gas emissions, (fossil) energy use and environmental impact.

Self-sufficiency and dependency analysis of virtual water trading at the nation's level

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In the world of today people from Japan indirectly affect the water resources of the USA and people in Europe indirectly and unconsciously affect water systems in South America. These connection depend on trade of food and agricultural goods, which entails global exchanges of "virtual" water, i.e. water used in the production process of alimentary products, but not necessarily contained within. A nation can export products that are produced from resources that are abundantly available within the country and import products that are produced with resources that are scarcely available within the country. Virtuous trades would entail a water-scarce country importing products that require a lot of water in their production (water-intensive products) and exporting products or services that require less water (water-extensive products).
The assessment of rationality in the virtual water import for a given nation, compared to what is nationally consumed, could thus give an approximate idea of the country's reliance and dependency on external resources from the food and the water resources point of view.
In this paper, a descriptive approach to the understanding of the degree of dependency of a nation from overseas water resources is first proposed, and indices of water trade virtuosity, as opposed to inefficiency, are devised, establishing virtual water balances between a country and the rest of the world, in terms of exchanges of water-related commodities.
The immediate goal of this approach is to highlight incongruent terms in the virtual water balances, at a nation's scale by the viewpoint of single products. Italy has been considered as the first case study.
Indices are based on the concepts of self-sufficiency and relative export, computed systematically on all products and on all the available years using the FAOSTAT Database.
Specific products, which are here referred to as "swap products", are identified as those that lead to inefficiencies in the virtual water balance due to their contemporaneously high import and export ratios. The inefficiencies due to the exchanges of the same products between two nations are calculated in terms of volumes of virtual water. Analysis of time series of the self-sufficiency and relative export can demonstrate the effects of state sustain programs and/or and market tendencies at the national level, and can give significant information to inform eater-related policies at the international level.

Ain Al Faras (Ghasouf) spring: the heart of the Old city of Ghadames western Libya: case study of rehabilitation of hydrological-population system

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The city of Ghadames is located in western Libya. It was established on the basis of Ain Al Faras water source (Ghasouf by local dialect) which is an artesian spring fed by a Cretaceous Aquifer known as Nalut Aquifer (350m deep). Water raised up to an elevation above ground surface high enough to make the water flow by gravity to irrigate the city farms around the city. This marvelous irrigation system was constructed in the form of covered channels that flow under the old city of Ghadames. This system and the unique architect of the old city made Ghadames a real pearl of the desert. This interaction between hydrology and society was in harmony for thousands of years and worked fine since the establishment of the city (some historians go back in that to 5000 years BP). In late 80's of the last century, the spring start to draw down, and the water declined to a level below which it can flow freely into the irrigation channels. Accordingly the irrigation of the farms of the old city became impossible. The agricultural economy of the city was interrupted and attempts to get the water back to its previous level were failed. The natives thought that the cause of the draw down is a seepage in reclaimed cavities that assumed to be existed somewhere in the spring sources. Rock fills using some boulders and gravel for this aim was tried but without any positive result and the water never come back to its original level. Few meters from the spring there exist an artesian well that fed from Kikla Aquifer (900m deep). Being a Geoscientist and a citizen of Ghadames, I have been consulted by the authority of rehabilitation of the old town of Ghadames to propose a solution to the problem. I proposed at that time to cement and fill by a concrete the old spring and consider it as concrete reservoir tank which should be fed from the nearby artesian well by a hidden water pipe, with discharge rate that could be controlled to be exactly the same flow rate of the Ain Al Faras spring which was 33 l/s .Unfortunately this consultancy was not implemented immediately as other attempts were carried out to raise the water level up, but all of them failed. After hard campaign and encouragement, the policy makers in Ghadames convinced and they go ahead with the mentioned proposal, and the irrigation system had been re-established and old city of Ghadames restored its original and glorious beauty. At the end of the day ever one was happy.