

ABSTRACTS OF VIEWRA INTERNATIONAL SYMPOSIUM
WATER ENGINEERING AND MANAGEMENT IN A CHANGING ENVIRONMENT



European Water Resources
Association



University of Catania
Department of Civil and
Environmental



Italian Hydrotechnical
Association



Abstracts of VI EWRA International Symposium

WATER ENGINEERING AND MANAGEMENT IN A CHANGING ENVIRONMENT

Edited by A. Cancelliere and G. Rossi

Catania, Italy - June 29th — July 2nd, 2011

QUADERNI CSEI Catania
III SERIE VOL. 6

ISSN 2038-5854



Pubblicazione finanziata dalla
Regione Siciliana
Assessorato dei Beni Culturali e dell'Identità Siciliana
Dipartimento dei Beni Culturali e dell'Identità Siciliana

Quaderni CSEI CATANIA
III SERIE VOL. 6

Abstracts of VI EWRA International Symposium
WATER ENGINEERING AND MANAGEMENT IN A CHANGING ENVIRONMENT
ISSN: 2038-5854

Finito di stampare nel mese di giugno 2011
presso **Arti Grafiche Ciminiera** di Catania

Il presente volume è stato redatto dal CSEI Catania
nell'ambito di un'attività finanziata dalla Regione Siciliana - Assessorato dei Beni Culturali e
dell'Identità Siciliana - Dipartimento dei Beni Culturali e dell'Identità Siciliana

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EWRA International Symposium <6.; Catania; 2011>

Abstracts of 6. EWRA International Symposium: Water engineering and management in a changing environment: Catania, Italy, June 29th -July 2nd, 2011 / edited by A. Cancelliere and G. Rossi. - Catania : CSEI Catania, 2011.

(Quaderni / CSEI. Ser. 3.; 6)

1. Acque – Utilizzazione - Atti di Congressi.

I. Cancelliere, Antonino. II. Rossi, Giuseppe.

333.9113 CDD-22 SBN Pal0234831

CIP - Biblioteca centrale della Regione siciliana "Alberto Bombace"

VI EWRA International Symposium

WATER ENGINEERING AND MANAGEMENT IN A CHANGING ENVIRONMENT

Monastero dei Benedettini, Catania, Italy - June 29th - July 2nd, 2011

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PROLEGOMENA

The global endorsement of the concept of Integrated Water Resources Management (IWRM) is mainly concerned with the achievement of global water security. This practically means that the desired outcome of IWRM is to secure that all people have access to sufficient safe water for their needs at affordable cost, provided that at the same time the natural environment and its resources are protected and enhanced.

In order to accomplish this goal of global water security, formidable challenges are ahead, as water demands are increasing and water availability and water quality deteriorates. Given the complexity of water systems and their interactions with the economic, social, climatic and environmental systems, the scientific community is in front of huge tasks in an attempt to achieve sustainability of water systems and prosperity of the society in a fast changing world.

The European Water Resources Association, with its systematic programme of activities (journals, symposia, conferences, publications), aims at assisting the scientific community to formulate holistic and adaptive procedures for enhancing the management of water resources. In these efforts the final outcome is to achieve better water resources governance through policy formulation, capacity building, stakeholders' participation and international cooperation.

Recently the EU directives on the water policy indicated a paradigm shift in water resources management giving emphasis to sustainability of ecosystems, paving the way from technocratic to collaborative management.

In this context the 6th International Symposium of EWRA in Catania is mainly dedicated to the assessment of the EU Water Directives implementation in the member states and other countries outside EU. Technological and management advances are also presented in an attempt to improve existing methodologies for more effective water resources governance.

From the invited speeches, the original contributions and the discussions of about 150 distinguished authors and participants, significant results are expected to be derived. Also, a large number of selected contributions will be further processed for publication in the journals of EWRA in order to achieve a greater impact on the scientific and professional audiences.

For the excellent organisation of the 6th International Symposium of EWRA I have to sincerely thank the Organising Committee for their perfect work as well as the Scientific Committee and the EWRA Secretariat for contributing to the success of the Symposium. I would also like to thank the University of Catania for hosting this event and all the participants and contributors.

I wish to all the participants, fruitful discussions and enjoyable stay in Sicily. Finally, we renew our appointment to the International Conference of EWRA in Porto (Portugal) in two years from now.

G. Tsakiris
President of the European Water Resources Association

PREFACE

Water is essential for human, animal and plant life and is also a key driver of economic and social development. In July 2010, the General Assembly of United Nations has recognized access to safe and clean drinking water and sanitation as a human right. Protection of water resources and promotion of a sustainable water use are therefore main cornerstones of environmental policies worldwide. Although important progresses on water management, infrastructure, technologies and legislation have been made over the past decades in many developed and emerging countries, further efforts are still required to properly face major concerns such as floods and droughts, water scarcity, water pollution, as well as access to safe sanitation, which can be further worsened by climate change, population growth and urbanization.

The VI International EWRA Symposium “Water Engineering and Management in a Changing Environment”, locally organized in Catania by the Department of Civil and Environmental Engineering of the University of Catania, and co-organized with the Italian Hydrotechnical Association, with the collaboration of CSEI Catania (Centre for Applied Economics in Engineering), aims at providing a forum of discussion about the aforementioned topics among scientists and practitioners. In particular, during the symposium, the following thematic areas will be covered both in oral and poster sessions, as well as in five invited lectures:

- Drought characterization, monitoring, forecasting
- Modelling of natural and dam-break floods and extreme events
- Water Framework Directives implementation
- Water quality management
- Assessment of climate change
- Water resources management
- Irrigation
- Innovations in water supply and distribution systems

One of the expected outcomes of the Symposium is to link scientific research with water management issues in Europe, also through the organization of specific sessions, such as the one devoted to Water Framework Directives implementation, in line with EWRA objective to contribute to improve water resources system planning and operation in Europe.

The symposium has attracted the attention of scientists and experts from several European and non European countries, and in particular from North Africa, Near and Middle East among others. The call for papers has been followed by more than 150 abstracts submitted, covering different themes, and their selection has been carried out on the basis of a review process by the members of the scientific committee, to whom goes our gratitude. This book includes the selected abstracts presented at the conference, as well as the full length papers, collected in the annexed CD.

The editors would like to thank Prof. George Tsakiris for proposing Catania as the venue for the VI EWRA Symposium, the Italian Hydrotechnical Association for providing a wider dissemination of the event and CSEI for the logistic support. Finally the editors would like to express their deepest gratitude to Brunella Bonaccorso, Antonio Castano, Leila Castiglione and David Peres for their invaluable help for the organization of the symposium as well as for the publication of this book.

June 2011

The editors

INVITED LECTURES

WATER QUALITY MODELS FOR RIVER AND STREAM. STATE OF THE ART AND FUTURE PERSPECTIVES

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The progress in computer technology has favoured the development of the mathematical models, which are currently applied for the water quality problems in rivers and streams. To work correctly, the models require proper data and the knowledge of the velocity field. The development of the model starts from the fundamental differential equation of pollution transport, which is made up by several terms, principally by those simulating the advection and diffusion transport that make up the fickian approach. The fundamental equation can be integrated analytically to simulate simple realities and analysing the pollution level in a river subject to an external discharge of pollutants. The progress in numerical calculus has promoted the development of numerical procedures, which have been intensively applied to the fundamental equation of pollutant transport. The finite differences method (FDM) and the finite elements method (FEM) are the most promising tools, now frequently and successfully working. More recently the finite volume method (FVM) has been proposed.

The majority of practical cases consider the one-dimension approach, which, in large rivers, gives a satisfactory answer, but a better simulation of the real behaviour requests a multi-dimension approach, or, at least, a two-dimension approach.

An important and frequent case of river contamination is due to the discharge of hot water, an occurrence that gives rise to the thermal pollution. In large rivers a considerable heat can be exchanged with the air, the river bottom, the embankments and the sediments.

The complexity of water problems in a river requires more tools to focus on the role that clean water plays in the management and protection of a complex resources system. An acceptable pollutant concentration in a river is the consequence of interventions involving all the contaminating sources, having economical, social and political impact. To analyse such a complex aspect the optimisation models are a powerful tool in the hand of the people who have responsibility to intervene and to decide how to utilise the available resources. In the general management of a river, the complexity of the problem cannot be fully analysed by means of a single model. Several models are therefore necessary, one another interacting, in order to better appreciate the various aspects of the reality under examination. After the model has been constructed and run for the first times, it is necessary to test it with the whole set of available data, proceeding to the calibration.

Even though the model has been successfully calibrated and validated, a doubt still remains about its capability of giving reliable results when it is currently applied to the largest set of practical cases. Any application is conditioned by the value of some terms that normally cannot be measured correctly or are assumed a priory, starting from exogenous considerations. Such a question leads to the sensitivity analysis, by means of which the model is run repeatedly after assuming several values for the parameters that make up its internal structure. While the sensitivity analysis is based on the assumption of arbitrary values for some model components, the uncertainty analysis takes into account that all the components can be characterised by uncertain values and have an impact on the final result.

In the abundant literature of water quality models the fickian approach still remains the scientific background for the simulation of pollution transport in rivers and channels. Innovative researches have proposed the non-fickian models, which could better take into account the particle motion, avoiding the complexities that characterise the application of the advection-dispersion algorithms. Several mechanisms, based on innovative forms of reality interpretation, are now examined and tentatively applied to specific cases of river pollution, in order to overcome the lack of confidence characterising the models application, also in view of making them a reliable tool, easy to apply to the ordinary situation of water quality control in rivers, natural streams and artificial channels.

INTEGRATING HYDROLOGICAL AND GLOBAL CIRCULATION MODELS FOR STUDYING CLIMATE CHANGE IMPACTS AT THE RIVER CATCHMENT SCALE

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Impacts from climate change are expected to be of great concern in arid or semi-arid climates like the Mediterranean, where data over the last few decades show a decreasing trend in levels of precipitation. If this trend persists, water allocation for different competing water demands, such as water supply, agricultural irrigation and hydropower production will be seriously affected.

This presentation is based on the results of previous investigations on the impact of climate change on river catchment hydrology, which integrated a physically based distributed hydrological model and a global circulation climate change model. The output of CLM (Climate Local Model) developed at the Max Planck Institute for Meteorology, Germany and derived from the coupled atmosphere-ocean global climate model ECHAM5/MPIOM, was used. CLM simulation results at 6 hourly intervals were produced for Europe, using a spatial grid resolution of 20x20 km. In order to take into account local conditions at the catchment scale, such as a basin's orography, geology and land use, CLM provided boundary conditions of a distributed hydrological model. Temperature and precipitation distributions obtained from this climate model were introduced as input data to the spatially distributed hydrological model MODSUR-NEIGE (MODélisation des transferts de SURface en présence de NEIGE, in French). MODSUR-NEIGE was developed at the Ecole Nationale Supérieure des Mines de Paris for simulating rainfall-runoff relationships at the river catchment scale.

The methodology is illustrated by the investigation of water resources management under climate change in the Mesta/Nestos river basin. This basin is shared between Bulgaria, where the upstream northern part (Mesta) is located, and Greece, with the downstream southern part (Nestos). The river ends in the Aegean Sea by expanding into the Nestos delta, which has a vast expanse of irrigated fields. The effect on the water flow in the delta region of different climate change scenarios and possible changes in land use in the mountainous area of the basin was analysed. Sustainability of alternative projects ensuring hydropower and irrigation needs under future climatic conditions were also investigated.

ACKNOWLEDGMENT: The work presented in this paper was supported by the UNESCO-HELP worldwide project.

CHALLENGES IN WATER RESOURCES MANAGEMENT WHEN SEARCHING FOR A SUSTAINABLE ADAPTATION TO CLIMATE CHANGE FOCUSING AGRICULTURE

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Climate change is well recognized fact but an insufficiently recognized process. It is well known that anthropogenic activities are emitting gases whose concentrations modify the greenhouse effect and therefore impact the climate system. The so called greenhouse gases (GHG) produce an increase of the energy absorbed by the atmosphere in a process of positive radiative forcing. The impacts in the climate system are now evidenced in terms of changes in temperature, which is generally increasing, or relative to forcing small scale or short term phenomena such as hurricanes and weather storms, as well as changes in the precipitation regime, with variable increase or decrease of rainfall. Despite climate change is assumed certain, the uncertainty of predictions is very high. Water resources availability are expected to change in relation to precipitation, both in terms of quantities, e.g., increased dry spells in many regions, and of intensity, thus producing more frequent and larger floods.

Expected impacts of climate change on agriculture, both rainfed and irrigated, relates with the vulnerability of agriculture to climate change. Temperature increases influence crops demand for water, i.e., crop evapotranspiration, and impact crops that have cold requirements, including chilling needs for their flowering and yielding processes. In addition these changes in temperature favour crop pests and diseases. The impacts of diminished precipitation are analyzed in relation to the predicted increase of the climatic demand for water due to the foreseen increase of the reference evapotranspiration and higher irrigation requirements. Particularly, the impacts relative to dry spells and, less likely, droughts are also analysed. Finally, predictable economic and social impacts are discussed together with required adaptation and mitigation measures which need particular research efforts, both in terms of water management and crop husbandry.

WFD RIVER BASIN MANAGEMENT PLANNING IN THE CONTEXT OF CLIMATE CHANGE ADAPTATION - POLICY AND RESEARCH TRENDS

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Discussions are on-going at EU level on how Member States should incorporate climate change considerations into the implementation of EU water policy. This issue is all the more a highlight with the development of the first river basin management planning under the Water Framework Directive (WFD), which operationally started in 2010. The integration of knowledge about possible climate change impacts on water policy implementation concerns various aspects such as risk characterisation, monitoring, design and implementation of action programmes and evaluation of the "good status" objective's achievements (in 2015). These questions have been and are currently discussed with a wide range of experts and stakeholders of the WFD Common Implementation Strategy (CIS) and the first part of this presentation will summarise key recommendations expressed in this framework. The second part describes research trends supporting policy developments, discussing in particular how scientific findings and recommendations on e.g. adaptation measures could be best taken on board by policy-makers and water managers within the forthcoming years. Examples of research projects funded by the European Commission will be used to illustrate this purpose, and perspectives for strengthening links among the scientific and policy-making communities in this area will be highlighted.

BREAKING THE HYDRO-ILLOGICAL CYCLE: PROGRESS OR STATUS QUO FOR DROUGHT MANAGEMENT?

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Drought is a normal, recurring feature of climate; it occurs in virtually all climatic regimes. It is the consequence of a natural reduction in the amount of precipitation received over an extended period of time, usually a season or more in length, although other climatic factors such as high temperatures, high winds, and low relative humidity are often associated with it in many regions of the world and can significantly aggravate the severity of the event. Projected changes in climate state and variability, especially the occurrence of extreme climatic events such as drought, are of particular concern today because of their potential impact on food security in many nations, especially those where water supplies are already scarce.

Many people consider drought to be largely a natural or physical event. In reality, drought, like other natural hazards, has both a natural and a social component. Drought risk is best defined as a combination of these two components, exposure and vulnerability. Exposure to drought can be characterized by the historical climatology of a region, i.e., the frequency, severity, and duration of previous drought episodes, including an analysis of trends or changes in climate state and/or its variability. With the projected increase in drought occurrence for many regions, there is concern about whether a region's drought climatology is indicative of the future for water management and planning purposes.

Impacts are a key indicator of vulnerability. Therefore, conducting a vulnerability assessment through an analysis of the historical impacts associated with previous drought episodes represents an excellent of societal resilience. These assessments when completed for regions, communities, population groups, and others will provide critical information on whom and what is at risk and why. These assessments, when integrated into the drought mitigation planning process, can enhance the outcome of the process by identifying and prioritizing specific areas where progress can be made in minimizing risk. Since societies are constantly changing, vulnerabilities are also changing. Thus, each drought occurrence will result in differing impacts resulting from these changing vulnerabilities. A key question for drought mitigation and preparedness planning is determining how or if societal changes are increasing or decreasing societal vulnerability.

One of the trends associated with recent drought events has been the growing complexity of drought impacts. In the past, drought impacts have been linked most closely to the agricultural sector, reducing the capacity of many nations to be food secure. Today, the impacts associated with drought are more far-reaching, touching many other sectors including energy, transportation, recreating and tourism, urban water supply, and the resilience of ecosystems. These impacts are often an indicator of unsustainable land and water management practices. It has been demonstrated that drought assistance or relief provided by governments and donors encourages land managers and others to continue these practices. It is precisely these existing resource management practices that have often increased societal vulnerability to drought (i.e., exacerbated

drought impacts). This approach to drought management may result in decreased resilience of individuals and communities and an increased dependence on government. One of the principal goals of drought policies and preparedness plans is to move societies away from the traditional approach of crisis management, which is reactive in nature, to a more pro-active, risk management approach. The goal of risk management is to promote the adoption of preventative or risk reducing measures and strategies that will mitigate the impacts of future drought events, thus reducing societal vulnerability. This paradigm shift emphasizes preparedness, mitigation, and improved early warning systems (EWS) over emergency response and assistance measures. Many governments and others now understand the fallacy of crisis management and are striving to learn how to employ proper risk management techniques to reduce societal vulnerability to drought and therefore lessen the impacts associated with future drought events.

There has been considerable progress towards improved drought mitigation and preparedness in the United States over the past 25 years. Although the United States has fallen short of the adoption of a national drought policy, there has been a dramatic increase in the number of states with drought plans. The formation of the National Drought Mitigation Center in 1995, passage of the National Drought Policy Act of 1998 by the U.S. Congress, the recommendations of the National Drought Policy Commission in 2000, and passage of the National Integrated Drought Information System Act in 2006 have all contributed to this progress and are signs of a changing paradigm for drought mitigation. However, even with this increased attention to improved drought early warning, mitigation, and preparedness, much remains to be done.

This presentation will chronicle the progress that has been made in the United States over the past 25 years to move the nation away from the traditional crisis management approach to a more risk-based management approach for drought. It will also provide a roadmap for future drought mitigation and policy development that must take greater advantage of the windows of opportunity associated with future drought episodes and the impacts of climate change on water supplies and other natural resources. Recent international initiatives in integrated drought management will also be highlighted. Hopefully, the lessons learned in the United States will be transferable to other nations striving to improve its management of drought and other extreme climatic events.

1. WATER FRAMEWORK DIRECTIVES IMPLEMENTATION

THE APPLICATION OF DPSIR (DRIVING-PRESSURE-IMPACT-STATE-RESPONSE) APPROACH ON SURFACE WATER BODIES

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Between the objectives of the Water Framework Directive (WFD; 2000/60/EC) are the establishment of a framework for the protection of water bodies and the achievement of “good ecological quality status” for all water bodies. This paper presents the methodological approach of DPSIR (Driving-Pressure-Impact-State-Response) as it is applied in Pamvotis Lake (NW Greece). The approach is based on determining pressures and impacts, on assessing the ecological status of the water body as well as on defining the response actions for reducing the impacts in the surface water body.

Based on DPSIR approach, it is concluded that the main driving forces which lead to pressures in the study area are agricultural activities, alteration of hydrological regime, contamination from the point sources, changes in the land use and fish stocking. The ecological status of the studied water body was assessed by analyzing data series of physical, chemical and biological parameters that are available dating back to the late 80s. The range of selected water quality parameters for Pamvotis Lake are: pH 6.91-8.61, total phosphorus (TP) 30-361 $\mu\text{g L}^{-1}$ and total nitrogen (TN) 0.13-1.94 mg L^{-1} ; while in terms of the above parameters the water quality status could be characterized as good, high to bad and high to poor, respectively with the overall status shifting to poor conditions. Concerning the biological indices, suggested by the WFD, the low species diversity, the shift to algal dominated conditions, the disappearance of macrophytes and the presence of invasive species suggest a poor ecological status. The impacts on the water body in terms of ecological and chemical status are evaluated. Among others, the response actions needed should include reduction of the application of fertilizers and chemicals in the cultivated land, removal of the point-pollution sources from the catchment, appropriate land use management and biomanipulation.

THE ECONOMIC ANALYSIS IN THE IMPLEMENTATION OF THE WATER FRAMEWORK DIRECTIVE IN SPAIN

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One of the most innovative elements of the Water Framework Directive (WFD) is the important role that economic analysis is assigned in achieving its environmental objectives. In Spain, like in other European countries, a great effort has been put forth by river basin agencies and other institutions involved in water planning and management to diagnose the current state of water resources and to implement the economic tools and principles required by the Directive. However, there have been a number of shortcomings in the way the economic analysis has been designed and applied during this process (as well as a significant delay in meeting the WFD's deadlines). The objective of this paper is to critically review the implementation of the economics of the WFD in Spain, and to come up with a number of general guidelines on how to deal with the problems that have been encountered. Our review shows that shortcomings have occurred in several stages of the implementation process. For instance, the characterisation of water uses that has been made is mostly descriptive and lacks prospective analysis. In the analysis of the potential for costs recovery of water services it has been incorrectly assumed that the financial costs of water provision are completely covered by the payment of legal tariffs. A problem in the selection of the measures has been that environmental and resource costs have not been included. The main reason for these problems is that water policy makers and water managers were unprepared for and inexperienced with economic analysis. To overcome the shortcomings and improve future revisions of the River Basin Management Plans, links between water planners and the academic world should be strengthened to take advantage of the long experience of the latter with the tools and principles of economic analysis.

ASSESSMENT OF THE TYPOLOGY AND THE TROPHIC STATUS OF TWO MEDITERRANEAN LAKE ECOSYSTEMS: APPLICATION OF THE WFD

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The European Water Framework Directive 2000/60/EC, requires the determination of ecological status in European waterbodies, setting out, as environmental objective, that minimum good ecological quality should be obtained by 2015. To reach this objective, water bodies should be typified and classified taking into account all pressures and impacts upon them. Concerning the classification of the lake quality status, WFD suggests the allocation of a lake according to physico-chemical elements supporting the biological elements. Thus a series of relevant parameters are included most of them ascribing their trophic status since lake eutrophication has been a major problem for decades.

The objective of this study is the implementation of the WFD in two Mediterranean lakes (Lake Kastoria & Lake Ziros) through the assessment of their typology and trophic status. Lake types were identified based on characteristics specified in Annex II of the WFD, while water quality data were used in order to evaluate the trophic status.

Both water bodies present a high degree of variation in their trophic state both in time and space. Applying both OECD and Carlson trophic indexes, Lake Kastoria is classified as eutrophic lake while Lake Ziros is a mesotrophic ecosystem with clear signals of eutrophication. Both ecosystems are considered “at risk” of not fulfilling the WFD environmental objectives due to the existence of certain anthropogenic pressures.

WFD IMPLEMENTATION ON TRANSBOUNDARY RIVER BASINS. THE IBERIAN PENINSULA CASE

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European shared river basin districts represent more than 60% of the whole territory. In accordance with that, the Water Framework Directive (WFD) strongly promotes the cooperation between the Member States so that 'good status' for Europe's surface and groundwater is achieved within a 15-year period on all rivers, including transboundary ones. The adoption of the first River Basin Management Plans (RBMPs), due to be completed in 2009, should be the first proven exercise of that cooperation, as that is an obvious important milestone for that European Union global water frame policy. The introduction of pricing policies and the implementation of the RBMP's programme of measures are two other important milestones to be taken into due account up to 2015.

The report on the first stage of the WFD implementation, due in 2007, aimed at evaluating the transposition of the WFD into national law, the definition of River Basin Districts (RBDs) and Competent Authorities, and the RBDs characterization. Portugal achieved a global reporting performance of 85% and Spain, because of some delay in complying with requirements on RBD's delimitation, about 50%. The report pointed out that, despite both countries effort on promoting joint work to attend WFD goals, a need for a more dynamic and coordinated implementation process was needed.

In fact, Portugal and Spain reinforced and reframed the bilateral cooperation on shared rivers water resources in the last decade, based on the so called Albufeira Convention, approved in 1998, and under the WFD umbrella. The two countries have chosen (at least for the first cycle of WFD implementation) a basin-based water management and a decision-making process framed on coordinated River (sub-) Basin Management Plans, one per country. Also, both countries decided that the Commission for Convention Appliance and Development shall be also the driving force for a common and co-operative WFD Iberian implementation process.

Nevertheless, although the WFD has been an important trigger of reform of the water policy and institutions in both Iberian countries, Portugal and Spain are currently (February 2011) among the EU Member States with major delays in the adoption of the RBMP's.

The internal and common effort of both countries to WFD implementation will be described and compared. It will be shown how a more dynamic and common effort is needed to achieve the declared goal of a near future integrated management of the shared river basins.

COST-EFFECTIVENESS ANALYSIS IN THE IMPLEMENTATION OF THE WATER FRAMEWORK DIRECTIVE: APPROACHES, EXPERIENCES AND CHALLENGES

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One of the most innovative aspects of the European Water Framework Directive (WFD) is the incorporation of economic principles and tools into water management and water policy in Europe. Amongst the various economic analyses stated or implied in the WFD, cost-effectiveness analysis (CEA) of mitigation measures needed to achieve the 'good ecological status' (GES) of all waters in Europe has been given pivotal place. This is aimed at establishing the least costly combination of measures to be included in the so-called Programme of Measures (PoMs), as a pre-requisite for the elaboration of the river basin management plans (that were due by the end of 2009 but that have been delayed in a number of countries). The literature on the methodological approaches to CEA in the specific context of the WFD is still very scarce. In this paper, first, we review and discuss the existing CEA methods as applied to the WFD measures and evaluate their appropriateness to the specific circumstances of some selected European countries (including the UK, Norway, Italy, Spain and Greece). Second, we assess the applications of WFD-related CEA studies, progresses made so far, and the limitations in the process of formulating water management plans. The overall aim is to assess the CEA approaches pursued, the achievements made, and the major challenges to-date in the design and implementation of WFD-related CEA studies to guiding water management and water-related policy decisions in Europe. Our results show that, despite having been adopted in national guidelines of most member countries, CEA has been applied with different levels of depth and accuracy (with the UK and Norway as forerunners and Italy and Greece relatively behind, with other countries like Spain in between). This is due not only to the differences in the speed of the implementation of the WFD itself, but also due to differences in a pre-WFD CEA culture in the area of water management and policy among the Member States. Some of the major challenges that remain for the foreseeable future include: (i) availability of data (i.e. data on both the effectiveness and costs of various measures); (ii) under or over estimations that may arise due to, for instance, externalities, co-benefits, and double counting problems; (iii) differences in technical capacities in terms of human resource needed to carry out the CEA; and iv) the challenges posed by climate changes.

DISPROPORTIONATE COSTS IN THE WATER FRAMEWORK DIRECTIVE: THE CASE OF A MEDITERRANEAN RIVER BASIN

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Water management is becoming increasingly important as water demand grow, diversify, and include more complex environmental concerns. Therefore, the European Commission adopted the Water Framework Directive (WFD) which aims at achieving good ecological status of all Community water bodies by 2015. The use of economical tools and principles for the achievement of the WFD objectives is one of its most novel aspects. Member States can justify an exemption (time or stringency) when the disproportionate costs are identified. From an economic perspective, Cost-Benefit Analysis (CBA) is the obvious tool to assess disproportionate costs. This tool requires that all costs and benefits can be assessed and estimated in an economic way. The aim of this research is to examine the issue of disproportionate costs of WFD implementation by reference to a Mediterranean River Basin. We used the CBA tool as the decision criterion. To predict the cost of the measures, we used various cost functions to estimate the costs, including those of investment, operation and maintenance. The quantification of the environmental benefits derived from improving the water quality is much more complex because they are not determined by the market. Therefore, using distance function approach we calculate the shadow prices of pollutants removed during wastewater treatment which represents a proxy to environmental benefits. In this way we assess whether the achievement of good status could be postponed based on the criterion of disproportionate costs. For the empirical application carried out, our results show that both the implementation of basic and supplementary measures to achieve good ecological status is economically viable. The net profit that is gained as a result of improving water quality in the river clearly shows the exemption of environmental objectives based on the issue of disproportionate costs cannot be justified. We would like to emphasize that this paper used the CBA approach, due to the ambiguity with which the concept of disproportionate cost is defined in the WFD. In this way, it is illustrated that the quantification of the environmental benefits plays a crucial role in the ultimate goal of WFD. Finally, it is verify that for the WFD objectives to be implemented successfully, a greater integration of economic and technical aspects with participatory and decision-making processes must be accomplished.

ROLE OF EUROPEAN COOPERATION PROJECTS IN THE IMPLEMENTATION OF THE EU WATER RELATED DIRECTIVES

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The Water Framework Directive and the Floods Directive create frameworks within which European Union Member States can operate and require governments to take a new holistic approach to manage their waters and oblige Member States and accession countries to use a river basin approach to manage water resources. Where a river basin includes more than one Member State or crosses from the EU to neighbouring countries, the water directives call for the creation of an international river basin district. The European Territorial Cooperation is one of the key goals of European regional policy for 2007-2013 and it supports cross-border, transnational and interregional cooperation programmes and projects focusing on innovative common approaches as required in the water directives.

In the context of South East Europe territorial cooperation programme, ISPRA is involved in the Danube Floodrisk "Stakeholder-oriented flood risk assessment for the Danube floodplains" project, a European trans-national project promoting the cooperation between spatial planning and water protection establishments in the Danube river basin. The project emphasizes the need to learn how to cope with floods and manage risk through a basin approach, with the participation of governments, municipalities and stakeholders.

The partnership of this project includes many organizations from the states along the Danube River that are responsible for flood risk management. For the first time, all Danube countries cooperate in concrete data management and harmonisation activities. Moreover, a joint trans-boundary implementation of flood risk assessment and mapping actions are developed in the project.

The goal is to link scientific progress in harmonization of approaches and data with practically oriented stakeholder and end user involvement. Vertical and horizontal cooperation are the two pillars of the project. The main expected results is a Danube atlas with flood hazard maps and flood risk maps and documentation of 3 pilot project applications in three Member States (Austria, Bulgaria, Romania).

TOWARDS GUIDELINES FOR DROUGHT PREPAREDNESS AND MITIGATION PLANNING WITHIN EU WATER POLICY

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The Water Framework Directive 2000/60/CE deals only marginally with the problems of drought management, either in terms of preparedness or mitigation. In order to overcome such weakness, a group of experts on Water Scarcity and Drought, established in 2003 among the Mediterranean countries of Europe, proposed a specific “Drought Management Plan” (DMP) to be drafted as an annex to the “River Basin Management Plan” of each hydrographic districts, in order to develop suitable strategies to cope with drought. . Despite the group provided general orientations for developing the DMP, yet specific guidelines are needed in order to draft the DMP as a powerful tool to prevent and reduce the negative impacts of drought on economy, society and environment of each European country.

Different European countries exhibit a great deal of variability in the features of drought events and of water supply systems, as well as in the legislative and institutional framework, particularly between North Europe and Mediterranean regions. Thus common goals, principles and strategies of drought management for the Europe as a whole should be followed by criteria specifically oriented to face the main critical conditions which, in the different regions, determine the limited reliability of systems to severe drought events and/or reduce the effectiveness of the planned measures.

In the paper, a review of the current drought management policy in Europe is presented and an analysis of the criteria suggested by the Water Scarcity and Drought Group for the DMP, including those devoted to allow the temporary relaxation of water quality requirements in water bodies during the prolonged droughts according to the WFD, are discussed. Then specific criteria are presented, oriented: i) to develop drought monitoring systems, which represent key tools for adopting a pro-active approach towards drought risk management, ii) to identify and implement adequate drought preparedness and mitigation measures able to avoid the most severe water shortages in supply systems and harmful impacts on people, economic activities and environment, and iii) to define the emergency actions to be implemented in the case of a drought declared as a natural disaster. Such criteria are drawn from scientific researches and management experiences carried out in Mediterranean countries in the last decade.

WATER COSTS ALLOCATION USING A COOPERATIVE GAME THEORY APPROACH

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The interdisciplinary nature of the planning and management of complex water resources systems requires methods that integrate the technical, economic, environmental, social and legal aspects into a comprehensive framework that allows the development of efficient and sustainable water management strategies. The Water Framework Directive 2000/60/EC (WFD) recommend that, in a river basin-scale, the pricing politics have to take into account the principle of recovery of costs and the economic sustainability of the water uses. Nevertheless the cost allocation methods currently adopted in Italy do not take into account the user's willingness to pay and, frequently, they do not permit the total costs covering. So there is the necessity of a change, overall in the Mediterranean Region, defining water rates.

In this article we present a methodology to allocate water service cost in a water resource system among different users that try to fulfil the WFD requirements. The methodology is based on the Cooperative Game Theory (CGT) techniques and on the optimization model WARGI, developed by the University of Cagliari. The CGT provides the necessary instruments to analyze those situations in which is fundamental to search a sharing mechanism that should be efficient, fair and it has to provide the appropriate incentives among the involved parts. Therefore, the cost allocation problem in a water system has been valued as a game in which it is necessary to determine the right payoff to be assigned to the different players, which represent in our case the water users. To apply the CGT principles in a water resources system is necessary the use of the optimization model WARGI.

The game solutions set is represented by the so-called "core". It represents the area of the admissible cost allocation values and, through this, it is possible to supply the boundaries values of cost for every player. Inside the core there are all the allocations which satisfy the principles of equity, fairness, justice, efficiency and which guarantee the costs recovery. The core of a cooperative game can represent a useful instrument to define or to adjust water rates. Moreover it can be used as a valid support in the management of the water resources for the achievement of the economic analysis required by the WFD.

The methodology was applied to a real water system in Sardinia (Italy) In this specific case, the OMR costs in the system were examined in order to share them among the water users.

HOW TO IDENTIFY RISK IN INTEGRATED WATER RESOURCES MANAGEMENT?

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The EU Water Framework Directive 2000/60/EC (WFD) introduces new and different approaches towards water management, both for the members who recently joined the EU as well as for the older EU-member states. It is noted that social participation is essential for better water management. However, it has not been easy to ensure active social participation in water management processes. Sometimes different interest groups have attempted to capture the water management processes to promote their own agenda's. Integrated Water Resources Management (IWRM) is a participatory planning and implementation process, based on sound science, that brings stakeholders together to determine how to meet society's long-term needs for water and coastal resources while maintaining essential ecological services and economic benefits

Possible failures in water management are mainly caused by inappropriate administration and water resources management. They are also connected with credibility of actual status diagnosis and uncertainty of forecasting changes. Proper assessment of size and spatial distribution of risk in water management, at the present time and in the future, has an essential significance in decisions concerning elimination or limitation of risk reasons.

The objective of this publication is to present the method based on Multidimensional Comparison Analysis enabling quantification of risk in integrated water resources management. It was assumed that proposed method should allow to:

create the hierarchy of problems from the field of water management in particular area;
identification of factors in the measures used in determination of risk, responsible for its size;
spatial and quantitative diversification of activities limiting the influence of particular factors for the risk size.

The accepted objectives may be achieved only with actual participation of authorities and local communities. As a consequence, fundamental for risk assessment is evaluation of the range of this participation, its form and both technical and matter-of-fact preparation. It is also necessary for this analysis to include natural and social-economical conditions of the locality as well as issues connected with spatial management.

2. ASSESSMENT OF CLIMATE CHANGE

EXTREME RAINFALL STUDY AND CLIMATIC CHANGE OF REDEYEF REGION IN SOUTHERN TUNISIA

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September 2009, Redeyef region has submitted to extremely stormy downpour weather (90 mm in 24 hours) and caused a flood of great importance. Therefore, in the present study, we tried to investigate “PMP” and fix the upper limit of likely maximum rain and also to settle the general trend of the evolution of rainfall in this region during the observation period. The PMP is generally used to evaluate runoff and consequently the probable maximum flow (PMF). It is useful for sizing hydraulic structures on rivers (spillway, etc.). The PMP is the highest precipitation in a given period. In this context, using the maximum rainfall observed (24 hours) at Redeyef station over a long period as 88 years, we evaluated the probable maximum rainfall. Adjusted at empirical frequency, the lognormal law (three parameters) is satisfactory. Over the period of observation; the maximum registered rainfall in 24 hours is 90 mm. It will have a return period of 154 years. This value is widely greater than maximum average rains. In 24 hours interval time, the PMP is estimated; using the frequency factor K_m (Hershifield 1961). The PMP will be approximately 250 mm / 24 h. Estimations of PMP are useful even if they remain dependent on the quantity and quality of observed data. Furthermore, we noticed that the rainfall variability is very important. The most extreme and violent rainfall are more frequent at the end of the observation period than at the beginning. After 1960, there was an increase in frequency and intensity of occurrence of extreme rainfalls. It seems that the general trend of extreme rainfall is upward. Considering annual scale, we noticed a decrease in rainfall and number of rainy days. The average behavior of the series of annual rainfall over the period of observation, suggests that there was a climatic change upward. The application tests segmentation rainfall data shows that 1989 is exceptional ($P_{jmax} = 90$ mm). The series has two segments; averages are significantly different, and not stationary.

THE STUDY OF CLIMATE CHANGE IMPACT ON WATER RESOURCES AND CONSUMPTION IN SEMIARID AREAS BY ATMOSPHERIC-OCEAN GENERAL CIRCULATION MODELS (CASE STUDY GONABAD PLAIN-IRAN)

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There is the most usage of temperature and precipitation data in processes that have been related to water resources. In this research our aim is to investigate AOGCM models in GONABAD plain in east of IRAN. It contains CCSR/NIES, CGCM2, CSIRO-MK2, ECHAM4, GFDLR30, HadCM3, and NCAR- DOEPCM models. First, monthly temperature and precipitation data were gathered in the reference period and also were analyzed for three successive periods of (2010-2039), (2040, 2069) and (2070, 2099) for investigating them under the A2 emission scenario. We have calculated the monthly weights of each model based on comparing of monthly temperature and precipitation in reference period with the mean observed temperature and precipitation method. Our findings have shown that CCSR/NIES model has the maximum weight in rainfall season (except summer) with precipitation data and in the summer and fall of 2080 it would be increased 50 and 40 percent respectively. Of course it is unimportant because we don't have enough amount of precipitation in the summer. And we also have 50 and 40 percent decrease in winter and spring that are two rainy seasons there. For the temperature parameter since all of the 7 models have almost the same predictions, so it is hard to distinguish a special pattern for next periods. But CCSR/NIES model has a better performance in comparison with others. Therefore we have the most changes for temperature in 2070-2090 periods in comparison with the reference period. The changes of spring to winter are 2.8-8.7, 2.9-9.3, 2.6-7.2 and 1.9-6.4 degrees centigrade respectively.

INSTRUCTIONS OF THE LONG SERIES OF ANNUAL FLOWS AND THE EXTREME DISCHARGE FREQUENCY, CASE OF UNDER AREA CATCHMENT OF THE RIVER OF ARAGON UPSTREAM OF DAM YESA, SPAIN.

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Historically, the middle of the XXth century, knew an important pluviometric deficit in the years 1940 in Europe and in the years 1970 in Africa. It results the illusion from it from climatic and hydrological fluctuations, with a cyclic aspect, in the short and medium term.

The analysis of the variations of simple and significant data like the annual average of the flows is known for a long time, that their interannual distribution reflects the data of the climate of an area. Also, the statistical analysis of the duration of flood and the low water levels of the runoff during the same year, allows a projection towards the hollow of the low water level or the gravity of the flood.

Two methods are then usable simultaneously: variations of the average annual discharge and statistical processing of flood and the low water levels. To expose these two methods, one will use the data of the Hydrographic Confederation of *EL EBRO* (Zaragoza, Spain), and which relate to 8 hydrometric stations on the Aragon river (collecting of the area catchments upstream of Aragon river with 2.200 km² of surface), with 46 observations of flows recorded between 1950 and 1995. Compared distribution of the average annual discharge of the rivers affluents: Aragon, Subordan, Veral and Esca, show, the occurrence of two pseudo cycles having short pulsations of almost decennial frequency, and a secular pulsation with a minimum, separating two high waters at the beginning and the end of the adopted succession year.

Using the definition of the mean discharge characteristic starting from the cantles raised on the curves of classified mean discharge (Pardé, Remenieras), the flood and the low water levels are defined by their multiannual frequency.

The method consists in counting each year, the days when the DC.10 and the DC.30 were exceeded to define the importance of the floods. Contrary, the number of days when the DC.270 and the DC.355 were not reached illustrates the gravity of the low water levels.

DESIGN MANUAL FOR FLOODS AND DROUGHTS UNDER DIFFERENT CLIMATE CHANGE SCENARIOS IN NEW BRUNSWICK, CANADA

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There is currently a broad scientific consensus that the global climate is changing in ways that are likely to have a profound impact on our society and on the natural environment over the coming decades. Climate change and its impacts on a global scale are the focus of intense, broad-based international research efforts in natural and social sciences. The present paper analyzes the climate change impacts on the discharge regimes of several catchments in New Brunswick, Canada. The hydrological response, given climate scenarios, was simulated using artificial neural network models. Future climate data were extracted from the Canadian Coupled General Climate Model (CGCM3.1) under the greenhouse gas emission scenarios B1 and A2 defined by the Intergovernmental Panel on Climate Change (IPCC). The climate change fields (temperatures and precipitation) were computed using the delta change approach. Using the artificial neural network, future floods and droughts river discharge was predicted for selected hydrometric stations. Then, a frequency analysis was carried out using the generalized extreme value (GEV) distribution function, and the parameters of the distribution were estimated using L-moments method.

WAAPA: A MODEL FOR WATER AVAILABILITY AND CLIMATE CHANGE ADAPTATION POLICY ANALYSIS

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In the water sector, institutions, users, technology and economy cooperate to achieve equilibrium between water supply and demand in water resource systems. The socioeconomic dynamics of the population act as an external forcing that separates systems from equilibrium. Water policy is designed to correct deviations and to recover equilibrium as a response to this socioeconomic forcing. Climate change is an additional forcing that should be considered in this continuously adaptive process. A methodology to identify and evaluate climate change adaptation policies in this context is presented in this paper. The methodology is based on the development of a GIS-based model, called "Water Availability and Adaptation Policy Assessment (WAAPA)", which computes net water availability for consumptive use for a river basin taking into account the regulation capacity of its water supply system and a set of management standards defined through water policy. Most data are taken from globally-available GIS-based public datasets. WAAPA model provides a simple way to account for the influence of socioeconomic factors (hydraulic infrastructure and water policy) on climate change impacts on water resources in the Mediterranean region. The capabilities of WAAPA are illustrated with the application to the Ebro river basin. Water availability is estimated under different climate change projections and is compared to water demand under several policy scenarios. As a conclusion, several adaptation options are proposed and quantified in terms of improvement of basin management, demand reduction or infrastructure development.

DIMMING/BRIGHTENING IN ATHENS: TRENDS IN SUNSHINE DURATION, CLOUD COVER AND REFERENCE EVAPOTRANSPIRATION

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Evidence of global dimming/brightening is mainly based upon few measurements of solar radiation. A need for more research supported and extended with the use of other climatic variables, such as sunshine duration (SD), recorded for a longer time period and successfully used as a proxy for solar radiation over the past 80 years, has already been urged. Thus, in this study, residual SD series computed after removal of the cloudiness-related variability, from daily sunshine duration and cloudiness data measured at the National Observatory of Athens are used for highlighting global dimming or brightening periods in Athens, during the period 1951-2001. Furthermore, the consistency of trends in radiation records and their implications for the hydrological cycle and especially the trends in reference evapotranspiration are examined, during the period 1951-2001. The analysis focuses on the seasonal decadal variations, determines and explains the causes of the seasonal trends from the inter-annual and decadal variability of the SD during the last half past century, with a special emphasis in detecting possible subperiods in Athens. The signs of trends in the modeled annual and seasonal reference evapotranspiration are estimated, according to the indicated global dimming/brightening periods.

BASIN-SCALE WATER RESOURCES ASSESSMENT IN A SICILIAN BASIN UNDER CLIMATE CHANGE SCENARIOS USING THE CONCEPTUAL MODEL TOPDM

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Climate change resulting due to the greenhouse effect is expected to have great implications for hydrological cycle and for existing surface and groundwater resources systems. The effects of climate variability and climate change have to be fully considered in current water management and planning, since water availability, quality and streamflow are very sensitive to changes in temperature and precipitation regimes. International literature proposes several models, attempting to assess accurately the available water resources under stationary and changing climatic conditions at different spatial and temporal scales.

In order to assess the potential impacts of climate change on surface and groundwater resources water availability in a Southern area of Italy, a conceptual hydrologic model, the TOPDM, was applied at daily scale to simulate the hydrological processes in the Belice river basin, located in Sicily. The analysis of the climatic forcing trend provided the parameters needed in order to generate synthetic climate forcing series through the use of stochastic approaches.

The hydrological model has been used to estimate the basin water balance components and the surface and groundwater availability in a no trend scenario, representing the current climate conditions, and in three different groups of scenarios, in which a decrease of precipitation, an increase of temperature, and a combination of these effect were reproduced. The application of TOPDM to the test basins provided some important conclusions about the implications of climate change in the Southern part of Italy. Results show that runoff and evapotranspiration reflect variations in precipitation and in temperature; in particular the negative trend in precipitation determines a decrease in surface and groundwater resources, and this effect is intensified in the scenarios that include a temperature trend as well. Therefore the climate change, occurring as precipitation amount reduction and temperature rise, could exacerbate the water resources stresses in the area of study, in which water scarcity is already an important issue for water resource management.

CHARACTERIZATION OF PRECIPITATION VARIABILITY IN THE MEDITERRANEAN BASIN

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Precipitation tendencies analyses, on different spatial and temporal scales, has been of great concern during the past century, mainly because of the attention given to global climate change from the scientific community. But along with negative and positive changes in rainfall amount, precipitation fluctuation play a dominant role in a number of water related issues, from water resources management planning to erosion and desertification risk assessment. With regard to the European context, an extreme rainfall variability, both in space and time, is the most relevant characteristic of the Mediterranean basin. Rainfall exhibit its fluctuation both at the season to season level (intra-annual variability) and at the year to year level (inter-annual variability). But water resources systems are affected at a different extent by intra-annual and inter-annual variability. In this paper an index based approach is proposed to the characterization of seasonal rainfall concentration and annual rainfall variability, and potential links between intra and inter-annual fluctuation are further explored. The method is tested on two regions included in the Mediterranean basin boundary, a South-West Italy region facing the Tyrrhenian Sea and a North-West region of Algeria facing the Mediterranean Sea. The case study regions typically experience a Mediterranean climate, with a maximum and a minimum in precipitation during the cold and the warm seasons respectively, but from their comparison potential impact of orography can also be explored.

A METHODOLOGY FOR THE ASSESSMENT OF CLIMATE CHANGE EFFECTS ON HYDROPOWER

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Among the fields that are most relevant in the study of climate change, hydropower plays a double role. On one hand, it will be affected by the change in water availability feeding hydropower plants. On the other hand, as the present major source of renewable energy, an effort must be performed in order to maintain or, if possible, increase hydropower production. The aim of this activity is the study of the impact of expected climate change and of future scenarios of energy demand evolution on reservoir management, in order to assess the variations in hydropower production and identify the possible changes in reservoir management. This activity is part of ACQWA project, a EU FP7 large scale integration project whose aim is the use of advanced modelling techniques to quantify the influence of climate change on the major determinants of river discharge and analyse their impact on society and economy. In particular, the workpackages devoted to the study of the drivers of change and the development and application of regional climate models and hydrological models will provide high quality data about the expected water availability and the evolution of electric power demand.

Our activity has been focused on the development of a model of the management of a complex hydropower system as a function of climate conditions and power demand. A conceptual scheme of the hydropower system in the case study, the Regione Valle d'Aosta, Italy, has been developed. Main hydroelectric reservoirs and hydropower plants has been identified, the topological structure of the system has been recognized and the hydraulic and electrical characteristics has been collected, together with the characterisation of present climate and present runoff in Valle d'Aosta. The management of the hydropower system has been computed by means of a simple optimisation tool and the expected variations in reservoir management and power production will be quantified through a comparison between optimisation results of present and future scenarios. At present only the present scenario has been completed.

FUTURE PATTERN OF DROUGHT OVER GREECE UNDER GLOBAL WARMING

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This study investigates the effect of global warming on drought patterns over Greece by comparing the projected climate periods 2021-2050 and 2071-2100 from the regional climate model RACMO2 (developed at KNMI) with the 1961-1990 base period. The projected daily mean-, minimum- and maximum- temperature and precipitation data at a high horizontal resolution (25 km) from runs produced within the framework of the EU –funded ENSEMBLES project, are translated into drought climatology. The new multi-scalar standardized precipitation – evapotranspiration index SPEI (Vicente-Serrano et al., 2010) based on monthly precipitation and evapotranspiration data, the widely used multi-scalar Standardized Precipitation Index SPI (McKee et al., 1993), based on monthly rainfall data and the Effective Drought Index EDI (Byun and Wilhite, 1996), based on daily precipitation data are tested in identifying drought variability in Greece.

IMPACT OF CLIMATE CHANGE AND DEVELOPING PROJECTS ON WATER SCARCITY OF THE GHEZELOZAN BASIN, IRAN

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Continuous limitations of available water resources and growing demands in different sectors have caused critical status on the water resources of Ghezelozan basin with total area of 54000 km². From another point of view, the boundaries of 8 Iranian provinces cross the basin and there are many developing projects under construction there that can change current inflows and outflows to and from the provinces. Furthermore, there is an important global external change due to climate change. These drivers may seriously change available water resources of the basin as well as the provinces and face them with new conflicts. This research work aims to evaluate impacts of the under construction projects on water allocation through the provinces and assess climate change on this issue, using HADCM3 GCM data and scenarios A2 and B2. The results show significant increase in the basin temperature and decrease in rainfalls. In general, scenario A2 faces the basin with more critical situation. Consequently, there will be drastic decrease in river flows, too. It is expected the river flow decrease from 2.3% to 14.5% in the 2010-39 period and 6% to 23% in the 2070-99 period. Exploitation of the developing projects will also aggravate these changes and especially shorten available water of the downstream provinces.

WATER SECURITY IN INDIA UNDER A CHANGING CLIMATE AND HYDROLOGICAL EXTREMES

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India is one among the countries highly vulnerable to the impacts of climate change. Impact of climate change on the water resources of India seriously affects food production, power generation and economic development which is reflected in all facets of life. Providing water for the basic needs of the fast rising population is a big challenge. Drylands of India are potentially threatened by desertification. Indian economy and life of the majority has been traditionally linked to agriculture, the largest consumer of water. Though irrigation developments programmes have been going on for decades, agriculture in a vast area is still rain-dependent. Extremes in rainfall associated with global anomalies always affect agricultural production. High seasonality in certain parts reduces groundwater recharge and summer water availability. Irrigation in the dry zones largely depends on groundwater resources. Increasing intensity and frequency of tropical storms salinise coastal aquifers. In the Western Ghats Mountain area, high seasonality and intensity of rainfall results in erosion and sedimentation, reducing reservoir capacity and summer flow in rivers. Retreat of Himalayan glaciers is likely to have large impact on water in almost all parts of north India. Slight increase in rainfall predicted in some parts may not be able to compensate for the loss in soil moisture due to rising temperature. Water related health problems worsens and spread into new areas. Many states of India largely utilize the hydel power potential. Irregularities in rainfall affect power production. Shortage of water may halt the industrial development and the present economic development. It may also lead to social issues such as migration, disputes over water allocation, pricing of water that is unaffordable to millions of poor creating unrest in society. This paper assesses the impact of climate change on water resources and its effect on different sectors of life in India. Changes in water availability in an altered climate have been estimated using hydrological model. Existing policies and adaptation strategies have been critically reviewed. Current policies and adaptation strategies are inefficient and their implementation mechanism often fails. India urgently needs to develop an appropriate strategy for water management and climate change adaptation and a comprehensive environment policy that includes, water and climate and an efficient mechanism for the implementation. Guidelines for this have been provided.

PRECIPITATION VARIATIONS OVER THE LAST HALF OF THE CENTURY IN GREECE

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Precipitation is the main driving factor for vegetation development especially for the natural and agricultural rain-fed ecosystems. Its time variation between years can affect the vegetation regime in a region. This study aims on the evaluation of precipitation variations over the last 50 years in Greece, occurred in forested and agricultural regions, with not significant land use changes occurred during the study period.

Precipitation data from 32 forest and agricultural meteorological stations with altitudinal (1-1.310 m) and latitudinal (37° 04' – 40° 29') expansion were analyzed for the time period 1951-2006 (for most of the stations). The trends in precipitation for each station along with their statistical significance were calculated on an annual, seasonal and monthly basis using the Mann-Kendall test. Mean slopes were also calculated using the Sen method.

The results of the study generally show significant decreasing trends in precipitation at most of the stations, with a mean slope of -5.5 mm y^{-1} . Greater negative slopes and significant trends are identified in winter, but maximum absolute slopes are found in January, especially at low altitudes (less than 500 m). In summer, the trends are negative but not statistically significant in most cases, because of the diminished rainfall at this time of the year in the Mediterranean region. On a latitudinal basis the trends are negative with greater absolute slopes in northern Greece, when at southern latitudes slightly positive and not significant trends are also found.

DETECTING IMPACTS OF A CHANGING CLIMATE ON DROUGHT CHARACTERISTICS IN IRAN

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The effect of a changing climate on drought characteristics in Iran is investigated by comparing the time series of the Standardized Precipitation Index (SPI), the Reconnaissance Drought Index (RDI) and the Standardized Precipitation Evapotranspiration Index (SPEI) on 12-month time scale. Indices are computed for the common time period 1961-2005 using monthly data from 44 main synoptic stations distributed throughout the country. Results suggest that the three drought indices strongly correlate with each other in mountainous areas of western and northern part of Iran where evapotranspiration is low due to the low temperatures compared with the other regions. On the contrary, the correlation coefficients between the considered drought indices noticeably decrease in most stations located in the southern, eastern and central parts of the country characterized by high temperatures and evapotranspiration, especially during the warm season. Though by definition the RDI and SPEI are relatively similar, it is found that the RDI usually tends to correlate well with SPI at all the stations, while the correlation between SPEI and SPI may reduce to very low values in some stations. To analyse if the observed discrepancies between SPI and the two other indices at some stations are related to the temperature increase in recent years, the monthly mean temperature in selected stations is checked for long-term trend using Mann-Kendall test. Results show that temperature is significantly increased at some stations in the south, east and centre of the country where noticeable discrepancies occur between SPI and the other two drought indices. The observed positive trends in the mean temperature at such stations appear to be associated with negative trends in the corresponding RDI and SPEI time series, and with more prolonged drought events in recent years. The effectiveness of using the RDI and SPEI to better capture the impact of increasing temperatures and evapotranspiration in semi-arid regions on drought characteristics is evaluated and discussed.

AN INVESTIGATION ON THE EFFECTS OF CLIMATE CHANGE AND GLOBAL WARMING ON WATER RESOURCES IN DRY COUNTRIES USING REMOTE SENSING AND GIS (A CASE STUDY: IRAN)

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For an efficient management of water resources, it is necessary to evaluate the occurrence of climate change and its country/basin wide consequences. Satellite images provide a powerful tool to monitor this phenomenon over large areas and also ground investigation could tune its results to come to a reliable conclusion. In dry countries, such as Iran, dryness is an intrinsic characteristic of climate and water resources; thus, the climate change and global warming issue is always controversial, and there is a weak consensus agreement about the effects of climate change in these regions. Iran is characterized by diverse climate and hydrologic regimes from south to north and from east to west. This diversity together with the well hydrologic condition of the rivers that originate from the snowy mountainous area of the neighbour countries, such as the Helmand River from Afghanistan, the Aras River from Turkey/Armenia, and the Tigris River from Turkey intensify this argument. In this research, using 696 concurrent images of monthly temperature and precipitation, the spatial and long term changes of these two most important climatological variables were investigated. A long term decreasing trend for temperature was obtained, and the variation of the precipitation across the country illustrated to be meaningful too. In this regard, in the North- Northwestern and South-Southeastern regions of Iran a descending trend of precipitation could be seen. The Mann-Kendal test verified the reliability of the captured trends for temperature and precipitation. There is always a lag time between climatological and hydrological variations; thus, the research continued to find the effects of the global warming on the hydrologic regime of Iran's water resources. Iran has been divided officially into 7 major catchments. To fulfill the mentioned purpose, some hydrometric and gauge stations, which don't suffer from anthropogenic effects, were selected and the long term average yield was computed for each of the 7 studied catchments. The observed decreasing trend in the available water across the country is in agreement with the results obtained from remote sensing analysis on the temperature and precipitation variables. By using SPI method it is also illustrated that the occurrence of the long lasting and severe/extreme droughts in recent decades in Iran, is not just a random process, but also could be a direct result of the climate change and universal global warming that could obviously lead to many negative impacts on water resources in the target area.

OPTIMAL GROUNDWATER RESOURCES MANAGEMENT OF AN OVEREXPLOITED AQUIFER UNDER GLOBAL CHANGE

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This paper presents a study for finding the optimal management of an overexploited aquifer under global change. The study area is the aquifer of Lake Karla basin and its water resources management is under strict restrictions because of the severe environmental conditions over the last three decades. The former Lake Karla occupied most of the eastern part of Thessaly plain until 1962, when the lake was drained. It was one of the most important wetlands in Greece. A smaller reservoir that was planned was never built causing serious environmental problems, such as the dramatic drawdown of water table due to groundwater over pumping. Nowadays, a reservoir has been constructed for the partial restoration of Lake Karla and it is planned to operate on 2012. The reservoir will supply water for irrigation of the surrounding agricultural fields and it is going to replace the groundwater pumping from the most degraded southwestern part of the aquifer, according to a pre-designed plan. A simulation optimization method has been used to evaluate the optimum volume of water that can be extracted from the aquifer and the optimum position of the remaining wells with the objective of water table rise to a desirable sustainable level. The method has been applied under the constraint of climate change. The modeling system consists of a series of interlinked models: a hydrological model (UTHBAL), a groundwater model (MODFLOW), a lake-aquifer model (LAK3) and a reservoir operation model (UTHRL). The modeling system has been calibrated for the historical period against observed runoff and groundwater hydraulic heads. An optimization tool (GWM) is used for the optimization exercise. The climate change forcing on precipitation and temperature has been evaluated using the outputs of Canadian Centre for Climate Model Analysis General Circulation Model (CGCMa2) and a hybrid downscaling method (Vasiliades et al., 2009) which combines a multiple regression (MLR) model and a timeseries model. The climate change has been assessed for the SRESA2 and SRESB2 socioeconomic emissions scenarios. The results of this study show that the impact of climate change is important on the optimal groundwater resources management, as it determines the optimum volume of the extracted water and the position of the remaining irrigation wells.

INFLUENCE OF SERIAL CORRELATION IN CLIMATIC VARIABLES TRENDS ANALYSIS IN SICILY

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The intense climatic anomalies occurred in the last decades, led the scientific community to officially admit the existence of climate change, mainly due to human activities. Researchers have studied trends and variations in temperatures and rainfall in several areas of the world. The analysis of precipitation and temperature trends has become a topic of particular interest because the knowledge of rainfall and temperatures evolution can become a support tool in forecasting future climatic scenarios and consequently for water resources management.

In several studies aimed at identifying trends in climatic data, the nonparametric test of Mann-Kendall is frequently used with the assumption that the observed data are characterized by serial independence. However, many hydrological series, such as minimum and average annual runoff, often show a statistically significant serial correlation.

This study is based on previous analysis of time series of precipitation and temperature recorded in Sicily in the past century, which have verified the existence of trend in precipitation and temperature time series, using the Mann-Kendall test. The aim of this work is to deepen the analysis of trends in rainfall and air temperature using techniques for removing the serial correlation in order to obtain results not influenced by it.

With this purpose, two different procedures have been used, namely the pre-whitening and the trend-free pre-whitening.

With reference to the monthly precipitation data, which are fairly self-correlated, the pre-whitening process identifies a number of decreasing trends less than those identified in the previous studies while the trend-free pre-whitening procedure doubles the number. When data are aggregated at seasonal and annual scale, the trend-free pre-whitening procedure individuates the same number of decreasing trends observed in the previous studies, while the alternative pre-whitening procedure, slightly reduces this number.

The temperature series are highly auto-correlated and for this reason, the pre-whitening procedure completely eliminates the trend presence. The trend-free pre-whitening procedure individuates more stations with positive trends than these relative to previous studies. If the temperature data are aggregated to seasonal and annual time scale, the trend-free pre-whitening procedure results are consistent with previous studies. In fact positive trends are observed at all levels of confidence and time aggregation.

STATISTICAL DOWNSCALING OF PRECIPITATION AND TEMPERATURE IN ASIAN COUNTRIES

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Downscaling of the global climate model output is necessary to local scale hydrological impact studies. In this paper, the Statistical Downscaling Model (SDSM) was used for downscaling precipitation and air temperature (T) in both the present and future climate scenarios (IPCC scenarios A2). It was applied to four river basins in four Asian countries (Thailand, Sri Lanka, Vietnam, and Philippines) by simulating the local scale daily temperature and precipitation based on the large scale atmospheric variables including National Centre for Environmental Prediction (NCEP) reanalysis datasets (1961-2000) and a general circulation model (HadCM3 GCM) outputs (1961-2099) with a coarse spatial resolution of 2.5° latitude by 3.75° longitude. The performance of the downscaling method is compared for both calibration period and validation period. The downscaling models' performance show that SDSM is efficient for downscaling average daily air T and the extreme maximum air T with high R^2 index. However, SDSM did not produce good results for downscaling the daily precipitation. The extreme maximum, minimum and seasonal precipitation and air temperature were then analyzed for both current and future climate scenarios. The simulated yearly average air T (1961-2000) by using HadCM3 datasets also reproduced well the observed ones in the local station. Average and maximum air T in future scenarios (2070-2099) predicted by the SDSM are generally found to be larger than those observed values (1961-1990). This study shows the applicability of SDSM downscaling techniques in evaluating the reliability of the downscaled GCM data for climate scenarios development.

COMPARATIVE ASSESSMENT OF WATER MANAGEMENT INDICATORS IN THE GEDIZ RIVER BASIN WITH FORESEEN CLIMATE SCENARIOS

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Gediz Basin is an agriculture-dominant river basin in the western region of Turkey along the Aegean coast. The most significant feature of the basin is water scarcity, which is due basically to competition for water among various uses (water allocation problems), mainly irrigation with a total command area of 110,000 ha versus the domestic and fast growing industrial demand in the coastal zone, and environmental pollution although the basin experiences significant droughts from time to time. Since the water resources in the basin are almost fully allocated to various uses, it is expected that the negative impacts of climate change will exacerbate the water crisis. In this study, the results of the project "Climate Change Scenarios for Turkey", funded by TUBITAK (The Scientific and Technological Research Council of Turkey) are used in Water Evaluation and Planning System (WEAP), in order to assess the climate change impacts on water resources and water demand in the basin. The WEAP is forced to simulate the water system between 2010 and 2100 with the time series of temperature, precipitation, evapotranspiration and surface runoff data projected for the Gediz Basin. The data used are the simulation results of ECHAM5 (European Centre Hamburg Model version 5) general circulation model and RegCM3 (Regional Climate Model version 3) regional climate model. The study is further based on IPCC (Intergovernmental Panel on Climate Change) A2 and B1 emission scenarios. The results obtained by WEAP model are evaluated for three (30-year-long) periods, and comparative assessments under foreseen climate scenarios are given with respect to water supply reliability, unmet water demand and crop yield.

3. DROUGHT CHARACTERIZATION, MONITORING AND FORECASTING

COMPARISON OF DROUGHT INDICES FOR A TRANSBOUNDARY BASIN

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Guadiana River is a transboundary river flowing through Spain and Portugal. The basin area of Guadiana River amounts to 66 800 km², from which 55 200 km² (83%) belong to Spain and 11 580 km² (17%) belong to Portugal. The length of Guadiana River in Spain is 550 km, while the river length in Portugal is 260 km. Many kilometers of total river length constitute natural borders of both countries.

Guadiana River basin represents a typical semi-arid area of southern Europe. The study region in this paper, from the point of view of drought, is that part of Guadiana River basin which belongs to Portugal. Daily rainfall data from 34 rainfall stations, for the time period 1931 – 2007, were available. 13 stations are situated in the study region, while 21 stations are situated around the study region.

In concrete terms, the following quantitative drought indices were calculated in order to investigate if drought conditions took place during the time period 1931 – 2007 in the study region:

“Percent of Normal” (PN), depending on the rainfall depth, on an annual and a monthly time basis. By means of this index, the trend of the annual (or monthly) rainfall depth can be estimated.

“Deciles”, depending on the rainfall depth, on a monthly time basis. By means of this index, a monthly rainfall depth can be classified into one of the following five periods: very dry – dry – normal – humid – very humid.

“Reconnaissance Drought Index” (RDI), depending on the rainfall and potential evapotranspiration, on an annual time basis. If this index obtains negative values, then there is drought risk.

“Annual deficit area” – “Area drought” (on an annual time basis), depending on the rainfall spatial distribution and rainfall depth. By means of these indices, the drought extent can be estimated.

“Drought duration”, depending on the drought extent, on an annual time basis. By means of this index, the number of drought years is determined.

“Annual water shortage” (on an annual time basis), depending on the rainfall depth and rainfall spatial distribution. By means of this index, the drought intensity is quantified. The general conclusion drawn from the present study is that, in the time period considered (1971 – 2006), an increasing trend of drought risk exists in the study region, which is estimated quantitatively by means of the above mentioned drought indices.

LARGE SCALE PROBABILISTIC DROUGHT CHARACTERIZATION IN EUROPE

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A probabilistic characterization of drought events can play a key role within a drought risk management approach, since it enables the evaluation of drought hazard over a region, which combined with drought vulnerability yields to the corresponding drought risk. Within this contexts, the reliable assessment of drought return periods is essential to help decision makers in setting effective drought preparedness and mitigation tools.

At local level drought events can be objectively identified through the theory of runs by two main characteristics, namely: drought duration and accumulated deficit. Such characteristics are statistically dependent and therefore a multivariate approach is the most appropriate for their parobabilistic analysis. Generally, due to the relatively limited number of drought events that can be observed from the historical records, an inferential approach (i.e. fitting parametric distributions to observed drought characteristics) is often unsuitable to model the marginal or joint probability distributions of drought characteristics. As an alternative, the marginal and multivariate probability cdf's of drought characteristics can be derived as functions of the parameters of the cdf of the underlying variable (e.g. precipitation), whose sample series is usually long enough to get reliable results in a statistical sense.

In this study, the latter methodology is applied to investigate the space-time variability of drought occurrences over Europe by using the CRU TS3.1 precipitation dataset for the period 1901-2009, which is produced by the British Atmospheric Data Centre through a software provided by the Climate Research Unit (CRU) at the University of East Anglia.

First, the goodness of fit of several probability distributions to the considered dataset is examined. Then, the marginal and bivariate cdf's of drought duration and accumulated deficit are analytically derived based on the proposed probabilistic approach. The derived cdf's of drought characteristics are then applied to determine the return period of critical droughts, computed as the expected value of the interarrival time between consecutive critical droughts. More specifically, return periods of fixed drought accumulated deficit and/or drought duration are computed and the corresponding spatial distribution is investigated. Also, a spatial analysis of the most harmful historical droughts at European level is carried out.

SPATIAL PATTERNS OF VARIABILITY FOR RAIN FIELDS AT DIFFERENT TIMESCALES: AN APPLICATION IN SOUTHERN ITALY

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Rainfall is characterized by spatial variability which depends on the timescale used. Experiences in analysing rainfall for different time periods have shown, in fact, that the spatial patterns of variability change within the time scale (from hours through days and months to seasonal and annual scales). Geostatistics offers a variety of methods for modelling spatial variability and mapping rain fields considered as realizations of random functions.

The aim of this study was to analyse and quantify the spatial structure of rain fields at various timescales for climatological and water resources purposes. An additional aim was to identify the reasons causing non stationarity of rain fields at any temporal scale (such as topography and proximity to seas) which are especially important in peninsular areas characterized by a marked orography like Southern Italy.

In Calabria (Southern Italy), high-quality datasets have been collected since 1916 by the former Italian Hydrographic Service, now “Centro Funzionale” of the Regional Agency for the Environmental Protection (ARPACAL) of the Calabria region. The data used in this study are a set of different timescales precipitation series registered in Calabria in the last years. Spatial structures of rain fields were identified over the range of timescales most often used in climatological and water resources studies varying from daily to seasonal, to annual timescale. The results seem to confirm that rainfall variability is influenced by orography and by the distance from the sea.

ON THE PROBABILISTIC ANALYSIS OF REGIONAL DROUGHTS

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Stochastic modelling of regional droughts is a topic of extreme interest due to its implications for a correct water resources management. The assessment of probabilities and return periods of regional drought characteristics represents a fundamental step toward a risk based water management in a region and can provide useful information for drafting drought management plans. The peculiar features of droughts, namely their multiyear spanning, the multivariate nature of their characteristics, as well as the need to take into account their spatial extent, requires the development of concepts and tools that differ significantly from those generally adopted to analyze other hydrological extremes, such as floods. Furthermore, due to the limited number of droughts that can be generally observed in historical series, the inferential approach, e.g. fitting of a probability distribution to drought characteristics from an observed hydrological sample, is not feasible since it can lead to potentially unreliable results.

In the paper, probabilistic features of characteristics of regional droughts are analyzed in order to estimate the corresponding return periods. Exact and approximate analytical expressions are derived for the moments of areal coverage of deficit, of areal deficit and of accumulated deficit making use of realistic hypotheses about the distributions of the aforementioned characteristics as well as of copulas concepts.

The derived moments, pdf and return period are applied for the characterization of regional droughts in Sicily island in Italy. The results of the application indicates that the derived expressions are able to model fairly well the occurrences and return period of droughts.

POTENTIAL OF SPI INDEX TO DETECT HYDROLOGICAL DROUGHTS

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In the last years, due to amplified occurrence and intensity of extreme events, the management of water supply systems is becoming more challenging; in particular, different approaches have been proposed aiming to an effective mitigation of the most adverse drought impacts, since the widespread physical and socio-economic damage caused by drought are significant.

The aim of the present study is to investigate the potential of the “Standardized Precipitation Index” (SPI) index as a detector of hydrological droughts, namely droughts associated with the effects of periods of precipitation shortfalls on surface water resources.

In particular, a comparison between droughts identified by means of SPI and an hydrological index termed as “Standardized Streamflow Index” (SSI) has been carried out with reference to a watershed in Sicily island.

A qualitative and quantitative comparison between the characteristics of the identified drought events is carried out also by means of correlation analysis and contingency tables in order to assess the capability of SPI index to monitor hydrological droughts.

The results show a fairly good agreement between drought characteristics identified by SPI and SSI especially for high aggregation time scale (e.g. 36 months).

STATION RANKING BY ANALYTIC HIERARCHY PROCESS (AHP) IN A HYDROLOGIC MONITORING NETWORK REDUCTION PROBLEM

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Sustainable water resources management must take into account multiple users, multiple criteria, and multi objectives. Therefore its success depends on monitoring activities. Many countries have developed extensive water quality and quantity monitoring networks and expanded them to multi-site monitoring. Such a development eventually raise the questions whether they produce the expected information, and whether monitoring should be continued ever whereas it is constrained by increasing budgetary restrictions. These questions have led monitoring agencies to assess their current networks for efficiency and cost-effectiveness and, to consolidate the networks while increasing their information productivity.

The presented study is initiated in respect of the above questions to examine the Analytic Hierarchy Process (AHP) to assess existing networks for possible consolidation (reduction) of a monitoring network. The analytic hierarchy process uses a hierarchical value tree for decision aid, where the problems are decomposed into a hierarchical tree of alternatives and criteria. The approach enables an analytic design for the decision making problem through the ranking of decision alternatives with respect to their “performance” under various criteria and management targets. AHP also deals with a decision matrix where the matrix is constructed by using the relative importance of alternatives in terms of each criterion. AHP may also be used to elicit weights of criteria through pair-wise comparisons by the principal eigenvector approach.

The outcome of the application of AHP to a network reduction problem gives a hierarchical ranking of the operational and non-operational stations in a network in terms of defined monitoring objectives and station attributes. This situation provides a valid decision making ground for the planners (e.g., monitoring agencies) to assess the operational state of a monitoring station.

The study is particularly focused on the need expressed by the Electrical Works Authority (EIE) in Turkey towards assessment of the performance of their monitoring practices. The introduced method is applied to Gediz River Basin in Aegean Coast of Turkey. The results are evaluated with respect to the ten operational and three non-operational streamflow gauging stations and the answer to the question “which are those three stations to be closed?” is searched. Additionally the advantages and disadvantages of the presented method are discussed.

SATELLITE-BASED VARIABILITY OF DROUGHT CHARACTERISTICS

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Drought indices are estimations of precipitation shortage and water supply deficit. A number of satellite drought-monitoring indices have been developed based on NOAA-AVHRR data exploiting the numerous remote sensing inventories acquired through different time intervals. The estimation of drought based on the Reconnaissance Drought Index (RDI) enables the assessment of hydro-meteorological drought, since it uses hydro-meteorological parameters. RDI is a fairly comprehensive index as it combines the simplicity of use and the successful assessment and monitoring of the phenomenon. In this study an easy applied and cost effective approach based on two main image processing techniques is explored on the 3, 6, 9 month and annual RDI time series computed through satellite data from 1982 to 2001 for Thessaly. Firstly, Principal Component Analysis (PCA) is applied onto 3-, 6-, 9-, and 12-month RDI time series for Thessaly followed by Clustering that was based on certain eigenchannels resulted from the previous PCA analysis. Both methods are orthogonal linear transformations capable to decorrelate the spatiotemporal information provided in the time series RDI measurements. The presented approach proved to be advantageous in relation to other statistical methods used to describe variability and provide excellent and fast results for Agrometeorology stakeholders and environmental organizations.

DEVELOPMENT OF STREAMFLOW FORECASTING MODEL USING ARTIFICIAL NEURAL NETWORK IN THE AWASH RIVER BASIN, ETHIOPIA

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Early indication of possible drought can help in developing suitable drought mitigation strategies and measures in advance. Therefore, drought forecasting plays an important role in the planning and management of water resource in such circumstances. In this study, a non-linear streamflow forecasting model was developed using Artificial Neural Network (ANN) modeling technique at the Melka Sedi stream gauging station, Ethiopia, with adequate lead times. The available data was divided into two independent sets using a split sampling tool of the neural network software. The first data set was used for training and the second data set, which is normally about one fourth of the total available data, was used for testing the model. A one year data was set aside for validating the ANN model. The streamflow predicted using the model on weekly time step compared favorably with the measured streamflow data ($R^2 = 75\%$) during the validation period. Application of the model in assessing appropriate agricultural water management strategies for a large-scale irrigation scheme in the Awash River Basin, Ethiopia, has already been considered for publication in a referred journal.

INTEGRATED SET OF PHYSICAL AND SOCIO-ECONOMIC INDICATORS FOR DROUGHT IMPACTS MONITORING

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Drought is largely considered as one of the major and most complex natural hazard. Empirical investigations emphasize the ambiguity in drought perception and definition. There is no unique definition of the problem, but each individual has her/his own perception of drought, which is influenced by previous drought experiences and by the mental models used to analyse these experiences. Defining drought simply as departure from the average rainfall considers only one aspect of the problem, i.e. the meteorological drought. This work describes an attempt to develop an integrated set of indicators to observe drought phenomenon and its environmental and socio-economic impacts, which usually develop later, by taking the local stakeholders' perception of drought into account. The activities were carried out in the Lake Trasimeno district (Central Italy). Due to their vulnerability, drought phenomena have had strong negative impacts on both the lake ecosystem and the socio-economic structure in the recent past. Several stakeholders were selected as representative of the main local economy components and involved in the participatory definition of drought indicators. Their drought's perception was elicited and structured in Cognitive Maps (CM) to facilitate the analysis. CM were used to identify the most important elements in each stakeholder drought perception and to support the debate. Hence, indicators were identified based on stakeholders' perception, then validated by the comparison with the main drought physical indicators, i.e. the level of the lake and the precipitation index. The latter was calculated as the Standardized Precipitation Index (SPI) at the annual scale (hydrologic year, September to August), in the whole Tiber basin, from 1952 to 2007, assuming a gaussian distribution of data.

This work describes the results of the comparison among indicators in the case study area. Some interesting, although preliminary, conclusions about the usability of local knowledge for drought monitoring are drawn. The more complex is the cause-effects chain leading to an impact (more causes), the less reliable is the stakeholders' drought perception. However, stakeholders perception could provide information at local level about drought development that physical indicators could disregard.

FREQUENCY ANALYSIS OF THE ANNUAL AND SEASONAL DROUGHT INTENSITY-DURATION RELATIONSHIP

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Drought is the most significant natural hazard that has the greatest effect on the human life and economy. Unlike other natural disasters, drought events evolve slowly in time and their impacts generally span a long period of time. Different drought indices are used for determining the temporal and spatial specifications of droughts. Standardized Precipitation Index is a powerful and simple tool to quantify the precipitation deficit for multiple time scales and for different climatic regions.

In this study drought is analyzed using the concept of standardized precipitation index (SPI). The long term precipitation and temperature data observed in 8 raingauge stations operated by The Turkish State Meteorological Service (DMI) in the regions of South-Eastern Anatolia in Türkiye are evaluated for the period of 38 years.

The precipitation values on the raingauge stations of South-Eastern Anatolia's Region stations are investigated for the periods of 3, 6, 9, 12 and 24 months according to the classification values of the SPI method, and the frequencies of drought classes of the drought intensity-duration-frequency analysis based on annual and seasonal precipitation records are obtained. Performing further statistical analysis of precipitation data has been studied the probability distributions of the precipitation.

METHODS TO ASSESS COSTS OF DROUGHT DAMAGES AND POLICIES FOR DROUGHT MITIGATION AND ADAPTATION: REVIEW AND RECOMMENDATIONS

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Drought is a natural hazard which causes many economic, social and environmental problems in different parts of the world. It is expected that the intensity and frequency of droughts are going to increase in the future due to climate change. In Europe, a warmer and dryer climate is expected in many countries, particularly in the Mediterranean region. The existing literature on the costs of drought is scarce, fragmented and heterogeneous and there is a need for comprehensive costs estimations to help designing effective policy responses. Namely, cost assessments of damages and of mitigation measures to droughts provide crucial information for decision support and policy development in the fields of natural hazard management and planning for adaptation to climate change. For these reasons, it is becoming increasingly important to identify and evaluate different approaches for estimating the costs of both drought damages and drought mitigation measures in order to provide recommendations on best practices.

This article starts with identifying all drought impacts and costs, including direct, indirect and intangible costs. It further explores potential policies for drought mitigation and adaptation. The study then examines available methods for assessing all types of drought costs, including those from damages and the ones arising from adopting mitigation measures. It considers the suitability of existing drought cost assessment methods for estimating costs in different economic sectors, their underlying theoretical assumptions, and application issues, such as their precision, reliability, data needs (and availability), and financial and human resources required. Finally, based on the inputs from drought experts and end users gathered during a workshop, our study provides recommendations for good practices and identifies disadvantages of (1) cost assessment methods and (2) drought mitigation and adaptation policies.

RESAMPLING METHODS TO CHARACTERIZE EXTREME EVENTS IN A PRISTINE RIVER BASIN OF VENEZUELAN GUIANA AFFECTED BY ENSO CONDITION

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Resampling methods are very efficient in hydrologic data because they do not require the Gaussian assumption to be made. Resampling-Bootstrap is used to characterizing the extreme event in flow series due to the highly skewed of data. The data flow series come from a pristine river basin of Venezuelan Guiana called Caura. El Niño Southern Oscillation (ENSO) is a large-scale coupled ocean-atmosphere oscillation that has profound effect in the earth climate system. The Caura watershed is affected by the ENSO phenomenon altering the natural flow in the river. To Identify the ENSO-events are used two indexes: ONI and MEI. The ONI index is used in the 3.4 region this has shown the best performance in teleconnection research. The Tropical North Atlantic Index based in SST anomalies is used to make correlations with the flow and to obtain regressions with ONI and EMI indexes. This work analyzes 33 years (1971-2003) of the very strong seasonal time series collected in four different hydrological stations of the river basin. Where found fifteen ENSO-events with different correlations and decadal drought-events. In order to detect the extreme events the POT (peak-over-threshold) and PDT (peak-down-threshold) series are used. Finally the Bootstrap distribution of the extreme events is calculated in order to estimate the density and forecast it.

POTENTIAL ECONOMIC VALUE OF DROUGHT INFORMATION TO SUPPORT EARLY WARNING IN AFRICA

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Here we present a methodology to estimate the economic value of improved drought information that would allow for better choices to be made in information flows (monitoring, forecasting, warning through indicators, and responding). The methodology includes 4 sequential steps. First two contrasting management strategies (with and without early warning) are defined. Second, the associated impacts of the management actions are estimated by using the EM-DAT database (The OFDA/CRED International Disaster Database –www.emdat.be – Université Catholique de Louvain – Brussels – Belgium). Third, the optimal management option is calculated as a function of the drought information and risk aversion of potential information users. Finally we use these optimal management simulations to compute the economic value of enhanced drought early warning systems in Africa. Our results show how timing highly affects the policy and public response to drought warnings and can therefore help to reduce expected losses. The proposed framework is developed within the DEWFORA project (Early warning and forecasting systems to predict climate related drought vulnerability and risk in Africa) that aims to improve the knowledge on drought forecasting, warning and mitigation, and advance the understanding of climate related vulnerability to drought and to develop a prototype operational forecasting.

AN ANALYSIS OF DROUGHT SPATIAL PATTERN OVER IRAN WITH RESPECT TO DIFFERENT SPI TIME SCALES

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Drought regionalization, namely the identification of sub-regions within a country characterized by independent climatic variability and different drought characteristics, is of particular interest for drought risk assessment and water resources management at regional level. The present study provides an analysis for Iran of the stability of drought spatial patterns as a function of time scales by means of the Standardized Precipitation Index (SPI). Gridded precipitation dataset GPCC with a spatial resolution of 1°x1° longitude by latitude and rain-gauge observations are used for the common period 1961–2004. Spatial patterns of drought have been analysed by applying the Principal Component Analysis (PCA) and Varimax rotation to the SPI field computed on 1, 3, 6, 12, 24, and 36 month time scales. Results obtained for GPCC dataset show four sub-regions for short time scales (say 1–6 months), while three sub-regions are identified for longer time scales (12–36 months). In the latter case, it seems that a sub-region in the north represents the merging of two distinct sub-regions identified for meteorological droughts. For all considered time scales a comparison with observations is provided showing that there is a satisfactory agreement between the two datasets. The analysis suggests that modes of drought variability in Iran are relatively stable with respect to the time scales usually adopted for monitoring the different kinds of droughts.

SPATIAL ANALYSIS OF DROUGHT SEVERITY USING RDI INDEX AND GEOGRAPHIC INFORMATION SYSTEMS (GIS) IN THE SOUTH OF IRAN

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Drought is a serious climatic condition that affects nearly all climatic zones worldwide, with semi-arid regions being especially susceptible to drought conditions because of their low annual precipitation and sensitivity to climate changes. Regional drought assessment is conventionally based on drought indices for the identification of drought intensity, duration and areal extent. Among them the Reconnaissance Drought Index (RDI) has been recently developed and applied. RDI is used to estimate the hydro-meteorological drought conditions based on precipitation and potential evapotranspiration. In this paper the RDI was used for drought characterization, analyzing historical meteorological data (1980-2009) for Fars Province in Iran. The RDI was computed at different time scales. After determining the drought severity, using the ArcGIS software, mapping and spatial analysis was accomplished. The results of the study showed that two variables of severity and local prevalence of drought will increase by prolonging and continuation of drought. Also results of this study indicated that, parts of northeast, southeast, south and southwest of Fars province are more vulnerable to drought than the other parts and also more exposed to drought. Therefore, the above-mentioned areas are more vulnerable in dry land which that survival depends on the rate of precipitation.

FIRST STEPS OF AGRICULTURAL DROUGHT MONITORING IN THE FRAME OF DROUGHT MANAGEMENT CENTRE FOR SOUTHEASTERN EUROPE

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To detect temporal and spatial variability of drought is one of the most challenging issues of drought monitoring in the specific country or region due to the fact that there is no standard definition of severity and duration of different types of drought. Moving from local to regional drought monitoring the main constraint represents data availability of different sources. Available global data sets are of assistance for preparing regional drought monitoring products. In the study specific products designed for regional scale of the Southern Europe are described: preliminary maps of Standardized Precipitation Index (SPI) and products generated by implementation of numerical weather prediction model (NWP). It seems to be a lot of potential in both products for a first overview of key meteorological parameters in the region.

Crop water requirements and crop water deficit simulated by crop water balance model supplemented with some in-situ soil measurements and remote sensing products (vegetation indices provided by Eumetsat's Land SAF) were used for verification of drought indicators over Slovenia.

Since data is available for past few years, main focus was put to last drought episodes in the years 2006 and 2007.

EVALUATION OF DIFFERENT METHODS FOR CALCULATING POTENTIAL EVAPOTRANSPIRATION IN DROUGHT SEVERITY ASSESSMENT

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The most common approach for drought severity assessment is through the calculation of drought indices. Popular drought indices are either of a complex nature, demanding a large number of parameters for their calculation (e.g. PDSI), or of a simple nature that usually disregard significant conditions that are contributing in the estimation of water resources availability in an area (e.g. SPI). However, in a changing climate, it is essential to use an index that can remain simple regarding data requirements and its calculation, but at the same time include other significant parameters apart from precipitation. Therefore, the Reconnaissance Drought Index (RDI) which is using precipitation and potential evapotranspiration (PET), the easiest additional significant determinant that should be included, is considered as an appropriate choice for drought severity assessment under climatic change. However, different methods for calculating PET may lead to different results, which in turn may influence the calculated RDI values. The paper uses widely accepted methods for estimating PET (Penman-Monteith, Hargreaves, Thornthwaite, Blaney Criddle, etc.) and evaluates them for areas of the Mediterranean region, using statistical indicators such as the root mean square error (RMSE) and the mean bias error (MBE). In order to compare the performance of each method, data from selected stations of Greece were used. Then, RDI is calculated using the results of the proposed methods and the different RDI values are compared against SPI results. The most appropriate methods for estimating PET, which should be used for drought severity assessment through RDI, are presented hierarchically.

AN EARLY WARNING SYSTEM FOR SPATIOTEMPORAL FORECASTING AND MODELLING OF DROUGHT

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Drought identification, forecasting and monitoring are fundamental stages in the planning and management of natural resources and water resource systems in a river basin. Early and timelines forecasting of a drought event can help to take proactive measures and set out drought mitigation strategies to alleviate the impacts of drought. In this study an early warning system is developed for spatiotemporal forecasting and monitoring of drought. The methodology is based on the integration of artificial intelligence techniques with geostatistical interpolation methods. The distributed raster-based integrated drought monitoring and forecasting system is demonstrated for operational drought management using a meteorological drought index the Standardized Precipitation Index (SPI). The basic elements of the system are determined, and important issues and processes are analytically discussed, such as the representation of the spatial and temporal simulation error, extraction of optimal design solution in machine learning methods for reliable and accurate spatiotemporal drought forecasting. The aforementioned elements are integrated algorithms combining various computational intelligence techniques such as artificial neural networks, genetic algorithms and geostatistical methods. The early warning system uses previous SPI values calculated at various timescales and analyzes the drought level based on the lead time of SPI for operational use via a hybrid spatiotemporal drought forecast model. To identify more clearly the hazard, advanced spatial interpolation methods are incorporated in the early warning system to produce raster drought forecast maps. Comparison of the forecasted drought maps with selected historical drought maps show that reliable and accurate predictions of drought characteristics (severity, duration and area) are estimated for medium term prediction intervals at larger timescales of SPI and for short term prediction intervals at smaller SPI timescales in Pinios river basin, Thessaly, Greece. It is believed that implementation of the early warning drought system with real-time rainfall data will help to judge if this region is a potential drought prone area. If the danger indicator is reached, the water managers and relevant civil protection agencies shall be properly informed to take preventive measures and minimize the possible loss according to the drought severity level.

4. MODELLING OF NATURAL AND DAM-BREAK FLOODS AND EXTREME EVENTS

THE CONTRIBUTION OF EARTH OBSERVATION TO FLOOD RISK ASSESSMENT IN CYPRUS: THE CASE STUDY OF YIALIAS CATCHMENT AREA IN NICOSIA

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Nowadays floods are considered to be one of the most devastating natural disasters worldwide. A flood can be determined as a mass of water that produces runoff on land that is not normally covered by water. Ecosystem and floods are closely related and any changes in the ecosystem, such as urbanization across the catchment's area, may trigger off a sequence of flood occurrence causes. However, earth observation techniques such as satellite remote sensing can contribute toward a more efficient flood risk mapping according to EU Directives of 2007/60.

The main goal of this study is the digital mapping of urban sprawl in a catchment area in Cyprus and the assessment of its contribution to flood risk. The area under investigation is the Yialias River at Potamia catchment area in the broader region of Nicosia - Cyprus. The certain area has suffered from several flood disasters in the recent past. For this study land cover maps were developed using multi-temporal satellite imagery (e.g Landsat TM\ETM+, ASTER, Quickbird, GeoEye, etc.). The land use regime has been examined in detail using sophisticated post-processing classification algorithms such as Maximum Likelihood, Parallelepiped Algorithm, Minimum Distance, Spectral Angle and Isodata. Moreover, object – based classification methodology was applied to Landsat images to segment and classify them in order to map the urban areas expansion not only according to their spectral characteristics but mainly according to their geometry. The land use change results were inserted to hydrological models in GIS environment and indicated the linkage of land use change and hydrological regime in terms of flood hazard. The results of diachronic land use cover highlighted a considerable increase of urban areas during the period of the last 30 years. These results denoted that the main driving force of the constantly increasing flood risk in catchment areas in Cyprus is generally found to human activities and socio-economic factors.

The project is supported by the Cyprus Research Promotion Foundation.

DETERMINATION OF FLOW PROPERTIES BY ENTROPY CONCEPT IN STREAMS

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In recent years, the importance of water has been increasing due to rising water demands which is related to higher population, industrialization and agricultural developments. However, the changes in the relation between rain fall and run off along with climatic and environmental parameters complicate the control and usage of water resources. The distribution of flow velocity, one of the basic properties of river flow is directly related to other flow properties, such as the shear stress distribution, secondary flow, as well as sediment and contaminant transport.

The velocity distribution profile in an open channel flow was depicted by an entropy-probabilistic approach. These analyses allow an easy employment in the field of applied hydraulic engineering due to the use of simply-derivable parameters instead of difficult and hardly measurable ones. The maximum velocity, v_{max} , at a cross-section in an open channel flow can be related to the mean velocity over that section, V , in conjunction with the entropy parameter, M . The M value of a channel section contains information about its overall hydraulic characteristics. The kinetic energy and momentum correction coefficients, α and β , also can be depicted as functions of M .

In this study, flow in Natural River has been investigated by using entropy concept together with field data. Field measurements were undertaken on Kızılırmak basin, which is located in the central Anatolia in Turkey. These measurements were taken at two different stations on Sarımsaklı River which is a branch of Kızılırmak River. Velocity measurements were taken for in bank flow conditions by using an Acoustic Doppler Velocimeter (ADV).

Flow discharge can be determined by entropy concept with predetermined M for a channel section. Also two-dimensional entropy velocity distribution equation gave good results with measured profiles than classical equation such as logarithmic distributions.

A NUMERICAL MODEL OF THE WAVE THAT OVERTOPPED THE VAJONT DAM IN 1963

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The Vajont landslide took place in Northern Italy on October 9th 1963 and caused a huge impulse wave to travel inside the artificial reservoir with an impressive runup that reached and damaged buildings located ca 235 m over the original height of the lake surface. A portion of the water displaced by the landslide overtopped the dam and reached the Piave river at Longarone. The wave flooded and devastated a considerable area along the Piave riverbed, reaching also villages located about 5 km upstream of Longarone. In this event about 1900 people died, 1700 of them only in the Piave Valley.

The water depth of the wave in some points exceeded 50 m. Although the phenomenon is clearly tridimensional, the application of a pure 3D hydraulic numerical model to this wide and natural territory is very difficult with the present computer technologies.

Recently, the authors have presented a numerical model of the impulse wave that wasted the Vajont basin as a consequence of the landslide. Up to date no numerical models have been developed or applied to study the evolution of the wave in the Piave Valley. In the present paper a 2DH finite volume numerical model is applied to study the effects of the overtopping wave in the Piave Valley.

The results of the simulations are compared with the documentation available in the literature, that consists mainly in historical pictures of the Piave Valley in the days just after the event, in order to verify if the simplifications assumed by a 2DH model still allow the evolution of the wave to be described in proper manner.

TWO-DIMENSIONAL MODEL FOR OVERLAND FLOW SIMULATIONS: A CASE STUDY.

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This paper deals with the problem of floods generation and propagation at catchment scale. The main aspect of the work is the use of 2D fully dynamic shallow water equations as tool of analysis for spatial and temporal overland flow evolution starting from an observed or predicted rain input. The rain input, and infiltration losses, may be considered as a source term in the mass continuity equation.

The paper firstly focus on the model description. As regard the hydraulic propagation model, the fully dynamic 2D shallow water equations are undoubtedly the most accurate approach to describe, from an hydraulic point of view, the overland flow behavior at catchment scale. In the past, the significant difficulty of achieving stable computations, especially in natural topography, have somewhat limited the use of this approach. In the paper these problems will be described and the solution will be proposed.

Then the methodology were tested using a well-described event occurred in a small basin whose drainage area is around 40 km².

MODELLING OF INDIAN SUMMER MONSOON RAINFALL USING GLOBAL CLIMATIC TELE-CONNECTION DATA

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Development of the models for forecasting the Indian Summer Monsoon Rainfall (ISMR) has been the subject of research among various researchers in the past. An extensive literature review in this area suggests a strong need to consider the global tele-connection data in and around Indian sub-continent in a systematic manner in order to develop meaningful models to forecast ISMR. Indian monsoon dynamics is extremely complex, non-linear, and dynamic in nature and needs to be modeled using tools capable of capturing such dynamics inherent in the data involved. A key step in the mathematical model development is the input variable selection. Most of the models proposed so far have employed the use of linear dependence measures of correlation coefficients, which are not suitable for assessing the strength of relationship inherent in the inputs and outputs of a physical system involving high degree of non-linearity and complexity. The attempts on the use of non-linear statistical methods based on mutual information and partial mutual information (PMI) have been lacking so far.

The objective of the present study are to (a) investigate the use of global climatic tele-connection data in developing models to forecast ISMR in a systematic manner, (b) investigate the use of non-linear input variable selection methods of PMI for developing mathematical models for ISMR prediction, and (c) employ both regression and artificial neural network (ANN) models to develop the monsoon rainfall in India. The monthly rainfall data for All India, global tele-connection data of monthly average surface temperatures, and monthly average of the zonal and meridional wind components at a resolution of $2.5^\circ \times 2.5^\circ$ in a window covering the entire Indian Sub-continent on the North and Indian Ocean up to Australia to South are employed in this study. The results from naive models, linear and non-linear regression models, and ANN models are presented here. The performance of various models is evaluated using a wide variety of standard statistical parameters and graphical aides. The preliminary results obtained in this study for forecasting monsoon rainfalls for the months of June, July, August, and September for All India indicate that the ISMR can be effectively modeled using the global tele-connection data in the window considered in this study. Further, it has been found that the non-linear methods based on PMI can be used advantageously in the modeling of complex systems. The systematic approach adopted for input variable selection in this study has helped in developing accurate models for ISMR prediction.

FLOW STRUCTURE IN A COMPOUND CHANNEL WITH SMOOTH AND ROUGH FLOODPLAINS

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Compound channels are the most usual configuration of rivers when extreme events of floods occur. The momentum transfer due to the difference of the velocities between the main channel and the floodplains flows generates a complex 3D flow. Accurate estimation of channel capacity remains a difficult issue.

Although several studies have been carried out in the past, a new experimental study aims revisiting some of the previous experiments in a facility where the upstream water supply is separated.

The first results of this study are presented in this paper and the main characteristics of the flow in a compound channel are described. The experimental facility consists in a 10.0 m long, 2.0 m wide and 0.7 m high rectangular horizontal flume. The main channel is 0.4 m wide with a water depth of 0.1 m. To simulate the compound channel, two symmetrical floodplains 0.7 m wide have been constructed. The slope of the flume bottom is 0.0011 m/m. The bottom is made of polished concrete. Half of the experiments presented in this work were done with the floodplains covered by artificial grass, a hydraulically rough boundary. Besides other measurement instruments, a Vectrino ADV was used allowing the measurement of both streamwise and spanwise velocity components. When the water depth is sufficient, namely in the main channel, the vertical velocity was also measured.

In order to avoid the mass transfer in the beginning of the channel, the upstream water supply is separated between main channel and floodplains taking into account the recommendations present in recent literature.

Four different discharges were tested, corresponding to uniform flows for relative depths (ratio of the water depths in the floodplain and in the main channel) equal to 0.15 and 0.3, for smooth and rough floodplains.

The influence of the relative depth and the floodplain roughness is evaluated and the main characteristics of the flow are presented. It includes the lateral distributions of streamwise and spanwise velocity components, boundary shear stress, Reynolds stresses and turbulence intensities.

Finally, a comparison of 1D methods for estimating the discharge capacity of this specific geometry and roughness is made. The models tested were the Divided Channel Methods (with several divisions), the Coherence Method, the Integrating Divided Channel Method, the Weighting Divided Channel Method and the Exchange Discharge Method (EDM). The accuracy of these models is assessed.

A NEW MODELING TOOL FOR DETERMINING THE CATCHMENT HYDROLOGICAL RESPONSE (CASE STUDY: ISONZO RIVER)

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The River Basin Authority Alto Adriatico is responsible for the management of rivers flowing into the Northern Adriatic Sea. With the purpose of contributing to the general objective of theme “Advanced models and methods to improve the understanding and mitigation of hydrological extreme events”, the paper contributes the experiences that are becoming part of the European project KULTURisk, that aims at developing a culture of risk prevention by means of a comprehensive demonstration of the benefits of prevention measures. KULTURisk first focuses 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. To achieve the aims of the project an innovative catchment scale hydrological model has been implemented.

The basin hydrological response is estimated using a semi-distributed, continuous, hydrological model based on a Geomorphoclimatic theory, relating the shape and scale of the catchment transfer function to stream network topology, channels characteristics and climate. Snow accumulation and melt are represented by using a distributed version of the UEB model, while the soil water balance is solved towards a realistic description of the temporal dynamics of soil moisture, with a physically based parameterisation which allows use of vegetation coverage, soil texture and local slope data. 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 (2000-2008) of quality-controlled hourly data.

THE USE OF METEOROLOGICAL INFORMATION IN REGIONAL RAINFALL FREQUENCY ANALYSIS

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The regional frequency analysis is useful to estimate more accurately precipitation quantiles than at-site frequency analysis, especially in case of regions with short record lengths. The identification of homogeneous regions has a significant effect on quantile estimation in the regional frequency analysis. In the Valuation of Flood in Italy (VAPI) project, the selection of homogeneous regions, for organizational reasons, was carried out starting from the “compartments” of the Italian Hydro-graphic Service. Both homogeneous regions and sub-regions, wherein the theoretical distribution of skewness and coefficient of variation (or the equivalent sampling L-moments) fit the sampling values, were selected by the use of cluster analysis.

This regional procedure, named “hierarchical approach”, based on the Two Component Extreme Distribution (TCEV) has been applied almost all over the National territory and intensively used in the hydro-geological plans (PAI). While the selection of distribution and the estimation of regional parameters were problems exhaustively detailed, the selection of regions and, especially, relationship between rainfall duration and homogeneity is an open question today. The hydrological homogeneity mainly arises from strong interactions between climate and orography. Use of meteorological information, combined with rainfall data may improve research of homogeneity. This work, after inferring many thermodynamic indexes that affect rainfall, tries to select some of them able to locate territorial homogeneity. Starting from 1958, more than 200 extreme events have been identified all over the National territory. The corresponding re-analysed meteorological data of the ERA40 archive of the European Centre for Medium-Range Weather Forecast (ECMWF) have been analyzed to locate homogeneous macro-regions for the Convective Available Potential Energy (CAPE), the Q vector Divergence (QD) and the Vertically Integrated Moisture Flux (VIMF). The latter, showed to be the best candidate to find regional homogeneities. This paper presents an application of the proposed methodology, based on the delimitation of homogeneous regions using the VIMF, for the Sicilia isle. Results show that the proposed methodology may be useful in regional analysis. A selection of seven homogeneous areas, inferring only by the VIMF data, verifies the homogeneity of the regions with the VAPI procedure and the heterogeneity test proposed by Hosking and Wallis both.

A PARAMETER ESTIMATION TECHNIQUE FOR THE NONLINEAR MUSKINGUM FLOOD ROUTING MODEL

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A novel optimal parameter estimation technique based on particle swarm algorithm is proposed for the nonlinear Muskingum flood routing model. In the proposed technique, a new approach based on penalty terms are imposed in the numerical solution of the model in order to prevent negativity of outflows and storages. The performance of the proposed method is compared with reported techniques given in the literature through two applications. The results obtained for two applications demonstrate that the proposed algorithm can confidently be applied to estimate optimal parameter values of the nonlinear Muskingum flood routing model.

STORMWATER MODELING IN AN URBAN RUNOFF COLLECTION SYSTEM USING SWMM: A CASE STUDY

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A common concern for municipality authorities in big cities is the management of storm water in urbanized areas with considerable percentage of impervious areas which causes to increase flood flows. Modeling existing urban runoff collection systems is a best way to evaluate the performance of the existing systems and to present potential best management practices (BMPs). This paper presents the performance of an urban runoff collection system modeled by a conventional storm water simulation model known as SWMM. The model was applied to the Jamshidiyeh river watershed, including a 2950 ha urban catchment and a 350 ha mountainous catchment located in northern part of Tehran city in Iran. Estimates of CN values were obtained using digital soil and land use maps. The hydrologic model was calibrated for a storm event using 50-year return period precipitation data generated from three rain gauges within and outside the watershed. To achieve a proper result in the case study, a fully distributed hydrologic model was made to account for the complex hydrologic, topographic, and network flow processes involved, and to reflect the greater location flexibility. Therefore, the catchment was separated into 16 subcatchments and some main channels draining storm water into the catchment outlet. Moreover, digitized model of the catchment was provided by using Surfer Software. Input file for SWMM was provided by editing all point data in Autodesk map software. Some point data was also extracted from networking and interpolation by Kriging method. Finally, the main channels were modeled by SWMM model to assess the capability of the system in collecting and transferring the storm water into the watershed outlet. Possible BMPs including detention ponds and main channels restorations such as the change in their dimensions were offered for the volunteering points where overflows would occur within storm water event. Some rules were also generated for the operation of control devices within the main channels to alleviate the magnitude of the floods. The results show the capability of the SWMM and BMPs in the management of storm water in urban areas.

NATIONAL ESTIMATION OF SOCIETAL RISK OF FLOODING IN CHINA

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Floods hits China every year with large damage in terms of loss of life and economic damage. The direct economic loss caused by floods accounts for roughly 1.6% of GDP per year in China (1990-2009) and the fatality is estimated at approximately 4510 per year during the past 60 years. This paper is going to address a question of what the nationally acceptable risk of flooding in terms of loss of life in China is. The objective is to estimate societal risk of flooding in term of loss of life in China, which provides a scientific basis for policy makers to make efficient and innovative mitigation measures on flood management. The main approach of estimation is based on the proposed risk averse measure of societal risk by Prof. Han Vrijling, which is used to test the situation on the loss of life of flood disaster on the national level and also proved by many applications in the Netherlands. The results indicate that it requires more efficient mitigation measures (engineering and non-engineering) on flood risk management.

PROBABILISTIC FORECASTING OF ANTECEDENT SOIL MOISTURE CONDITIONS AS FLASH FLOOD PRECURSOR VARIABLES

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Flood forecasting is a rather complicated task, particularly in those catchments which are prone to flash flood formation or in which the response time is of the order of few hours and, even brief anticipation are important and appreciated. In this context, some kind of hydrological precursors can be considered to improve the effectiveness of the emergency actions (i.e. early flood warning). Now, in literature has been widely recognized how soil moisture is an important factor in flood formation, because the runoff generation is strongly influenced by the antecedent soil moisture conditions of the catchment. The basic idea of the work here presented is to use soil moisture forecasting to define a first alert phase in flash flood forecasting chain. For the soil moisture conditions modelling and forecasting, the UBC model which is a semi-distributed continuous conceptual hydrologic model was used. The model is made up of several sub-routines: the sub-routine for the distribution of the meteorological data, the soil moisture accounting sub-routine, and the flow routing sub-routine. The soil moisture sub-model sub-divides the water input (rain and snowmelt) into four components of runoff namely, fast, medium (interflow), slow (upper groundwater) and very slow (deep groundwater). An important aspect of the soil moisture sub-model is the “impermeable area” - fast responding region of a watershed which is assumed to be adjacent to a well developed stream channel system. This area changes as a function of soil moisture deficit and has been used to describe the fast responding watershed runoff behaviour. Application of the proposed methodology has been carried out with reference to two river basins, one in Cyprus and another in Sicily, Italy.

LABORATORY EXPERIMENTS OF DAM BREAK FLOWS DOWN AN INCLINED CHANNEL

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Dam break waves are extreme hydrologic events that occur in diverse settings. They may result due to the collapse of either natural or man-made dams and they have been responsible for huge economic and human losses. The study of such a phenomena is extremely important in providing the information needed for risk assessment and management of river valleys.

Laboratory experiments were undertaken to investigate a range of pure water-driven dam break flows down a variably sloping, rectangular fixed bed channel. A 3 metre long, 10 centimetre wide channel made of two vertical glass walls and an aluminium bottom was built for the experiments. An upstream reservoir was connected to the channel by a gate perpendicular to the bottom that could be opened suddenly by two pneumatic jacks simulating a rapid dam break. The effects of varying the controlled parameters (i.e., the channel slope, the bed roughness, the volume of water in the reservoir) were explored. The channel inclination has been varied between 1,5° and 24°. In order to test for the effects of varying the bed roughness, three different types of channel beds were considered: an aluminium plate smooth bed and two different rough beds realised by glass beads fixed to the aluminium plate itself, with nominal diameters of 0.75-1mm and of 2mm.

A high-speed digital camera, running between 500-800 Hz, was used to track the flow along the first 2 metres of the channel: it was necessary to capture the first and the second metre in two separate experiments and to illuminate the channel with 4000W to achieve the required optical resolution. The images were processed using the commercial software *MatLab* to compute the front wave position and velocity, the maximum water height, the passing wave depth and the wave profile.

The continuity of results observed over the first metre transition where camera locations changed indicates good experimental repeatability. It was found that various dimensionless variables were applicable to some of the results that negated the influence of the volume of water in the reservoir. The regression analysis of the raw data and trends of the data fitting coefficients could be particularly useful for scaling and extrapolating the flows to full scale.

A SYSTEMIC ANALYSIS OF THE FLOOD THREAT IN GORGANROOD BASIN, IRAN; USING A DPSIR FRAMEWORK

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In the recent decade, dramatic flood events have impacted Gorganrood Basin, in the North-east of Iran. To investigate and analyze the causes of flooding and its influences on the basin socio-economic system, a DPSIR (Driver-State-Pressure-Impact-Response) framework has been developed. Based on the framework, the present paper will deal with the important driving forces responsible in flooding such as climate change and changes in land use. It will be shown how development of causal chains can help better identify the inter-relations of elements and issues in the area. Using the DPSIR framework, the paper goes further to develop indicators to measure and monitor responses associated to the other four parts, i.e. drivers, states, pressures, and impacts in the basin. The indicators are also used to analyze responses in terms of flood resistance policies and actions. A major response to flooding in the basin was to construct a reservoir (named as Golestan II dam). Having analyzed the casual chains, the paper will show that structural responses such as construction of the dam was not a sufficient response since it initiated other drivers to grow resulting in more flood damages. It is required to control the main drivers using appropriate policies mostly rooted in social and economic sectors.

MONTHLY MONSOON RAINFALL FORECASTING USING REGRESSION AND ARTIFICIAL NEURAL NETWORK MODELS

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Forecasting of monsoon rainfall has been one of the most important tasks in water resource development and management. Indian agriculture sector heavily depends on monsoon rainfall for successful harvesting. In the past, prediction of rainfall was mainly performed using regression models, which provide reasonable accuracy in the modelling and forecasting of complex physical systems. Alternatively, Artificial Neural Networks (ANNs) have been proposed as efficient tools for modelling and forecasting. The objective of this study is to investigate the use of ANNs in forecasting of monsoon rainfall in the North Central region of India and for whole of the country. A feed-forward multi-layer perceptron type of ANN architecture trained using the popular back-propagation training algorithm was employed in this study. Other techniques investigated for modeling monthly monsoon rainfall in India include regression and naive models for comparison purposes. Both linear and non-linear regression models are developed. The data employed in this study include monthly rainfall and monthly average of the daily maximum temperature in the North Central region in India and all across India. Specifically, four regression models, two naive models, and one ANN model have been developed. The performance of various models was evaluated using a wide variety of standard statistical parameters and graphical aides. The results obtained in this study for forecasting monsoon rainfalls for the months of June, July, August, and September for North Central region of India and All India have been encouraging. India's economy and agricultural activities can be effectively managed with the help of the availability of the accurate monsoon rainfall forecasts.

IDENTIFICATION OF THE SCS-CN PARAMETER SPATIAL DISTRIBUTION USING RAINFALL-RUNOFF DATA IN HETEROGENEOUS WATERSHEDS

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Knowledge of the mechanisms controlling runoff generation is important in hydrology, civil engineering and other environmental sciences. Simple methods for predicting runoff from watersheds are particularly important in hydrologic applications, such as flood design and water balance calculation models. The Soil Conservation Service Curve Number (SCS-CN) method is widely used for predicting direct runoff volume for a given rainfall event. However, previous results indicated that when the CN value is determined from measured rainfall-runoff data in a natural watershed it is not possible to attribute a single CN value to the watershed, but actually the calculated CN values vary systematically with the rainfall depth. In a previous study, the authors investigated the hypothesis that the observed correlation between the calculated CN value and the rainfall depth in a watershed reflects the effect of the inevitable presence of soil-cover complex spatial variability along watersheds. It was shown that the presence of spatial variability in the watersheds produces a progressive decrease in the calculated CNs as the storm size decreases and for excessively large storm sizes the CN tends to stabilize in an asymptotic “composite” CN value.

In this study, a method to determine SCS-CN parameter values from rainfall-runoff data in heterogeneous watersheds is proposed. This method exploits the observed correlation between the calculated CN values and the rainfall depths in order to identify the spatial distribution of CN values along the watershed taking into account the specific characteristics of the watershed. The proposed method utilizes the available rainfall-runoff data, remote sensing data and GIS techniques in order to provide information on spatial watershed characteristics that drive hydrological behavior, which is valuable in environmental hydrologic analysis and modeling. Furthermore, it allows the estimation of CN values for specific Soil-Land Cover complexes in more complex watersheds.

The proposed method was tested in a small experimental watershed in Greece. The watershed is equipped with a dense hydro-meteorological network, which along with a detailed land cover and soil survey using remote sensing and GIS techniques provided the detailed data required for this analysis.

DAM- BREACH HYDROGRAPH MODELLING: AN INNOVATIVE SEMI-ANALYTICAL APPROACH

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The implementation of the EU- Flood Directive is based on a three phase estimation of flood risk in flood prone areas. The first phase aims at the preliminary determination of the areas potentially affected by flood hazard of any cause whereas the second and the third phases are devoted to detailed calculations for producing flood hazard maps and flood risk maps. In a particular class of flood prone areas (although not explicitly mentioned in the directive) belong those areas which are located downstream of all constructed dams. The delineation of the areas exposed to flood hazard created by the dam existence and its possible failure, needs a thorough simulation of the dam-break incident. Further the downstream flood levels and discharges resulting from the dam failure require the best possible estimation of the breach outflow hydrograph.

The study presented in this paper focuses on the simulation of the dam breach formulation and the resulting outflow hydrograph using a semi-analytical approach. The method belongs to the category of methods with minimal data requirements. It is based on the scientific findings of the last decades, on the acquired experience from real dam break events and on the experience from dam break studies during the design stage of several dams. The method addresses the simulation of earthen dam breach due to overtopping and the calculation of breach outflow hydrograph. Simple, mostly linear, physically based and semi- empirical equations are used for simulating the breach formation and for attaining the outflow hydrograph from the dam breach. Algebraic equations for simulating the dam- breach and the outflow hydrograph are obtained for the parabolic shape of the breach.

Finally sensitivity analysis is performed for the values of the main parameters and assumptions adopted in the study. It was concluded that the most sensitive determinant is the rate of vertical erosion. The method is illustrated through case study of an earthen dam studied under hypothetical scenarios of failure.

STORM DEPTH DURATION MODEL FOR A SEMI-ARID AREA IN PAKISTAN

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Rainfall depth varies both spatially and temporally in nature. The current research is conducted in Khyber Pukhtoonkhwa of Pakistan (different adjacent zones with continuous data record of 5, 15, 16, 17, 21, 24, and 26 years) for these behaviors of storm from depth-duration developed model gives an estimation for expected floods. Method of least square of the regression analysis, multiple regression analysis, annual extreme series and method of trial and error are used for the purpose. The values of exponent 'n' found out are 0.18, 0.18, 0.22, 0.29, 0.31, 0.37, 0.39 are within the standard limit of 0.20 to 0.50 (V. M. Ponce, 1990) increasing from south towards north as in table IV. Return period and probability have also been estimated (table III). The functions are plotted (Fig.4), are compared with that of Sicily, Sardinia, India and world's largest events of rainfall 0.38, 0.34, 0.20, 0.50, 0.475, 0.48 respectively. The value of 'n' found out by current methodology is 0.49 for world's largest events. The variation in the value of 'n' shows the temporal and spatial nature of rainfall. The functions developed may be used for estimation of storm depth of any duration for the future.

5. INNOVATIONS IN WATER SUPPLY AND DISTRIBUTION SYSTEMS

WATERLOSS MODELLING FOR URBAN WATER DISTRIBUTION NETWORKS

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Control of water losses associated with inefficiencies of the underground water distribution system is very important for all countries with arid climate conditions and shortage of water supplies, because they are causing not only revenue losses for the local Water Boards but most importantly they negatively affect the national water reserves. Presented herein is an integrated mathematical model for the management of water distribution networks based on data from two different water distribution networks, spanning a period of about 10 years. The proposed methodology focuses on the sustainable management of water piping networks through the development of a mathematical model which aims the creation of a multiparameter decision system based on artificial neural networks and fuzzy logic. The goal is to enable the field engineers and maintenance technicians of water utilities to better manage condition assessment information, to process historical records with a number of analytical and numerical models, to identify underlying data patterns with artificial intelligence techniques and eventually to assess the corresponding risk of failure of each network element. Such management strategies should assist the network owners evaluate the condition of their network, assess historical incident and risk of failure data and prioritize the work based on the inherent risk and cost of action.

The effort is part of a research project funded by the Cyprus Research Promotion Foundation (under Grant No. PENEK/0308/36) and the European structural funds, titled “*Urban Water Distribution Modelling, Simulation and Optimization of Leakage Detection Via Sensing Technologies (UWDM)*”, having at its core not only the aforementioned analytical tools but also the utilization and integration of wireless sensor networks for the processing of information on operational characteristics of the network.

EVALUATION OF RESERVOIR PERFORMANCE BY AN ENTROPY-BASED INDEX

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Operation of water supply reservoirs in scarcity periods requires appropriate rules for the proactive reduction of water release, aiming to prevent very severe and unbalanced deficit concentrations. Operation rules need to be evaluated in order to ascertain that an improved time-spreading of release does not imply unacceptable increase of the overall deficit due to increased evaporation and overflow. Also, it is necessary to check unacceptable sacrifices on any user. Evaluation is a major step in the development of rules. Despite the multiobjective nature of the problem, the complexity and controversial nature of a multi-index approach and the need of skimming alternatives ask for a synthetic evaluation.

A synthetic performance index I_p is introduced for a joint evaluation of the overall release and of the "goodness" of the deficit distribution in time and space. It is defined as the product of a "base value" R_b expressing the overall release as ratio to overall demand, times a reduction coefficient C_e expressing the deficit concentration, in time and among users:

$$I_p = R_b \cdot C_e$$

The Shannon entropy S is borrowed from the communication theory as the base for the measure of the spreading goodness. According to Shannon, entropy measures how much uncertainty is in a discrete probability distribution P_i , with $i=1, N$. It is defined as follows:

$$S = - \sum_{i=1, N} (P_i \cdot \ln P_i)$$

In order to transfer the entropy concept, the following specifications apply:

- N is the number of "release cells", equal to the sum of the number of time cells with non-zero demand, extended to all users;

- $P_i = D_i / (\sum_{j=1, N} D_j)$ is the probability of a droplet of deficit D to occur at cell i :

In order to stay in a 0-1 range, entropy is normalized with respect to its maximum. Its complement, measuring the non-uniformity of the distribution, is multiplied by $(1-R_b)$ in order to weight it with the overall deficit. Its complement to unity is assumed finally to serve as the disuniformity coefficient C_e :

$$C_e = 1 - (1-R_b) \cdot (1 - S/S_{max})$$

so that

$$I_p = R_b \cdot [1 - (1-R_b) \cdot (1 - S/S_{max})]$$

The use of the proposed index is shown for the real case of the operation of Lentini Reservoir, in Sicily.

EVALUATION OF DOMESTIC WATER SAVING BY ROOFTOP RAIN WATER COLLECTION IN SICILY

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In many parts of the world, domestic rain water harvesting (DRWH) has become an important water source option, especially for areas affected by restricted availability of freshwater.

It is largely recognized that rain water can replace potable water from mains for several less quality-exigent uses in houses such as toilet flushing, terrace cleaning, or private garden watering. Results of investigations concerning the analysis of water uses in urban households for water saving objectives have shown that up to 30% of water in houses is typically used for toilet flushing. This value suggests potentially high water saving benefits from the primary use of harvested rain water for the toilet flushing. For this use storage tanks with limited size are required, being the daily toilet water demand as relatively constant during the year.

There is a large literature concerning methodologies to estimate performance and sizing of rainwater harvesting systems. Approaches include water balance simulation analysis, probabilistic methods and economic optimization. In general, results indicate that storage capacity cannot be standardized, being markedly influenced by site-specific variables such as local rainfall, roof area, potable water demand and number of people in the household.

In order to generalise results, some authors have recently started investigating the variability of water saving at different spatial and temporal scales. Fewkes (2000) investigated how spatial and temporal fluctuations in rainfall could be incorporated into behavioural models of DRWH systems.

In 2009, a specific research program has been launched at the University of Catania (Italy), to investigate water saving obtainable by rooftop rain water harvesting for domestic use.

In this paper research results concerning a regional scale analysis to evaluate the water saving performance of rooftop DRWH systems are presented.

The adopted methodology to evaluate water saving is presented along with an application to 17 rainfall gauging stations in Sicily (Italy). Compared to existing methods in literature, a novel dimensionless parameter, namely modified storage fraction is introduced to better describe the character of the rainfall patterns.

A parameter-parsimonious and easy-to-use regional regressive model to evaluate the water saving performance of a DRWH system is derived, based on the results of a daily time step behavioral model with a yield-after-spillage algorithm as tank release rule.

The region wide regression model for fixed frequencies of exceedance demonstrates good fits (R^2 close to 0.98) between model predictions and simulated water saving performances

URBAN WATER DISTRIBUTION NETWORK PERFORMANCE UNDER INTERMITTENT WATER SUPPLY CONDITIONS

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Faced with extended periods of drought and in short supply of water, Cyprus had in recent years turned to enforced intermittent water supply as a measure to curb consumer demand and to prolong the country's national water reserves. The measure, even though extreme and unthinkable in many other countries around the globe, was deemed a must by the Cyprus' national and local authorities as the extended drought engulfing the island coupled with an observed desertification and a heightened tourism-related demand for water, brought the water reserves to a dangerous low and the island to its knees.

The measure for intermittent supply was enacted nationwide in April 2008 and eventually ended in mid 2010, upon the successful accelerated construction of additional desalination and wastewater treatment plants that significantly increased the volume of available/usable water. Noteworthy is also the fact that during the same period (2008-2009) and in wait of the new water plants to come online, the national authorities had gone through the extreme measure of importing water from a neighbouring country by use of tankers.

The work presented herein investigates the effects of intermittent supply on the performance of the underlying urban water distribution piping networks (UWDN) and on the fragility of such networks, examining the resulting water losses, inefficiencies and overall maintenance cost on these networks during such extreme operating conditions. The analysis is based on a six-year dataset (2003-2009) from the largest urban locale on the island, and it includes information on breakage incidents, operating network parameters, external factors (such as the prevailing weather conditions) and vulnerability assessments.

A variety of data-mining and survival analysis techniques are employed in examining the aforementioned factors and in evaluating the effects of such intermittent supply strategies on the vulnerability of the water pipes and on the sustainability of the strategy. Preliminary analysis results show an increase in the number of water-leak incidents of approximately 28% during the year of enacting the intermittent water supply policies, mostly due to breaks on the house connection pipes. An analysis of the data for years 2009-2010, even though still in progress, also shows a increasing trend, adding to the alarming signals in relation to the effects of intermittent supply and the increased vulnerability of UWDNs. Data stratifications of the type, the material and diameter of each pipe, the seasonal weather, the soil conditions and the water pressure levels at the time of each water-leak incident are also in progress, shedding light to the behaviour of the piping network under the aforementioned adverse operating conditions.

WATER SUPPLY NETWORK PROTECTION FROM MALICIOUS ATTACKS BY SECTORIZATION

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Water supply networks are sensitive to several malicious attacks that can potentially affect every single phase, from water adduction to distribution to end-users. One of most dangerous threats is a backflow attack that occurs when a pump system, easily available on the market, is used to overcome the pressure gradient of network pipes. In this case a contaminant can be introduced into the water system and disseminated into the network affecting the areas surrounding the introduction point.

The introduction point can be anywhere in the system but by network hydraulic simulation it is possible to choose the points where the contaminant diffusion can become more massive and dangerous.

In this work, after modeling a simple backflow attack by introducing cyanide into the water network of Parete, a town in the Province of Caserta, the areas of greatest vulnerability have been investigated and an introduction point has been chosen. The network vulnerability has been analyzed by computing the cyanide concentration ingested by users during a given time interval of peak water consumption.

Then water system has been subdivided in different subsystems according to water network sectorization techniques used to improve the leakage search and reduction of a Water Distribution System (WDS). These techniques consist in defining some permanent districts, called District Meter Areas (DMA) where boundary valves are installed in order to simplify water balance and pressure management.

In this work, a Parete network sectorization has been proposed to mitigate the perspective damages of a malicious attack. The results show how as network DMAs can significantly decrease contaminant diffusion and protect part of users from cyanide adsorption. Then network sectorization can also reduce the risk of simple malicious attacks because several introduction points are necessary in order to have a wide negative impact on the network. .

The proposed method of water network protection can be developed together with the other improvement techniques of WDS management (leakage reduction, pressure management, etc.) thus becoming cheaper.

COMPARISON OF TWO DIELECTRIC SENSORS FOR SOIL WATER MEASUREMENTS

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Knowledge of the soil water content is a necessary input for a rational irrigation water management. Recently new devices have been manufactured and promoted, which cheaply, easily and non-destructively provide estimates of the soil water content, θ , on a routine basis. These are named “dielectric” devices, since they estimate θ from the dielectric constant of the soil, ϵ . Before using these devices, a calibration procedure is recommended and also an investigation is needed for their safe θ -estimation and accuracy limits under various conditions, regarding soil water content uniformity, presence of salts, soil structure and mineralogy etc.

Two such dielectric devices, namely the WET and the ML2-theta probe have been studied, which operate at frequencies 20MHz and 100MHz respectively. The results concerning their calibration and performance are presented. These results will be useful both theoretically and practically.

RESERVOIR CAPACITY DETERMINATION WITH A DESIRED RELIABILITY; APPLICATION OF HYBRID ACO-LP ALGORITHM

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The optimal determination of reservoir capacity considering reliable operation of reservoir belongs to a class of large combinatorial optimization problems. The paper proposes a combined Ant Colony Optimization algorithm (ACO) and linear programming (LP) method, named ACO-LP for solving this problem. The basic concept with the proposed modified hybrid ACO is to decompose a large-scale highly nonlinear optimization problem between ACO solver and a LP model for addressing the complicating and non complicating variables, respectively. In the proposed hybrid ACO-LP model, ACO generated solutions of some decision variables that this converted the complicated model to a simple linear programming model. These produced variables are imported into a virtual LP model to satisfy the constraints. With the calculated values of the variables, the objective function is assessed and the results are moved back to ACO model to evaluate and produce some other decision variables to modify the objective function. For showing the applicability of the proposed method, this model was applied to determination of Dez reservoir capacity in Iran. The results are compared with hybrid GA-LP method and MILP model and showed the appropriate performance.

VORTEX SHEDDINGS ON THE INSTABILITY AT SUBSEA SUSPENDENT PIPELINE

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The pipeline will be located at the narrowest section of the strait formed by Turkey and the Cyprus island and will provide water at a rate of 75 million m³ per year (2.38 m³/s). The pipeline will be a submerged floating structure and the subsea section of the pipeline will consist of 1.6 m diameter HDPE (High Density Polyethylene) pipe approximately 78 km long. In the shore approaching sections of the route, the pipeline will be either resting on the seabed or be trenched and backfilled below seabed level. Between the 250 m depth contours on both the Turkish and Cyprus sides, the pipeline will be suspended at a water depth of minimum 250 m. The pipeline will be spanning from vertical tethers anchored to the sea bed in spans of approximately 400 - 500 meters length each.

Under loading wave and current loads and consequence of von Karman vortex shedding the structure of pipeline have horizontal displacement by lateral vibration. So as, pipeline have very long dimensions, the vortex sheddings are dislocated on the two hands in checker-wise (zigzag). The mathematical description of these lines gives in complex view [1,2]. In this form distribution

of vortex shedding are stable by following condition: $\sinh \frac{h}{a} \pi = 1 \Rightarrow \frac{h}{a} = 0.281$, where a – wavelength on the pipe, h – height of wave. The frequency of these vortex shedding are definition

as, $\theta = 0.22 \frac{v}{D}$, where v – velocity current (m/s); D – diameter of pipeline (m); 0.22 – Struchal number for cylindrical systems. The wave forces on the pipeline are defined over Morrison equation.

So as, sub sea suspending pipeline have analogy with suspending bridge, we have dynamical instability case [3].

During symmetrical vibration modes may be parametric resonance case [4]. Defined internal forces: bending moments and tension in legs by vertical and horizontal displacement of pipeline during longitudinal and lateral vibration.

INNOVATIVE INITIATIVES IN PUNJAB IRRIGATION DEPARTMENT FOR EFFECTIVE MONITORING OF CANAL OPERATIONS

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Irrigated agriculture is the major determinant of economic growth potential of the Punjab Province as it accounts for 26 percent of the GDP and caters for over 40 percent of the province's work force. Over 90 percent of agricultural output in Punjab-Pakistan comes from farmlands irrigated by one of the largest contiguous irrigation systems in the world. The colossal irrigation conveyance network is serving 21 million acres (8.4 million hectare) Cultivable Command Area (CCA) with cropping intensities generally exceeding 120 percent. Hydraulic infrastructure has deteriorated and large deficits in (O&M) maintenance have led to sub-optimal service delivery levels characterized by low water conveyance efficiencies and inequitable water deliveries.

Aware of the crucial importance of water for sustainable socio-economic development, the present Government is according the highest priority to the water resources development and management. The main areas of focus have been rehabilitation and up-gradation of irrigation systems, modernization of barrages, lining of irrigation channels, harnessing power potential, monitoring and improving canal operations and checking water theft, and institutional reforms. In order to improve equity and transparency in the system, Programme Monitoring and Implementation Unit (PMIU) was established in 2006 to implement efficient and optimal canal operations. The Unit has developed Irrigation Management Information System (IMIS) and Decision Support System (DSS) in order to improve the equity and transparency in the system. The Unit has also developed Irrigation web portal (<http://irrigation.punjab.gov.pk>) and different data collection & monitoring modules for timely communication /sharing of information among the stakeholders. A State-of-the-Art Short Messeging Service-Data Transmission System (SMS-DTS) and Complaint Management System (CMS) have been established which helps in communication of field data to the database directly and also addressing the public complaints effectively.

This paper describes the monitoing procedures/modules developed to improve the efficiency of canal operations. Performance Evaluation System (PES) has been framed by linking the IMIS and DSS to closely monitor the channel operation activities to improve equity, reliability and transparency in providing available canal supplies. The above PES has been implemented during Kharif 2007, 2008 and 2009 which resulted an overall improvement of about 5% in delivering irrigation supplies at tails during Kharif 2008 as compared to Kharif 2007. Similarly improvements have also been observed as 14% in Kharif 2009 as compared to Kharif 2007. This improvement is despite 10% and 8% less availability of supply at the head of main canals during Kharif 2008 and Kharif 2009 respectively as compared to Kharif 2007 Season.

EU LIFE PALM PROJECT - DEFINING THE OPTIMUM LEVEL OF LEAKAGE

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Operating a water network efficiently is the stated objective of most water utilities, but it is one that is seldom achieved. The reasons for this are many, but most relate to the lack of detailed understanding of the system. As a result, the network evolves in an ad hoc way, with seemingly one operational purpose: ensuring that all the customers receive some water. The reality is that such an approach is unacceptable as it is neither efficient nor capable of providing an adequate quality of service to the customers.

Leakage is an inevitable cause of the deteriorated condition of a network. As the presence of a leak is not always visible, the situation very quickly get out of hand. The solution is to divide the network into sectors, usually referred to as District Meter Areas (DMA), supplied by a single pipe on which is installed a flow meter. In this way, it is possible to identify immediately the presence of a new leak and direct the detection activity to where it is located.

Reducing leakage has a cost, not just to create a permanent control system, but to locate and repair the leaks. The more leakage is reduced, the more it costs to eliminate. Of course this is offset by the reduction in production costs, which can be enhanced by optimising the pumping. What then is the optimum level of leakage? This is the objective of the innovative, three-year, EU-funded PALM (Pump and Leakage Management) project based in Perugia, which brings together leading international experts in leakage control and pump management.

The city of Perugia is located at the foot of the Apennine. It is supplied by a spring source located high up in the mountains which feeds the city through a number of cascading reservoirs. This source is augmented by a number of boreholes situated in the lower plains, from where the water is pumped up the hill. Not only is the energy cost of this configuration high, but the deterioration in the quality of the aquifer due to agricultural activities, necessitates expensive treatment. It is clear therefore that there is significant scope for optimization. But at what point does the cost of recovering the loss exceed the saving in production? This is what PALM sets out to define, not just in Perugia, but for all networks. In fact, an important output of the PALM project will be the "Efficiency Calculator", which will be freely available on the project web site and which, with the input of key data, will determine the scope for improvement of all networks.

MITIGATION OF DROUGHT EFFECTS ON WATER SUPPLY SYSTEMS

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When a drought occurs, institutions and stakeholders react with impact assessment, response, recovery, and reconstruction activities to return the region to a pre-disaster state. These responses to the hazard effects often result in inefficient technical and economic solutions. The proactive approach to drought management is a more effective mitigation strategy. Risk assessment procedures and optimization of mitigation rules are particularly required for the more vulnerable parts of the systems: the water supply systems. For their management, water storage, as well as demand fluctuation, play an important role. For that reason a dynamic indicator relating supply and demand is required in order to identify situations when there is risk of water shortages. The hydrologic state of the system is evaluated defining some threshold values, expressed in probabilistic terms. Threshold values can be linked to specific actions in an operational context in different levels of severity, like the normal, pre-alert, alert and emergency scenarios..

A simplified model of the water resources system is built to evaluate the threshold values and the management rules. The threshold values are defined considering the probability to satisfy a given fraction of the demand in a certain time horizon, and are validated with a long term simulation that takes into account the characteristics of the evaluated system. The levels and volumes in the different reservoirs are simulated using 30-40 years time series. A demand reduction is related to each threshold level. The rules to manage the system in drought conditions, the threshold levels and the reductions are optimized using long term simulations with different hypothesized states of the system. The critical situations are assessed month by month in order to avoid conditions of total water shortage. Synthetic sequences of flows with the same statistical properties of the historical ones are produced to evaluate the performances of the system. The idea is to test it under a variety of conditions using longer sequences of flows than historically available containing more extreme events than observed.

The methodology is applied to the urban area Firenze-Prato-Pistoia in central Tuscany, in central Italy. The considered demand centres are Firenze and Bagno a Ripoli that have, accordingly to the census ISTAT 2001, a total of 395.000 inhabitants.

PREVENTIVE MAINTENANCE FOR WATER UTILITIES

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Preventive Maintenance for Water Utilities (PM4WAT) is a European Project which develops an innovative web-based platform and courseware for Vocational Education and Training (VET) on state of the art practice on preventive maintenance of urban water utility networks. The project aims at improved maintenance, increased reliability and decreased disruption of service. The proposed training programme involves: (a) a theoretical part, which includes web-based courseware that covers the principles of preventive maintenance for water utilities including the benefits, the limitations and the organisational aspects, and (b) a practical part, which involves a system that integrates a Geographical Information System, Reliability Analysis and Database Queries to compute how ageing and natural hazards affect the reliability of a network under different environmental conditions. The system offers the trainee suggestions on how best to rehabilitate the network under study.

Among the objectives of the above VET Multilateral Project for the Development of Innovation, which is convened in the framework of Lifelong Learning Programme Leonardo da Vinci of the Education, Audiovisual and Culture Executive Agency of the European Commission are: (a) to transfer state of the art preventive maintenance methodologies to personnel of urban water utility networks from domain experts from the participating countries, (b) to develop a simulation platform that advises the trainee on the reliability of the overall network and examines various 'what-if' scenarios, and (c) to develop courseware for web-based as well as offline training on preventive maintenance of urban utility networks which can be tailored to urban networks from all participating countries (Greece, Italy, Cyprus, Turkey).

WATER DISTRIBUTION SYSTEM PERFORMANCE ASSESMENT: BENCHMARKING THREE GREEK CASES USING A MODIFIED WATER BALANCE METHODOLOGY

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The present paper deals with a benchmarking process of three water supply systems performance evaluation in Greece. The goals of the study are: (a) to evaluate the water distribution system performance; and (b) to compare the results taking into account the local factors influencing them. The IWA water balance and performance indicators methodology is used for the performance evaluation of the distribution systems. Basic performance indicators such as Real losses, Apparent Losses, Non-Revenue Water, Unavoidable Annual Real Losses (UARL) and the Infrastructure Leakage Index (ILI) are being estimated. A new proposed modified water balance is used since it is found necessary for the water losses assessment in Greek cases. The proposed modified water balance although remaining a volumetric oriented water audit tool; it also incorporates the economic dimension of the water balance. The present paper uses the results of the water distribution systems for three different Greek cities (Larisa, Kos and Veria). Each one of these three systems has its own characteristics and its operation is being influenced by different local factors/ conditions. These differences make the whole benchmarking process worth attempting. This process revealed that, although all three water utilities experience high water losses levels, they do not actually implement any kind of water losses reduction strategies. Therefore their water systems are categorised in the “worst” category regarding the ILI performance Indicator. Although this “attitude” seems strange and illogical, it has a quite easy explanation. In Greece, the predominant water pricing policy, water utilities apply, includes a minimum fixed charge linked to a minimum water use. This means that when the actual water use of a consumer lays below a certain level (threshold), he is being charged with a minimum amount of water use, even if he never consumes it. This is a clever but not socially just way for the water utility to recover a significant part of the system’s real losses revenues. Finally suggestions are given in the form of a multi steps methodology for the reduction of the water losses.

WATER DISTRIBUTION SYSTEM RELIABILITY BASED ON MINIMUM CUT – SET APPROACH AND THE HYDRAULIC RELIABILITY

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Reliability analysis of water distribution systems is a complex task, as it requires both definition and calculation of several reliability measures. In this paper, a methodology for evaluating water distribution system reliability is developed and demonstrated on a real water distribution network based on the minimum cut set method to express the mechanical reliability and the concept of hydraulic reliability.

The minimum cut-set method is usually used in order to investigate the topology of a water distribution network and the detection of its critical elements whose failure will effect the network operation. The minimum cut set is a set of system components which, when failed, causes failure of the system but if just one component of the set has not failed no failure of the system occurs. Following the cut – set method an estimation of the mechanical reliability of a hydraulic network can be achieved.

For simplification purposes the graph theory is proposed in order to determine the minimum- cut sets. This method is based on the counting of paths between vertices. Using the step function for hydraulic availability and assuming that the occurrence of the failure of the components within a minimum cut set is statistically independent and by applying the principle of inclusion and exclusion, the probability of the pipes break can be estimated.

Furthermore, the general concept of reliability is proposed to include apart from the mechanical reliability, the hydraulic reliability. Therefore even if the network is not disconnected because of the break of a pipe, the pipes break may cause the hydraulic unavailability. The proposed Newton –Raphson method revisited by Spiliotis and Tsakiris (2011) based on h-equations offers a programming support. The sense of hydraulic unavailability can be expressed as a fuzzy set. Moreover the hydraulic nodal reliability is modified to represent the significance of the node based on the nodal demand compared with the total demand. A numerical example is presented to illustrate the proposed methodology.

6. IRRIGATION

COST BENEFIT ANALYSIS OF THE USE OF RECLAIMED WATER IN AGRICULTURE

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The European Water Framework Directive (WFD) prescribes that all water bodies in Europe should achieve the “good ecological status” (GES). Maintaining a certain water flow is a precondition for the achievement of the GES in areas of water scarcity, where the pressure over the resource imposed by the different water users (agriculture being the most important of them) is already very high. This pressure will only increase in the future due to climate change. In this context, the reuse of treated water for agricultural irrigation is considered a promising option and there is an increasing number of reuse projects going on in southern European countries. As part of assessing the viability of the use of reclaimed water in agriculture, and in line with the economic principles underpinning the WFD, a comprehensive economic analysis of this water management option is still needed. The aim of this paper is to contribute to fill this knowledge gap by producing a full cost-benefit analysis of the use of reclaimed water in agriculture in the specific context of the WFD. For this purpose, we undertake a case study in the Segura River Basin, in southern Spain, where the costs of the reuse of reclaimed water in an experimental farm producing mandarins are compared with its benefits. The novelty of our study is that we also incorporate non-market benefits (obtained with the use of a stated preference approach) as the welfare improvements obtained by general public from a more sustainable use of water to ensure the provisioning of environmental services. This type of “intangible” benefits is often ignored in economic analysis, due to the difficulty of its estimation and the hypothetical nature at the basis of the methods available to assess them. However, only the combination of market and non-market costs and benefits can, in line with economic theory, produce a balanced assessment of water management options leading to an efficient and sustainable allocation of the resource.

WASTEWATER REUSE POTENTIAL FOR AGRICULTURAL IRRIGATION IN SICILY

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In Mediterranean countries, water shortage is becoming a problem of high concern affecting the local economy, mostly based on agriculture. In addition, often the problem is not only the scarcity of water in terms of average per capita, but the high cost of making water available at the right place, at the right time with the required quality. In these cases, an integrated approach for water resources management including wastewater is required. The management should also include wastewater (WW) reclamation and reuse, especially for agricultural irrigation, that is becoming a common and rapidly increasing practice in Mediterranean regions, notwithstanding law restrictions and local acceptance. In Italy, WW reuse is regulated by a quite restrictive approach (Ministry Decree, D.M. n. 185/03), especially for some chemical compounds and microbiological parameters; this approach has led some difficulties in promoting WW reuse. On the other hand, at international level, the *Guidelines for the safe use of wastewater, excreta and greywater*, issued by the World Health Organization in 2006, can be used as a basis for the development of standards and regulation to managing the health risk from hazards associated with wastewater use in agriculture.

The main aim of the present paper is the evaluation of the potential of the WW reuse in Sicily. In order to achieve the objective, a Territorial Information System (TIS) at regional level was built to quantify and locate the available WW volumes. In particular, the characteristics of the wastewater treatment plants (WWTPs) (location, altitude, equivalent inhabitants, treatment level, working state, treated volume ...) were integrated, through the TIS, with data on irrigation district areas (surface, location, altimetry, potential evapotranspiration, water needs, available water resources, distance to the nearest WWTP...). Moreover, in order to evaluate the Italian approach to the WW reuse for agricultural irrigation, the water quality of different WW treatment effluents, were analysed on the basis of both the Italian law and the WHO guidelines. The microbiological quality standards of the D.M. n. 185/03 were too restricted. A specific national legislation on acceptable maximum concentration of microorganisms, especially for vegetable crops eaten raw, is desirable.

AN EARTH OBSERVATION ASSISTED TOOL FOR IRRIGATION WATER MANAGEMENT

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Water is a critical issue worldwide and water conflicts are arising in many regions, with available resources diminishing in quantity and quality and the range of uses in competing sectors increasing. Periodic droughts and floods exacerbate conflicts and reveal the increasing vulnerability of water uses. Water for food production, and hence water for irrigation, represents by far the largest share among all uses, while water demand is still growing with increasing population, especially in developing countries.

This paper focuses on newly developed technologies for irrigation water management within a research and technological development project funded by the European Commission's 6th Framework Programme, entitled PLEIADeS (Participatory multi-Level EO-assisted tools for Irrigation water management and Agricultural Decision-Support). PLEIADeS addresses the efficient and sustainable use of water for food production in water-scarce environments. It aims at improving the technical, environmental and economic performance of irrigation schemes by means of a range of measures. A key feature of the project is a set of systems and services integrated with the comprehensive space-time coverage of Earth observation (EO) data and the interactive networking/connecting capabilities of Information and Communication Technologies (ICT). It is also the basis for technical and social learning that enables farmers to act responsibly by fine-tuning their on-farm irrigation management in accordance with the river-basin water status and management decisions.

The project has benchmarked the technical, environmental, and economic performance of irrigation systems in the pilot river-basins, conducted trial campaigns with EO- and ICT-assisted products in a participatory evaluation with stakeholders, and assessed the effect of the new tools on water productivity and performance of the pilot irrigation systems.

In the presented study, the tool introduced and tested by PLEIADeS Project is briefly explained in terms of the Turkish case study irrigation system, while discussing the capabilities of the new technique for irrigation water management and its role in improving the performance of irrigation schemes along with measures that consider the economic, environmental, technical, social, and political dimensions of water management.

SOIL MOISTURE CHARACTERISTIC CURVE DETERMINATION BY USING RICHARDS APPARATUS AND TDR SENSOR (PRELIMINARY EXPERIMENT)

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Knowledge of the soil hydraulic properties, moisture retention curve and hydraulic conductivity is an important issue in every aspect of soil water dynamics and management. Irrigation scheduling and system selection, drainage application, soil quality and land evaluation assessment are procedures requiring the knowledge of the soil hydraulic properties. From the above mentioned properties, moisture retention curve (MRC) is more easily determined in the Laboratory. This can be accomplished in undisturbed or disturbed soil samples collected from various locations and soil depths to suit the application needs. There have been developed various methodologies by which one could determine MRC, such as the Haines apparatus, pressure membranes or Richards cells and others, depending mainly on the pressure head H - range one wants to know the respective volumetric soil moisture Θ . Hydraulic conductivity $K(\Theta)$ or $K(H)$ function is then estimated through the application of a conceptual model which exploits MRC and needs also an independent estimate of K_s , the hydraulic conductivity value at saturation.

In this paper an attempt is made to determine the MRC of an undisturbed soil core in the laboratory by using the Richards apparatus together with a TDR sensor. The apparatus used and the experimental methodology are analytically presented. The advantages and disadvantages of the proposed methodology are discussed. Also a comparison between the proposed methodology and the determination of the MRC only with Richards apparatus is made. Furthermore issues such as using repacked or undisturbed soil cores for MRC determination and time needed for reaching equilibrium at every applied pressure head are discussed.

PRODUCTION OF A 5-YEARS DATASET OF SOIL MOISTURE MAPS ON ITALIAN TERRITORY WITH AN OPERATIONAL ALGORITHM

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The knowledge of the soil moisture state is fundamental in water resources management, agricultural application and drought and flood events prediction. The evaluation of such variable at watershed scale can be achieved by mean of remote sensing techniques. In this work maps of Land Surface Temperature retrieved by satellite imagery have been used in a variational assimilation framework named ACHAB (Assimilation Code for Hydrologic and Atmospheric Budget) in order to provide optimal estimates of the land surface energy balance components and daily maps of soil moisture saturation index (SMSI). The assimilation procedure is able to discern the soil and the vegetation components, and requires ground observations of air temperature and humidity, solar radiation and wind velocity. ACHAB utilizes LST maps from different sensors, in this work images from MSG-SEVIRI and Terra-MODIS have been used. The simulation has been performed over the whole Italian territory for five years (2005-2009) with about 4 km of spatial resolution. A climatology of the SMSI maps has been computed and reliability index maps have been provided for the period of analysis. This study was realized in the framework of “OPERA – Protezione Civile dalle Alluvioni, a project of the Italian Civil Protection aimed to the operational use of satellite data for floods prediction and water resources management.

WASTEWATER REUSE FOR ENERGY CROPS IRRIGATION: CO₂ BALANCE IN TREATMENT SCHEMES FOR CONTROLLED REMOVAL

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The objective of this study is the assessment, by the CO₂ emissions balance, of the environmental and energetic sustainability of urban wastewater reuse for irrigation of energy crops.

The hypothesis is that wastewater is sent to the wastewater treatment plant (WWTP) characterized by treatment schemes for controlled removal, able to remove pathogens and dangerous components for the environment, but able to release nutrients useful for fertigation of biomass.

The wastewater reclamation is obtained modifying a conventional activated sludge process. The new controlled-release scheme produces wastewater with high concentrations of fertilizers and nutrients, such as nitrogen and organic matter, but minimizing risks for the environment, in order to minimize total emissions of equivalent CO₂.

The advantage is that with the same system, setting up a plant configuration rather than another, monitoring the CO₂ emissions induced by treatment reuse chain, we can define the quality level of the effluent that may be more suitable for irrigation of biomass or for the protection of the receiving water.

To test the hypothesis of the proposed simplified scheme, numerical simulations have been carried out by implementing the ASM1 model (Activated Sludge Model No. 1), developed by the International Association for Water Quality using SIMULINK - MATLAB code.

The developed model is able to estimate the emissions of equivalent CO₂ in function of: energy consumption due to wastewater biological, according to the simplified schemes of controlled release; variation of sludge production as a function of different plant configurations; energy consumption for sludge management and disposal; agronomic recovery of nutrients released by the proposed treatment; energy recovery from biomass irrigated with wastewater.

The innovative feature of this research is the assessment of budget of the climate-changing greenhouse gas emissions caused by the simplified treatment for controlled release and reuse of reclaimed wastewater for energy crops irrigation.

This practice expected to promote, first a new management of wastewater treatment plants based on monitoring of climate-altering emissions; second the development of energy biomass and the improvement of agronomic characteristics of soils, especially in Mediterranean areas, that are normally characterized by poor quality soils, lack of organic matter, water shortages and pre-conditions of desertification.

PIXEL-ORIENTED LAND USE CLASSIFICATION IN ENERGY BALANCE MODELLING

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The mass and energy transfer between soil-vegetation and the atmosphere is the process that allows to maintain an adequate energy and water balance in the earth-atmosphere system. However, the evaluation of energy balance components, such as net radiation, sensible and latent heat fluxes, is characterized by significant uncertainties related both to the dynamic nature of heat transfer processes and surfaces heterogeneity. Therefore, a detailed land use classification and an accurate evaluation of vegetation spatial distribution are required for an accurate estimation of these greatneses. For this purpose, in the present paper, a supervised classification was applied to obtain land use maps of the Basilicata region, in Southern Italy, by processing three Landsat TM and ETM+ satellite images. An accuracy analysis based on the overall accuracy index and the agreement Khat of Cohen coefficient evaluation showed a good performance of the applied classification method and a good quality of the obtained maps. Subsequently, these maps were used in the application of a Simplified Two-Source Energy Balance (STSEB) model for estimating the actual evapotranspiration at a regional scale. The comparison of the simulations made by applying the STSEB model and the regional land use maps of the Basilicata with the lysimetric measured data and with the processing of the same model by using the CORINE Land Cover map, has shown the applicability and validity of the proposed methodology. This approach, therefore, represents an evolution from previous applications, because, while maintaining the same level of accuracy in the estimation of evapotranspiration (and sometimes even improving it), allows to process a single image for all the variables within the energy balance equation, describing the physical reality in a more timely and scientifically more correct way.

ECONOMIC VALUE OF WATER IN AGRICULTURE: APPLICATION IN LAKE KARLA, GREECE

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The irrational use of water in agriculture is often responsible for several problems concerning the pollution or depletion of water resources. These problems must be confronted according to the principles of sustainability. Therefore, specific policy measures should be designed so as to protect water resources from harmful agricultural activities, mitigating at the same time their potential impact on agricultural development and on farmers' welfare. The application of economic measures, such as irrigation water pricing, may be conducive to this policy direction, by rationalizing farmers' behavior towards water consumption. The aim of the paper is to assess the economic value of irrigation water, the spatial variability of water values in the boundaries of a river basin, as well as the correlation of those values with significant changes in spatial demand for irrigation water. For these reasons, an indirect valuation method, called "change in net income" has been applied in the study area (Lake Karla, Greece). This method estimates the value of water according to the change in net income between the current irrigated crops and the most economic efficient scheme of dry farming. According to this methodology, the farmer's willingness to pay in a predefined increase in water quantity is considered equal to the change in farmer's income, resulting from this water increase. The irrigation needs of the crops were calculated using the index "Near Irrigation Requirement" (NIR). The result of this method is the estimation of the demand curve of the irrigation water, which graphically depicts the amount of water consumed by a farmer within a range of probable values. The final outcome of "change in net income" analysis displays the spatial variability of water values in Lake Karla Basin. These values fluctuate from 0,030 €/m³ up to 0,129 €/m³. The average value of irrigation water in the reference area was finally found equal to 0,062 €/m³. Finally, important conclusions resulted, regarding the probability of implementing a pricing policy of irrigation water in the future, as defined by the Water Framework Directive and the new national legislation. Such pricing should be based on prices that reflect the real value of the natural resource, in order to achieve the rational and effective use of irrigation water.

WATER MANAGEMENT USING GEOINFORMATICS AND REMOTE SENSING TECHNIQUES: THE CASE STUDY OF MANDRIA, SW CYPRUS

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Estimating crop evapotranspiration (ET_c) is a crucial parameter for monitoring water balance. Further to empirical equations or sophisticated equipments –such as lysimeters- often used for calculating daily ET_c, remote sensing data have been also applied successfully in many parts of the world. The latest has expanded the capabilities of local authorities, since satellite imagery provides a systematically and overall coverage of a vast agricultural area. The final results can be then provided in near –real time to the end users using GIS technology and friendly interfaces.

This paper presents the results of daily ET_c over specific crops in Mandria village, SW Cyprus, using remote sensing data compared to FAO 56 method. Moreover the authors have built the necessary framework where the end users such as the farmers can be benefit from such techniques and innovations. This framework combines both satellite imagery and ground spectroradiometric measurements for verification of the results. Furthermore GIS technology is used in order to archive and analyze the vast amount of data. Water management software can be used from the local authorities for an overall water balance management e.g. irrigation demand. The end users may be alert for any over or below ET_c measurements in their field. This project is funded by the Cyprus University of Technology Research Committee.

ASSESSING THE ECONOMIC FEASIBILITY OF WATER REUSE PROJECTS FOR ENVIRONMENTAL RESTORATION

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Economic considerations are of high importance when assessing the potential of water reuse projects. Economic feasibility studies are essential tools in the decision making process for the implementation of water reuse projects. However, complete feasibility studies is a complex task because while internal impacts may be easily translated into monetary units, external effects are not considered by the market, thus requiring economic valuation methods for their quantification. With the aim to integrate economic and environmental aspects in the design and implementation of water reuse projects, the current study presents a method to assess the economic feasibility of water reuse projects taking both internal and external impacts into consideration. Internal benefits are those directly linked with the process of water regeneration and reuse. On one hand, internal income includes revenues from the sale of reclaimed water. On the other hand, internal costs are the result of the sum of investment, operating and maintenance and financial costs of the wastewater treatment plant. External impacts are costs or benefits that occur when the actions of firms and individuals have an effect on people other themselves without economic compensation. Water recycling projects create a number of externalities, environmental benefits being one of the most important. The estimation of these external impacts is the main obstacle. In order to solve this problem, we suggest the use of the concept of directional distance function as an alternative to conventional methods of economic valuation. This concept aims to calculate shadow price value of pollutants arising from wastewater treatment. It allows obtain the value of the positive externalities associated with water reuse. This methodology is implemented using 13 water reuse projects located in the Valencia region (Spain). Results show that if the economic feasibility study is based on internal benefits, not all water reuse projects are feasible. However, when external benefit is taken into consideration, water reuse is feasible for all projects in the current study since the results obtained are positive. As a general conclusion, we emphasize that when the economic feasibility of a water reuse project is assessed, water management authorities and companies should not only consider the benefits of market value, because the development of such projects may also be justified by other reasons, such as environmental benefits.

RESPONSE OF SOME FOOD CROPS FOR IRRIGATION WITH MAGNETIZED WATER UNDER GREEN HOUSE CONDITION

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Agricultural sciences take an interest not only in the common and valued crop-forming factors, but also in those less expensive, safe environmentally and generally underestimated. The technology of magnetic water has been developed and subsequently used widely in the field of agriculture in many countries such as Australia, USA, China and Japan. Desperate its importance, it is not yet explored in Egypt. Therefore, the present work was carried out to study the response of some food crops using magnetized water for irrigation purpose under green house condition. Monocotyledonous such as wheat and flax and dicotyledonous such as chick-pea and lentil plants were selected for the present study. Based on the results of our experiments revealed all the plants which were irrigated with magnetic water exhibited a remarkable increase in vegetative growth and biochemical constitutions. Further the results indicated that the number of protein bands got increased in plants treated with magnetized water when compared to untreated control plants. Moreover, the magnetized water treatment increased yield and yield component traits of all crops. The increases in seeds yield/plant in monocotyledonous crops reached to 10.00% and 33.33% for flax and wheat, respectively and in dicotyledonous crops reached to 26.92% and 46.62%, for lentil and check pea, respectively compared with crops irrigated with tap water. It may be concluded that the preliminary study upon the utilization of magnetized water could led to improve the quantity and quality of crop production under Egyptian condition.

WATER MANAGEMENT OF IRRIGATION DAMS CONSIDERING CLIMATE VARIATION: CASE STUDY OF ZAYANDEH-RUD RESERVOIR, IRAN.

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Dependency of water demands on the climate variation occurs especially in regions, where agricultural demand has a significant share of the total water demands. The variability between demands that are based on annual climate conditions may be larger than the uncertainty associated with other explanatory variables in long-term operation of an irrigation dam. This paper illustrates certain benefits of using variable demands for long-term reservoir operation to help manage water resources system in Zayandeh-rud river basin in Iran. A regional optimal allocation of water among different crops and irrigation units is developed. The optimal allocation model is coupled with a reservoir operating model, which is developed based on the certain hedging that deals with the available water and the water demands mutually. This coupled model is able to activate restrictions on allocating water to agricultural demands considering variation of inflow to the reservoir, variation of demands and the economic value of allocating water among different crops and irrigation units. Using this model, long-term operation of Zayandeh-rud dam is evaluated considering different scenarios of inflow to the reservoir as well as agricultural demands. The results indicate that the use of operating rules which consider variable demands could significantly improve the efficiency of a water resources system in long-term operation, as it improves the benefit of Zayandeh-rud reservoir operation in comparison with conventional water supply approaches.

QUANTIFICATION OF CONSTRUCTED WETLAND EVAPOTRANSPIRATION USING LYSIMETERS

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Constructed Wetlands (CW) are an effective alternative method for wastewater treatment. Their advantages include low construction, operation and maintenance costs, together with a satisfactory effluent quality and simple operation. Although a relative published literature exists, the main mechanisms responsible for their effectiveness are still under scientific research. A main design parameter is evapotranspiration (ET).

The purpose of this study was to examine the role and importance of ET on CW operation through controlled experiments. For this, ten pilot-scale cylindrical metal tanks of diameter 1.5 m and height 1.0 m were designed and constructed, and operated as lysimeters to evaluate ET. Four different porous media were used: river sand ($D_{50} = 6$ mm, range 0.25-16.0 mm), medium gravel ($D_{50} = 24.4$ mm, range 4-25 mm), cobbles ($D_{50} = 90$ mm, range 30-180 mm) and soil clay, with a total thickness of 0.5 m. The plant types used were *Phragmites australis* (common reeds) in two CW units, *Arundo Donax* in two units and *Typha latifolia* (cattails) in four units, while two units were kept unplanted. Six units simulated horizontal subsurface flow CWs and four units free-water surface systems. Under this configuration, interesting conclusions can be drawn about the effect of substrate material and plant on ET rates. All units operated for nine months, during which daily measurements of ET were made based on the water budget method.

Results showed a seasonal variation of ET values (higher values in summer, lower in winter) for all planted units, while the unplanted unit had significantly lower alterations. Higher ET values were observed for the unit planted with reeds. On the other hand, the control unplanted units showed the lower ET values among the ten units, which is indicative of the significant contribution of plant presence. Moreover, reeds generally showed increased ET rates compared to cattails, although cattails were found more active during the summer months. The measured data were used to produce simple relations to predict ET rates according to plant and substrate material.

USE OF SALINE RECLAIMED WATER ON GRAPEFRUIT CROP IRRIGATION

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A four year experiment (2007-2010) was conducted at a commercial grapefruit orchard located in Campotejar (Murcia, Spain). The main objective was to evaluate the effects of different irrigation water qualities used in Mediterranean agriculture, on grapefruit tree crop and their effects on plant physiology, leaf mineral status, soil chemical properties, water content, yield and fruit quality. Na, B and chloride concentrations exceeded the phytotoxic level in reclaimed water used for irrigation, although no toxic symptoms have been seen during the four seasons. A tendency was identified in terms of salts accumulation in the soil, during the last season in RW treatments. Soil infiltration problems can occur in the long term in RW treatment, because SAR values exceeded the recommended range. Leaf B concentration was over the phytotoxic limit, more marked in RW treatment, although no toxicity symptoms were observed. Yield reductions were not significant between treatments, although a tendency to reduced number of fruit per tree was detected in the RW treatment. Among fruit quality parameters, a tendency of higher fruit weight and size were observed in reclaimed water treatment. Nevertheless, further studies are required to assess the long-term effect.

APPLICATION OF TREATED URBAN WASTEWATER THROUGH SUBSURFACE DRIP IRRIGATION IN SUNFLOWER CROP

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In order to satisfy the increasing population's need for water and to protect the environment and public health, the scientific combined with the political world have made many efforts concerning measures and proper practices for the confrontation of these vital meaning problems. Already in many regions with dry conditions and limited rainfalls, that face the problem of reduced water resources, the use of treated municipal wastewaters for irrigating purposes is being given a boost, especially in the energy crops section. Energy crops constitute raw material for the bio fuels production, which they are considered part of the renewable energy resources.

Due to this effort, the present research is dealing with the study of the subsurface drip irrigation effects combined with the treated urban wastewater and fresh water, through the development and productivity of the annual sunflower (*Helianthus annuus*). It is also concerning about the percentage of the fresh water saved by using treated wastewaters.

The research took place in the farm of the University of Thessaly, at Velestino area and constituted a full randomised pattern with two treatments (fresh water and treated wastewaters) in four replications. The extension of territory was 200m², which divided in 8 similar experimental parts of 20m² each (5m length και 4m width). Four of the eight experimental parts corresponded to the fresh water treatment and the four remaining to the wastewater treatment.

The treated wastewaters were provided from the Municipal Enterprise for Water and Sewage of Volos and the application of both fresh water and the sewage was made by a double subsurface drip irrigation system that had been installed. In every replication of wastewater treatment, parameters such as the concentration of nutrients (N, P, and e.t.c.), the concentration of chloride ions, Ph, electrical conductivity, chemical oxygen demanded (C.O.D.) and the concentration of N-NH₃ and N-NO₃ were measured and analysed.

In daily base climate data was receiving from an automatic meteorological station. The measurements that have been taken in both treatments concerned the height, the diameter of the sunflower disks, the number of leaves, the production of fresh and dry biomass, ground humidity and the leaf area index. The comparison of measurements in both treatments indicated that there was not statistically important difference among them and a major saving of water about 22% as an outcome of the use of wastewaters in combination with fresh water.

PERFORMANCE ANALYSIS OF LARGE PRESSURIZED IRRIGATION NETWORKS: EFFECT OF HEAD LOSSES EVALUATION

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Large-scale pressurized irrigation networks operating on-demand have been widely used in the distribution of irrigation water over the last decades. Computer simulation models are used to analyse their performance and define their deficiencies in terms of pressure head. There are two approaches in the analysis of these networks. The analysis with the indexed characteristic curves provides information on the general performance of the network while the analysis at hydrant's level offers a more detailed description on the hydrants and pipes presenting a pressure deficit.

The available software implementing such analysis is ICARE and COPAM. ICARE is a commercial program developed by CEMAGREF in MS-DOS environment and calculates indexed characteristic curves, several steady flow regimes and a statistical analysis at hydrant level. COPAM (Combined Optimization and Performance Analysis Model) is a free distributed programme, developed by FAO and CHIEAM-Bari Institute in Windows environment. COPAM apart from the indexed characteristic curves also gives information on the exact hydrants presenting deficiencies, the extent of their deficiencies and their reliability indicator.

For both analyses computation of the head losses for the determination of the pressure heads is a crucial step. Each of the available analysis software incorporates a different formula for the calculation of head losses. ICARE uses Calmon and Lechapt formula for the determination of head losses combined with Colebrook-White formula for calculating friction coefficient. COPAM uses the Darcy equation in combination with Bazin roughness parameter (γ) for the computation of head losses.

In this work, the effect of the formula used for the calculation of head losses on the determination of the characteristic curves is examined. In particular, the Darcy –Weisbach equation with the Colebrook – White and with the Swamee and Jain formulas, the empirical equation of Hazen-Williams, the Darcy equation with Bazin roughness coefficient, the Calmon and Lechapt equation and the most recent Valiantzas (2008) explicit power formula are compared in terms of the characteristic curves of large-scale pressurized irrigation networks operating on-demand.

CALCULATION OF REFERENCE CROP EVAPOTRANSPIRATION USING THE PENMAN-MONTEITH METHOD

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The rational designing of irrigation systems requires the calculation of the evapotranspiration in the best possible way. Reference crop evapotranspiration (ET_r) is the rate at which water, if available, would be removed from the soil and plant surface of a specific crop, arbitrarily called a reference crop. A large number of more or less empirical methods have been developed over the last years by numerous scientists and specialists worldwide to estimate evapotranspiration from different climatic variables. Relationships were often subject to rigorous local calibrations and proved to have limited global validity. Testing the accuracy of the methods under a new set of conditions is laborious, time-consuming and costly, and yet evapotranspiration data are frequently needed at short notice for project planning or irrigation scheduling design. The analysis of the performance of the various calculation methods reveals the need for formulating a standard method for the computation of ET_r . The Penman-Monteith method is recommended as the sole standard method. It is a method with strong likelihood of correctly predicting ET_r in a wide range of locations and climates and has provision for application in data-short situations. The use of other reference ET methods is no longer encouraged. Because of the required calculating procedure when the Penman-Monteith method is used, is very complex and calls for a lot of calculations we present in this paper, a computer system of estimating ET_r using this method. The system facilitates irrigation network designers in calculating reference crop evapotranspiration. It is simple in use, do not demand special informatics knowledge, and it is approachable to a wide range of researchers. System's architecture includes a user-friendly interface for the data input, a computational module and the output subsystem, where the user is given a detailed table of results. The computer system provides a quick and accurate solution to the problem of estimating ET_r . In addition, it could be incorporated as subroutine of integrated software dealing with hydraulic calculations.

KIWIFRUIT IRRIGATION SUSTAINABILITY UNDER CLIMATE CHANGE SCENARIOS IN FAENZA AREA (NORTH ITALY)

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The hilly area of Faenza (Emilia-Romagna, North Italy) is characterized by kiwifruit orchards, a crop with high irrigation water needs, and a wide presence of artificial water storages. In the last years the area was subject to water scarcity episodes. The aim of this work is to model the irrigation water needs of kiwifruit and its sustainability under climate change scenarios.

In the framework of Agrosценari project, funded by Italian Ministry of Agricultural and Forest Policies (Mipaaf), we produced climate change scenarios of temperatures and precipitation, statistically downscaled on six Italian study areas, including Faenza. The scenarios are referred to the period 2021-2050, starting from output of large scale fields (temperature at 850 hPa, geopotential height at 500 hPa, mean sea level pressure) of five AOGCMs from the European ENSEMBLES Project based on A1B IPCC emission scenario.

The statistical downscaling process provides seasonal anomalies, with respect to the 1961-1990 reference period, used as input in a Richardson-type weather generator in order to produce synthetic daily series of temperatures (minimum and maximum) and precipitation. These daily weather series are the input of a water balance model (CRITERIA), by means of which the agronomical impacts of climate change on crop irrigation water needs are assessed. Starting from the model outputs, we defined the Irrigation Recharge Ratio (IRR), a new agro-environmental index able to evaluate the sustainability of irrigation requirements in a Human-Nature competitive system.

This work describes the modelling chain and analyze the results on the study area. The skill of Criteria in the simulation of irrigation water needs of kiwifruit was calibrated on experimental data of Faenza area. On the basis of last years data, the IRR trend was analyzed in order to assess a threshold corresponding to water scarcity episodes. The water requirements and sustainability of kiwifruit in the area under climate change conditions were studied.

7. WATER QUALITY MANAGEMENT

BIODEGRADATION OF XENOBIOTIC COMPOUNDS AND THEIR INFLUENCE ON THE PERFORMANCE OF MUNICIPAL WASTEWATER TREATMENT PLANTS

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Xenobiotic compounds have had an impressively fast as well as large diffusion in the last century thanks to advances in science, technology and industry and although have positively contributed to improve, on the whole, the quality of life, their often uncontrolled use and discharge have been responsible, over the years, for a rising worsening of the environmental quality with consequences that, at the moment, is not possible yet to quantify.

Indeed xenobiotics containing sewage are often not suitable to be treated in conventional wastewater treatment plants because of the low biodegradability that characterizes such compounds. For this reason and because of untreated discharges as well more and more often and in higher concentration over the last years their presence has been detected in water bodies where they can accumulate and persist for ages because of their low sensitivity to be degraded by microorganisms causing serious damages to the aquatic ecosystem even in presence of low concentrations.

In the aim of avoiding the damages that these substances can cause, it is absolutely necessary to limit their release providing for the elimination of all untreated discharges that may contain xenobiotics, as well as for the identification of treatment systems and cycles suitable to remove these compounds from sewage. For this reason, in recent years numerous studies have been carried out aimed at estimating the biodegradation kinetics of many xenobiotic compounds as well as at determining wastewater treatment systems capable to remove these compounds.

Focused on these issues a research work was carried out at the University of Naples *Federico II* where:

- (i) It has been experimentally evaluated the biodegradability (K_{bio}) of twenty xenobiotic compounds;
- (ii) It has been determined, on a bench scale reactor, the effectiveness of a MBR (membrane bio-reactor) treatment system in removing from sewage 4-nitrophenol, a widely diffuse xenobiotic compound as it is an intermediate in the synthesis of paracetamol and also has been assessed, on another bench scale reactor, the effects due to the presence of the same compound on the biodegradation activity of microorganisms in an activated sludge process;

It has been developed a predictive model for the aerobic biodegradation of chemical substances by relating the rate of the consumption to the structure of the compounds.

HYDRODYNAMIC AND QUALITY MODELING OF YAMCHI RESERVOIR

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Hydrodynamic and quality modeling of reservoirs and lakes has been considered as one of the most important management tools in the last decades. Prediction of Eutrophication and the effects of management measures is one of the capabilities of these tools. Eutrophication is the most common problem in Iran. Yamchi reservoir is located in northwest of Iran and is the main source of drinking water of Ardabil town, the capital of Ardabil province. Serious taste and odor problems, has been reported in recent years. Field investigation represents algal bloom that is the main ecological effect of eutrophication. In this study, Yamchi reservoir is simulated using a 2-D laterally averaged hydrodynamic and water quality model, CE-QUAL-W2. Input data include bathymetry of reservoir, meteorological data, inflows, temperatures and constituents concentrations of inflows, outflows and initial conditions. The duration of calibration is two years and the model has been verified for 2010 data. Finally, some practical solutions have been recommended.

SOLUTION OF RELEASE HISTORY RECOVERY PROBLEMS OF GROUNDWATER POLLUTION SOURCES USING HARMONY SEARCH OPTIMIZATION ALGORITHM

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Groundwater contamination may originate from point and non-point sources. The major point and non-point sources are the leaking from the underground storage tanks, waste disposal sites, manufacturing facilities, and agricultural activities, etc. Note that contamination process of groundwater systems results with a pollution plume no matter where the contamination starts. This plume transports through subsurface based on the advection and hydrodynamic dispersion. To control the spreading process of this plume through longitudinal and transverse directions, the identification of its release history is a required task. In this paper, a new solution model is proposed for solving the release history recovery problems of the pollution sources in groundwater systems. In the proposed solution model, groundwater flow and transport processes have been simulated through MODFLOW and MT3DMS models, which are widely used solution models in groundwater modeling. These models are then integrated to an optimization model in which recently proposed heuristic harmony search (HS) optimization algorithm is used. The performance of the proposed solution model is compared to previously developed artificial neural networks (ANN) and genetic algorithm (GA) based solution models for error-free and measurement error conditions. The identified results indicate that the proposed solution model provides better results than both ANN and GA based solution models even if the measured pollution concentrations include high measurement errors.

WASTEWATER AS NON-CONVENTIONAL WATER RESOURCE

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Water is becoming an increasingly scarce resource and planners are forced to consider any sources of water which might be used economically, ecologically, and effectively to promote further development. At the same time, with population expanding at a high rate, the need for increased food production is apparent. The potential for irrigation to raise agricultural productivity has long been recognized. Whenever water is scarce treated wastewater will have to be considered for use in agriculture. Many countries have included wastewater reuse as an important dimension of water resources planning.

This paper deals with theoretical part of wastewater use in agriculture, where included: global water resource limits and water scarcity, sustainable development, sources of wastewater, health protection measures, monitoring and system assessment, sociocultural and environmental aspects, economic and financial considerations, and policy aspects.

At the same time, results from one case study of wastewater application in agriculture in northern part of Serbia (Vojvodina Province) are presented. The development of livestock breeding in Vojvodina Province is characterized by building up of large-capacity farms involving wet discharge technologies, and most often, by inappropriate solutions to the treatment and disposal of the originated wastewaters. In the majority of cases such wastewaters are temporarily collected in lagoons. The applicability of these waters is determined by their characteristics, amounts, the natural characteristics of the region, and the possibility of growing particular crops. The choice of crops depends upon the local pedological, climatic, and market conditions, and especially on the degree of sensitivity of crops to the contents of macro- and micro-nutrients, as well as to some hazardous components present in these waste waters.

In the frame of a complex research project at the lizimeter station Rimski Sancevi the effect of irrigation with diluted wastewater from the pig-raising farm has been studied. The experiment encompassed investigation concerning the control of shallow groundwater quality, microbiological activity of the soil and shallow groundwater, chemical composition of the soil, as well as the observation of phenological stages of the crops. The obtained results point out to the possibility of wastewater use in agriculture under natural conditions of Vojvodina, without significant disadvantages.

ASSESSMENT OF GROUNDWATER POLLUTION RISK BY USING FUZZY LOGIC

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The present article is aimed at illustrating a methodology for a rapid and effective assessment of groundwater pollution risk connected with the presence of pollution sources and in particular uncontrolled landfills. The risk assessment has been carried out with a conceptual fuzzy model, which includes the groundwater vulnerability and the intrinsic hazard of landfills. In particular, in order to define the hazard of landfills, the fuzzy logic theory has been applied. The assessment of groundwater vulnerability has been carried out with the GNDCI-CNR method. The developed conceptual model has been applied to the Region of Basilicata for the assessment of pollution risk of aquifers which underlie some uncontrolled landfills, identified in the surveys carried out in 2002 on the national territory by the "Corpo Forestale dello Stato" ("Italian Forest Rangers"). The fuzzy approach has been then combined with the sensitivity analysis in order to overcome the problem of uncertainty associated with both the input data and the implemented fuzzy model, and at the same time reduce the subjectivity. The sensitivity analysis allowed a series of simulations characterized by different input parameters. The simulation results were subjected to statistical analysis in order to assess which fuzzy scheme could better represent the input data distribution. In order to compare the distributions variances of each fuzzy model and the input data, and consequently choose the best fuzzy model, an F test was carried out. The index environmental risk, obtained through the developed fuzzy scheme and characterized by the Gauss2 membership function and the Centroid defuzzification method, was successively revised for a classification of the risk in linguistic terms (Very low, Low, Medium, High, Very high), by using a cumulated frequency distribution curve.

The proposed fuzzy approach, supported by the sensitivity analysis, has revealed to be an important tool for supporting decisions, in order to optimise technical and economic resources. The present study suggests an innovative methodology characterised by the integration between the fuzzy approach and the sensitivity analysis, able to mitigate the problems connected to the subjectivity and arbitrariness of the evaluations based on the fuzzy approaches normally present in literature, especially concerning the choice of the membership functions or the defuzzification methods.

STRATEGIC PLANNING AND MANAGEMENT OF WATER RESOURCES QUALITY BY DETERMINING THE TRENDS OF HUMAN IMPACTS IN BASINS WITH NON-AVAILABLE WATER QUALITY DATA

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Surface water quality is directly influenced by natural phenomena as well as sources of pollution created by human activities within a basin. Human induced impacts are usually of more concern in water resources quality management because unlike many natural causes, they are capable of being managed and controlled.

Developing countries and countries in transition are striving to manage their water resources more effectively. In such countries on one hand, human activities mainly consisting of industrial and agricultural development followed by demography changes skyrocket causing accelerating external drivers on the quality of water resources. On the other hand however, water quality monitoring systems, as a tool for detecting trends of pollution variations are usually unavailable.

In this study regarding the purpose of strategic planning and management of basin-level water resources quality, the potential loads of Nitrogen, Phosphorus and BOD pollutants are applied as indicators to determine trends of pollution sources within a basin in the north of Iran where agricultural and industrial activities are being practiced in a great extent adjacent to the surface water resources. The obtained results from trends of proposed indicators are applied in decision making upon the optimum water resources pollution control strategies within the studied area.

PHARMACEUTICALS REMOVAL FROM URBAN WASTEWATER BY MEANS OF BIOLOGICAL AND PHYSICAL-CHEMICAL TREATMENTS IN FULL SCALE PLANTS

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During last ten years international regulatory bodies paid a special attention to "emerging contaminants" in water, also known as "xenobiotics"; these pollutants are present in water in low or very low concentrations, they are ubiquitously diffused and their effects on human health and environment are, in a wide measure, still unknown. The European Community, in the Water Framework Directive (WFD), refers to various products that are not yet subjected to quality standards in water bodies and it established to minimize negative impacts: personal care products (PCPs), flame retardants (PBDE, TCPP), fuel additives (MTBE), plasticizers (DEHP), hormones and pharmaceutical products (APC).

This paper presents a study about two pharmaceutical products, Carbamazepine (CBZ) and Oxcarbazepine (Ox-CBZ), and about six of their metabolites, produced after assumption for therapeutic purpose. These molecules are monitored in wastewater of two areas of the Lombardy (Italy) served by two different wastewater treatment plants: one (city of Pavia) has a traditional scheme, with primary and secondary treatment phases, the other (S. Antonino Ticino, Varese), fed with urban and industrial wastewater, has usual primary and secondary treatment, nitrogen removal and tertiary treatment for a treated water quality improvement; after this plant a part of treated water is released into the first ground water level.

The results of monitoring show different behaviours of the considered molecules. The biological treatment for the removal of organic material and nitrogen is not always effective for the treatment of such compounds, but a strong oxidation (ozonization) is more effective.

THE REUSE OF TREATED WASTEWATER: KORBA (TUNISIA) CASE STUDY

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The planning and development of water resources in Tunisia integrates the treated wastewater (TWW) reuse. TWW is used in Tunisia since 1965 and is one of the solutions adopted for water scarcity problems intensified by population growth, rising living standards, and accelerated urbanization.

We evaluated the environmental and health impact of the reuse of TWW for crops direct irrigation or for the recharge of the local aquifer in Korba (Tunisia). The investigation of TWW quality showed that in most samples oxygen demands do not exceed the Tunisian standards for TWW used in agriculture (NT 106.03). It was also the case for temperature, electrical conductivity (EC), salinity and pH. While heavy metal concentrations were under the detection limits, the analysis of nutrients revealed relatively low concentrations of nitrates, nitrites and orthophosphate but high potassium and ammonia levels. We did not detect any salmonella and intestinal nematods, whereas high concentrations of total coliforms, thermo-tolerant coliforms, faecal streptococci and E. Coli were found. At the same time we discovered the poor quality of the aquifer unfit for irrigation. These observations leaded us to conclude that the best use of TWW in this region would be its infiltration for the recharge of the aquifer. It would help at the same time to solve the problems of water scarcity, destruction of the regional aquifer and soils, as well as TWW safe elimination.

ASSESSING SALINE WATER IRRIGATION OPTIONS WITH THE USE OF SOIL-WATER-ATMOSPHERE-PLANT (SWAP) MODEL

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Assessing some of the parameters for the use of high salinity water in agriculture with the aid of a well-tested simulation model like SWAP (Soil-Water-Atmosphere-Plant) is the subject of this paper. SWAP is an agricultural model that simulates the transport of water, heat and dissolved solids in unsaturated-saturated soils. Simulations were executed for the Agoulinitza network, which is part of Alfio's river irrigation system in western Peloponnese (Greece). Drainage water of the region could potentially be used for irrigation purposes. The Total Dissolved Solids (TDS) of drainage water which were measured in the post irrigation period varied between 300 and 12000 mg/l.

The results of water and soil classification tests were used as input data in combination with meteorological and crop data. Simulations were applied for various ranges of the salinity of application water, irrigation depth and interval. The impact on the soil profile from the accumulation of salts under these practices was estimated. The results showed that the use of saline water is suitable but should be adapted to the crop pattern of the region since salt tolerance varies for every crop. Finally, SWAP can be used for the estimation of the leaching fraction in order to control the concentration of salts in the soil profile.

PARAMETER SENSITIVITY ANALYSIS OF A POLLUTANT PREDICTION MODEL FOR ESTIMATING SOIL SEDIMENT IN RIVERS WITH DIFFERENT SPATIAL SCALE

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Suspended sediment yield (SSY) is the main vector for pollutants and nutrients generated from river runoff by affecting the clarity and turbidity of the water and contributing to the distribution of toxic materials. Therefore, estimation of SSY is essential for characterizing water quality and water resources management. The aim of this paper is to propose a method to estimate the total amount of suspended sediment load carried by rivers across Japan. First, based on the analysis of SSY observation data at about 400 agricultural and forest watersheds in Japan, the relationships between SSY and hydrogeography were examined. Suspended sediment transport was found to be importantly affected by changes in river discharge and watershed characteristics. Then, the multiple regression and empirical models were proposed to test the national scale estimation for the indicator of SSY. The resulted estimation of SSY provided satisfactory simulations in terms of the selected performance criteria comparing well with the observed SSY. The R^2 index are 0.72 and 0.66 for empirical and regression model, respectively. Finally, the parameter sensitivity analysis was then conducted for the proposed models for estimating SSY in rivers with different spatial scale. The calibrated model parameter of runoff load factor from forest area is found to be the highest among all factors. The impact factor of crop land and geology is also larger than that of soil, urban land, wetland, and paddy land. This study provided a useful base for further investigation of soil sediment pollution in rivers.

EVALUATING THE EFFECT OF RECENT DROUGHT ON THE QUALITATIVE AND QUANTITATIVE GROUND WATER CHANGES IN MARVDASHT PLAIN IN IRAN

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In this study, we evaluating the effect of precipitation status and drought of that on qualitative and quantitative water changes of pyzometric wells in Marvdasht plains (Rustam & Kharameh, Shiraz, Iran) and determine the trend of these changes from 2006 to 2010 years. In this regard the mean annual precipitation and water quality indices calculated then based on existing standards and recommendations for agricultural water, its quality at each station were studied. To check the quality of irrigation, the amount of precipitation and underground water level changes in these plains were evaluated. Results showed that with reduced rainfall and underground water level in most of the wells in these plains, the quality of water has severe loss. So the water salinity of these fields isn't suitable for irrigation and in terms of chlorine, sulfate, sodium absorption and acidity aren't in good condition and because of drought in recent years, the level of groundwater has reduced and with continuing decrease in rainfall and excessive withdrawal can state that these plains as a major farming area close to critical state.

APPLICATION OF PARTICLE SWARM ALGORITHM TO THE OPTIMAL MANAGEMENT OF UNCONFINED GROUNDWATER SYSTEMS

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In this study, a robust simulation-optimization model for the optimal management of unconfined groundwater systems is proposed. In the management model, a second-order finite difference groundwater flow model is used as the simulation model and a particle swarm algorithm is used as the optimization model. The performance of the proposed method is compared with reported techniques given in the literature through a maximum pumping example. The results show that the proposed algorithm can confidently be applied to groundwater management problems.

PREVENTION OF GROUNDWATER CONTAMINATION IN WIDER MINING AREAS USING COMPOSITE PERMEABLE REACTIVE BARRIERS

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The high risk of groundwater contamination in wider mining and waste disposal sites is due to the production of acidic leachates over long periods of time even after cease of activities.

The present paper explores the potential of composite permeable reactive barriers containing mixtures of organic and inorganic materials, mainly by-products of other industrial operations, for the treatment of leachates and the prevention of groundwater contamination. Upflow column experiments (5 cm internal diameter and 45 cm height) simulating permeable reactive barriers operation were carried out in the lab to assess the efficiency of organic (goat manure) and inorganic (zero valent iron, fly ash and red mud) reactive media for the clean up of acidic leachates (pH 3) containing Cu, Zn, Pb, Ni (50 mg/L) and sulphates. The columns were filled up with each reactive mixture and packed slightly to simulate field conditions regarding groundwater or leachate flow. Leachates were collected periodically and analyzed for pH, oxidation-reduction potential and ion concentration. The effect of each reactive medium was assessed and the most important mechanisms contributing to leachates clean up were identified and discussed. The longevity of each system was also estimated. The experimental results indicate the potential of this approach for the prevention of groundwater contamination.

SUITABILITY OF SURFACE WATER FOR DOMESTIC USE: AWALI RIVER CASE STUDY

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The Arab region is currently challenged by securing sufficient water resources for sustainable development. Although, Lebanon is considered relatively “the reservoir of water in the Middle East”, still, the provision of adequate, sustainable safe domestic water remains a major challenge to be met. The city of Beirut hosts one third of the Lebanese population due to progressive urbanization, resulting mostly from decentralization of services and economic activities. Faced with this challenge, the tendency is to reduce dependency on groundwater resources and supplement it by surface water. The Awali River is among the 16 perennial flowing water resources, at a relatively convenient distance from the Capital (Beirut). The objective of this work is to evaluate the river water basin to determine the optimal extraction points, water quality variability and the need to develop and sustain proper river basin management and quality control programs. Accordingly, water samples were collected throughout the year from identified sampling locations. Complete physical, chemical, microbiological (pH, Conductivity, TDS, TOC, Ca, Mg, HCO₃, SO₄, NO₃, Na, K, Fe, Zn, Cu, Pb, Cd, Mo, Co, *Total Coliform*, *E. coli*) quality profile based on standard methods and procedures were conducted. Further data was analyzed using SigmaStat statistical package and water modelling software AquaChem. Preliminary results reflect on minimal exposure to sources of pollution other than domestic sewage. This further emphasizes the need to meet the water and sustainable goals of the water for life decade 2005-2015. Moreover, promoting and sustaining water and sanitation projects becomes a must.

MICROBIAL ENRICHMENT METHODOLOGY FOR BIODEGRADATION OF POLYBROMINATED DIPHENYL ETHERS, RECALCITRANT XENOBIOTICS IN SEWAGE SLUDGE IN ITALY

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Microbial biodegradation of persistent xenobiotics represents a necessity of industrialized countries. Among xenobiotics emerges polybrominated diphenyl ethers (PBDEs), used as flame retardants in a wide array of products, including building materials, electronics, furnishings, motor vehicles, airplanes, plastics, polyurethane foams, and textiles. Aims of this study were to determine the PBDE concentrations in sludges samples collected in different waste water treatment plants (WWTPs) in Italy and identify aerobic microbial strains capable to biodegrade PBDEs. All samples were analysed by a gas chromatograph Agilent 6890 connected to a mass spectrometer Agilent 5973 Network (Agilent Technologies) with a negative chemical ionization ion source (GCMS-NCI). Microbial degradation sludge was made by two bacterial aerobic strains (*Rhodococcus jostii* (RHA1) e *Burkholderia xenovorans* (DSMZ 17367) added to microbial flora sludge on culture medium and on bench scale pilot plant. Primary sludge samples were collected from 8 WWTPs located in the North and Centre area of Italy between June 2007 and March 2010 treating different effluents (municipal, industrial and/or combined). The capacity of the WWTP investigated ranged from 35000 to 1250000 population equivalents and from 12500 m3/day to 432000 m3/day. PBDE concentration data for sludge samples collected from the 8 wastewater treatment plants showed total tri- to hepta- BDE concentrations (sum of significant congeners BDE 28, 47, 99, 153, 54 and 183) ranging from 19.48 to 99.89 (median 45.73 ± 26.61) ng/g d.w. and deca-BDE (BDE209) concentrations from 131 to 7122 (median 2741 ± 2849) ng/g d.w.. BDE 209 dominated the congener profile, contributing between 73% and 99% of the total BDE (mean: 90.0 ± 9.9 %), suggesting the present use of this technical formulation in the investigated WWTP. Results experiments on culture medium are not yet available. Experiments on bench scale pilot plant produced considerable results demonstrating microbial attach of commercial deca-BDE on sludge: halving penta-BDE mixture (929,4 Vs 463,5 ng/g), great reduction of octa-BDE mixture (258,5 Vs 105,5 ng/g) and increase mono-BDE mixture (slr Vs 48,8 ng/g).

ASSESSING THE IMPACTS OF WATERSHED CHARACTERISTICS ON DAMS' WATER QUALITY

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In Japan, dam is essential for domestic use, irrigation, industrial production, and other activities. It has represented a domain of interest of geomorphology causing irreversible changes in the dynamics of fluvial systems. The sediment and pollutant from the upper streams flow to dams and the water quality in dams always become worse due to the increasing of pollutant concentration with the evaporation and reservation of water. Moreover, the dams' water quality directly affected the water quality and environment of the downstream and the security of drinking water. The necessary of dams and the construction of new dams become a hot topic in recent years. In this study, the water quality data, discharge data and watershed characteristics of 90 dams were collected. The indicators of water quality analyzed are biochemical oxygen demand (BOD), chemical oxygen demand (COD), dissolved oxygen (DO), total nitrogen (TN) and total phosphorus (TP). The watershed characteristics of these 90 dams include land use, soil type, area, slope and geographical information. Based on the statistical cluster analysis of the collected database, 90 dams are divided by two groups. For each group, the correlations between the water quality indicators and discharge, watershed characteristics were statistically analyzed. Based on the correlation analysis, two regression models were built for these two groups to estimate the potential water quality loads in dams. The regression models resulted in the high values of R² for group 1 and 2, respectively. Finally, different scenarios of land use and climate change were input to the regression models and the water qualities in Japanese dams were evaluated under these scenarios. This study could support the statistical information of the dam water quality and explain the relationship among the dam water quality and watershed characters.

PHARMACEUTHICAL MICROPOLLUTANTS REMOVAL BY MBR: A COMPARISON WITH A FULL SCALE WWTP

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Pharmaceutical substances, and on a more general basis, persistent micropollutants removal from wastewater is an important issue since their discharge into the environment might damage ecosystems. Nevertheless, knowledge about their fate in wastewater treatment plant is still scarce and pharmaceuticals discharge has not been regulated in Europe yet. In the last years, some studies have presented MBRs as a process that leads to higher pharmaceutical substances removal rates, when compared to conventional activated sludge processes. However, they compared CAS working at standard SRT, to achieve Nitrogen removal, and MBR working at much higher SRT. Hence, when comparing both processes working in parallel and in comparable conditions, it appeared that for some compounds, MBRs might achieve a slightly higher removal, while for those which are either well removed in CAS or not removed at all, no difference was observed.

This work presents results obtained on a 280L anoxic-aerobic MBR pilot plant operating at two distinct SRTs, compared to a conventional activated sludge treatment.

Average concentrations of the analyzed pharmaceutical in the WWTP, in ng/L, and standard deviations were measured for each of the 39 substances investigated. The mean standard deviation of 77.7% confirms the high influent concentration variability of these compounds in the wastewaters. Removal efficiencies in the pilot plant were evaluated to compare MBR results when operating at different SRTs. Most of the substances display similar removal rates. Nevertheless, Ciprofloxacin, Ofloxacin, Demethyldiazepam, Salbutamol and Ketoprofen exhibit a higher removal at 15 days. This might be explained with the fact that these compounds tend to sorb to the sludge and therefore their elimination increase at increasing amount of excess sludge removed. Diclofenac, Furosemide and Atorvastatin are better removed at higher SRT leading to the hypothesis that there might be a slight effect of the SRT on their biodegradation rates. Nevertheless, Diclofenac seems to be mainly influenced by operating parameters such as the influent composition and the SRT. High removal rate were also observed in the CAS. Nevertheless, influent concentration differs of 8-fold between the two campaigns and is likely to significantly influences the removal rates.

REMOVAL OF OILY XENOBIOTIC COMPOUNDS FROM SLOPS AND BILGE WATERS ORIGINATED FROM OIL TRANSPORTATION BY TANKERS

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Oily wastewater are generated by ships mainly in engine-rooms (bilge waters) and by washing oil tanks (slops) in amounts of millions of tons annually. Many of these fluids are very stable emulsion, which make chemical treatment difficult and normal separation processes alone (gravity, flocculation, skimming) rarely effective. The standard methods for treatment of emulsified oily wastewater is chemical de-emulsification followed by secondary clarifications, which requires the use of a variety of chemicals such as sulphuric acid, iron and alumina sulphates, ect. Coagulation is widely used in water and wastewater treatment. The water phase from chemical treatment has to be further purified to meet today's effluent standard for discharge systems. This can be achieved by granular activated carbon (GAC) filtration. Once a GAC column is exhausted, the GAC must be replaced and disposed of or recycled in some way (i.e., landfilling, incineration, or thermal reactivation). Replacement and disposal of exhausted GAC is quite expensive. Encouragement of biodegradation—where one or more of the SOC's are biodegradable—should lengthen the GAC service life for some SOC mixtures. Very little work has been done on the biodegradation and adsorption of salty mixtures of biodegradable and nonbiodegradable SOC's. This lack of research is particularly problematic because such salty SOC mixtures are widespread in the environment, and many nonbiodegradable SOC's may cause adverse health effects.

Focusing on these issues the research work investigated the feasibility of a complete treatment including:

- (iii) A simple separation by gravity as a pre-treatment;
- (iv) A chemical coagulation as a primary treatment;
- (v) A filtration on activated carbons as secondary treatment
- (vi) The bio-regeneration of the exhaust carbons (GAC) in order to reduce the GAC regeneration costs. With regards to these treatment phase, bacteria for inoculation, *Halobacterium* sp and *Alcanivorax borkumensis*, were taken from DSMZ microorganisms culture collection as they were considered petroleum-degrading organisms able to survive to the extreme salinity conditions.

The research has also led to a proper characterization of the specific wastewater typologies as available scientific data are incomplete or too scattered.

WATER QUALITY IN DON REGION (RUSSIA)

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Many regions face a variety of water-related challenges, and the continent as a whole is rapidly going to have to address the issues of population increases, changing climatic conditions and increased water usage. These challenges are made more complex by the fact that different areas of the region have reached different stages of economic development. Proper management of water resources can lead to the development of the region. Access to proper sanitation and safe water are also pressing issues.

Nowadays there is an urgent problem – water shortage. Many European countries face this problem, Russia is not the excluding. In addition, there is a problem not only of water quantity, but quality as well. Although Don region is well provided with fresh water, the water resources are unevenly disturbed within region.

Don region is heavily populated and receive moderate rainfall. Groundwater has a limited capacity for renewal. At the same time, it is industrial and agricultural one that is why pressures from agriculture, industry and domestic users affect the quantity of water resources. Agriculture is also the biggest user of water anywhere in the world and the biggest impacts. Both water quality and availability must be integrated in long-term planning and policy implications concerning water management.

Part of the Don region is Rostov region. Due to zonation of Rostov region we have found regions with water of high quality and positive ecological situation. 95,8 % of surface water and 4,2 % of groundwater is used in water supply system.

Groundwater and surface resources are limited and water is not of high quality. Mainly, river water that is formed in the central part of Russia is good neither in quality nor in quantity. It is used surface (70 %) and groundwater (30 %) for water supply. Groundwater has a number of advantages as a water supply sources, but, on the main part of the region groundwater are not of high quality.

Rostov region can be divided into three parts: northern districts, central part of the region and southern ones. Main cities in the region have not enough available drinking water. In the region ground water is used for curing and water supplying purpose.

It was found that there is a positive tendency in water supply system in Rostov region during last 3 – 4 years. Nowadays the biggest meaning has bottled water. This is one of the ways to solve the problem of water supplying with water of high quality.

EXPERIMENTAL STUDY OF CONTAMINANT TRANSPORT BY GROUNDWATER

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Groundwater is the safest and most important source of available freshwater. However, it is threatened by pollution arising from various activities.

In this study the contaminant transport in homogeneous media is investigated by means of an experimental system available in the hydraulics laboratory of Dokuz Eylül University. The experiments were carried out in an aquifer which is 2 m long, 1 m wide and 0.10 m high. The homogeneous porous medium has a thickness of 10 cm and it is prepared with medium texture sand. Two level adjustable reservoirs are placed at upstream and downstream part of the aquifer. 20 observation wells are placed in the aquifer longitudinally and transversally to measure groundwater levels and the electrical conductivity (EC) of the water. Hydraulic conductivity of the porous material is found as 4.9 cm/sec from application of the Darcy Law. NaCl solution which represents contaminant is injected from a well instantaneously, as a point source. EC values of the water are measured by using the suitable probes from the observation wells. Measurements are taken at specified time interval. These conductivity values are converted to concentration values by means of the calibration curve which is established prior to experiment. The results are evaluated and interpreted.

MONITORING TURBIDITY IN ASPROKREMMOS DAM IN CYPRUS USING EARTH OBSERVATION AND SMART BUOY PLATFORM

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This paper presents the methodology and some results obtained from an existing running project between the Cyprus University of Technology and Water Development Department in Cyprus for monitoring the water quality in dams in Cyprus. In the framework of this project an autonomous, energy efficient floating sensor platform (buoy) was installed in the outlet of Asprokremmos Dam in Paphos District in Cyprus. The buoy, equipped with various water quality sensors such as turbidity and temperature, served as an automatic real-time sensor acquisition tool for remote monitoring of water quality. The data acquired from the sensors are transferred via a wireless link to a remote central database. On-board sensors are used as additional information to satellite imagery for further calibration and testing. Based on the fact that satellite remote sensing can be applied efficiently due to the high availability of cloud free images, the authors proposed to develop a regression model that will be used for systematic monitoring of water quality from space in the near future. Results obtained from the last summer campaign will be presented.

MULTIOBJECTIVE SIMULATION-OPTIMIZATION APPROACH IN POLLUTION SPILL RESPONSE MANAGEMENT MODEL IN RESERVOIRS

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In this study, multi objective particle swarm optimization (MOPSO) technique is adopted to derive a Pollution Spill Response Management Model (PSRMM) in reservoir to characterize the existing trade-off. PSRMM consist of spatial system analyzing (SSA) model, 2D hydrodynamic and water quality simulation model (CE-QUAL-W2) linked to MOPSO to derive optimum strategy and/or emergency planning for Incident Commanders and/or decision makers during chemical pollution spill injection in reservoir. The simulation-optimization (SO) routine of PSRMM provides pareto optimum reservoir operation strategy in selective scheme to minimize reservoir cleanup time, no. of water quality standard violation, and downstream worst water quality. The proposed methodology is applied in Ilam Reservoir in Iran, as a multipurpose hydraulic project providing water for drinking, irrigation, and flood control, during an accident spill of conservative hazardous material.

RESERVOIR OPERATION STRATEGY TO ENHANCE DOWNSTREAM WATER QUALITY; NEW APPLICATION OF CE- QUAL-W2

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In this research, various reservoir operation strategies in selective withdrawal framework under different water supply reliabilities are defined in Karkheh Reservoir. The “what-if” scenarios in Karkheh Reservoir, as a largest and multi purpose project in Iran are evaluated using CE-QUAL-W2 model. The 2D hydrodynamic and water quality simulation model is modified to blend water from multiple vertical outlets and calculate the performance criteria to choose appropriate reservoir operation in the selective longitudinal and/or vertical withdraw scheme. CE-QUAL-W2 model is applied to evaluate Karkheh Reservoir responses to various boundary conditions and to explore the potential for changing reservoir operations in order to improve downstream water quality to enhance the declining Karkheh Ecosystem. Total Dissolved Solid (TDS), NO₃, PO₄, and dissolved oxygen (DO) are the main indicators considered to evaluate the performance of different reservoir operational strategies. Application of the simulation methodology demonstrated the utility of this approach, which works well and provides proper results.

METHOD OF PROGNOSTICATION OF DISTRIBUTION OF RADIO-ACTIVE CONTAMINATIONS IN SURFACE WATER

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The method of prognostication of distribution of radio-active contaminations was developed with use of the offered box model (UNDBE) of incomplete interfusion with lagging argument. Model UNDBE takes account that the transposition flows past in two stages. In the first steps each portion of the water and pollution only moves through box till the outflow. There are no dilution, interaction with bottom and suspended sediments, chemical and physical transformations. In the second step only at the end of transportation each portion of water and pollution mixes up in a certain part (V/n) of compartment volume V and interacts there with sediments and bottom depositions as in usual box model.

Such approach allows taking into account time of transporting of water masses and intermixing of contamination in some part of volume of the compartment at the moment of a termination of transporting.

The assumptions reduce in a model which is described by a system of the usual differential equations with retardation parameter T_R (T_R - transportation time through reservoir). The new model is simple, less requiring for full-scale measurements, short time of computation. Short time of calculation gives the opportunity to solve the task of parameters identification. It contributes to increase the accuracy of the model and provides the possibility of its adjustment to a particular water object.

Results of calibration of the model on a dataset of field measurements through critical 1994, 1991, 1999 a comparison with the box model for complete mixing and validation on data (^{90}Sr) through critical situations are given. The post-Chernobyl measurements were used.

The research of passing of ejections tritium in 350 kilometers channel Loire River (France) was made in the framework of the IAEA program EMRAS. The data for calculations was prepared by EDF-LNHE (France). A calculations of tritium dispersion for 11 points along the river during a half-year taking into account water discharges from tributaries and using real hydraulic conditions of the year 1999 with 1 hour time step was conducted with help of the model. The ejections of ^3H take place in an outcome of normal work of five NPP. Comparison of results demonstrates good coincidence of outcomes of modeling and measurements and shows that box model UNDBE gives coincidence with measurements not worse of the more complicated 1-dimensional models. Results are demonstrated.

CASE STUDY OF RAINWATER QUALITIES AND MANAGEMENT CHALLENGES IN NORTH OF IRAN AS A NEW RESOURCE OF WATER SUPPLY

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Lack of water resources, country and industry development in recent years have caused to increase seeking for finding new and reproducible water resources by water sectors managers. Meanwhile rainwater is one of the most accessible water resources in societies with high rainfall seasons, which could be utilized as sustainable and reproducible resource of water supply. In the study area (north part of Golestan province) in northern part of Iran, there is no permanent resource of water supply during year, so rainwater is the most accessible water supply for area inhabitant. The most significant problem has been reported is rainwater quality in study region, where rainwater TDS (Total Dissolved Solids) in study area is about (2-15) MgL-1 and TH (Total Hardness) is about (2-7) MgL-1. Also biological specification like Total Coliform was measured, and the rate ranged between (0-3) Coliform per 100 ml of water. Rainwater collecting methods has a significant impact on biological quality of rainwater. Important key about rainwater management in study area is to organize and training people about collecting situation of rainwater in order to obtain water supply with acceptable quality. Special consideration for the proper utilization of rainwater should be though to provide potable water with good quality for inhabitant of study area.

BEST PRACTISES IN THE MANAGEMENT OF HOSPITAL EFFLUENTS

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In the last decade, greater attention has been paid to the presence in the water of emerging contaminants (including pharmaceutical and personal care products, pesticides, flame retardants...), that are quite often unregulated compounds. Hospitals are one of the most important sources of pharmaceutical compounds (PhCs) in a concentrated area and, together with households and industries, can be seen as significant urban area hotspots for discharging these contaminants into the sewer network and surface waters, with a potential impact on ecosystem.

Hospital wastewaters (HWws) are composed of the effluents of different services: kitchen, internal laundry, heating and cooling systems, laboratories, radiology departments, outpatients' departments, transfusion centres and wards. By law, HWws are often considered to be of the same pollutant nature as urban wastewaters (UWws), and so they are generally discharged into sewer networks, collected at a wastewater treatment plant (WWTP) and treated along with UWws.

WWTPs were originally built, and more recently upgraded, with the aim of removing C, N and P compounds: the pollutants regularly arriving at the WWTP in concentrations to the order of mg/L. HWws represent a particular kind of WW due to the nature and quantity of the micro-pollutants typically present at µg/L: active substances of medicines and their metabolites, chemicals, heavy metals, disinfectants and sterilizers... Moreover, HWw flow rates in many cases, (but not always!), amount to only a small percentage of the total influent flow rate for co-treatment at a municipal WWTP. Consequently, dilution of HWws with UWws usually results in a decrement of the PhCs content in the final effluent (from µg/L to ng/L), but not in the total load released daily into the receiving water body.

This paper analyses the differences between a hospital and an urban settlement in terms of hydraulic load as well as pollutants load and concentration and it discusses if is correct to consider these two effluents of the same pollutant nature and if/when HWws could be conveyed to a municipal WWTP for co-treatment with UWws. Moreover it discusses the strategies in treating hospital flow rate (on site or off site, dedicated treatment or cotreatment at a municipal WWTP) on the basis of the hospital pollutant and hydraulic loads and finally it presents and discusses the most adequate treatment for HWws on the basis of the recent results of the researches on the removal of PhCs..

A SCREENING BATCH TEST TO ASSESS THE FATE OF ORGANIC MICROPOLLUTANTS IN AN ACTIVATED SLUDGE SYSTEM

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The concentrations of organic micropollutants are usually low in the wastewaters (order of magnitude of mg L⁻¹). However, their emission standards, especially in case of cancerogenic and bioaccumulating substances, are often much lower (order of magnitude of µg L⁻¹). Since these substances can be in some cases adsorbable or volatile, their removal ratio via volatilization, biodegradation or sludge adsorption in a WWTP becomes a significant feature to embody in the usual design process, in order to verify the gas and sludge emission standards too.

The test presented is a screening lab scale batch test aimed at defining the environmental fate of organic micropollutants into water, sludge and air. The test set-up is quite simple and is composed of ordinary laboratory instruments. In order to simulate real operational conditions of a full-scale plant, the input concentrations are very low (usually between 0.02÷1 mg L⁻¹). Aim of the test is to analyze the different removal dynamics occurring at the same time during an activated sludge process (i.e. biodegradation, volatilisation, absorption). Therefore, not only one single process is investigated (as happens during biodegradation or volatilization tests), but the whole removal process is considered and the prevalent removal mechanism of the system may be found out in a relatively short time. The test was applied to four organic micropollutants with different chemical properties (i.e. toluene, benz(a)anthracene, phenol and benzene).

The results obtained show that the screening test proposed can be a useful tool to assess in about one month the fate of organic micropollutants in an activated sludge tank of a WWTP. The test was found to be reliable and suitable also for molecules with different chemical-physical properties. In particular, the good results obtained for toluene allow the application of this test for the VOCs. Finally, the presented test allows to analyse the biodegradation and volatilization processes that occur in an activated sludge unit in terms of competition between the two processes..

MATHEMATICAL MODEL FOR FOOD INDUSTRY WASTEWATER TREATMENT PROCESSES

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The purpose of this paper is to obtain a mathematical model for a food industry wastewater treatment pilot plant based on the ASM1 model. It aims to establish a simplified model, which allows the implementation of advanced control strategies of the process. Parameters identification was performed using datasets from the pilot plant for wastewaters taken from the dairy industry.

A wastewater treatment pilot plant which is completely controlled by the computer was conceived for studying and implementing control algorithms and it is located in our university. The objective of the pilot plant is the efficiency improvement of the biological treatment processes of various types of wastewaters from food industry in aerobic conditions using control methods.

For parameters identification and sensitivities analysis was used AQUASIM software. Modal analysis was done under MATLAB environment, frequency analysis establishing the medium dynamic of the process.

The first step for model obtaining is the analysis of parameter sensitivities. As a result of the sensitivity analysis only two parameters were considered for identification: maximum specific growth rate for heterotrophs and yield for heterotrophs.

Further on the identification of parameters previously established using datasets provided by the wastewater treatment pilot plant from dairy industry has been done. Results obtained on different datasets have shown a good concordance between the experimental data and the data obtained through model simulation.

Finally the model determined in the paper was subjected to a modal analysis in different operating points of the process. This has lead to a simplified model better suited for implementing different advanced control strategies of the process.

A simplified model was obtained which parameters were identified based on data from the wastewater treatment pilot plant. This model can be used for the implementation of advanced automatic control algorithms in order to improve the wastewater treatment system efficiency.

2DV HYDRODYNAMIC MODELING OF RESERVOIRS

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Recently, simulation of hydrodynamic and water quality variables of a water body with numerical models is a common approach. Increasing in computer power and accuracy of laboratory results for field data are two important factors in rapid increasing in using these models. In this study, non linear and unsteady equations in Cartesian co-ordinate system are splitted and solved with finite volume method in staggered grid. Considering non-hydrostatic pressure, artificial compressibility approach is used for coupling velocity and pressure. Calculation of water elevation depends on user. Choosing a coefficient determines rigidity or being free surface. The effects of TDS and temperature have been considered for evaluating stratification of reservoir.

HYDROGEOLOGICAL SETTING, HAZARD AND MITIGATION OF RECLAIMED AREA IN WADI EL-SAYDA NORTH ASWAN, EGYPT

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Owing to the excavation of irrigation and drainage systems and utilizing the flood method for irrigation the reclaimed area in Wadi El Sayda (WS) north Aswan governorate, a lot water ponds and new water bearing are formed. The article aimed to identifying the hydrogeological setting, hazards and solutions. There are two groundwater aquifers in WS namely; Quaternary and Nubian Sandstone. Different pizometers have been drilled in Quaternary for detection aquifer extension, observation water level and monitoring salinity with time. The groundwater level increases about 1.8 cm from 14/1/2010 to 9/2 owing the continuous recharge from irrigation canals and seepage from irrigation of sugar cane, while slightly increases 1.255 cm from 9/2 to 1/4 may due to stop irrigation of sugar cane. The salinity decreases from 14/1 to 9/2, while slightly increases from 9/2 to 1/4 due to the stop irrigation of sugar cane and upward leakage through fault systems. Seven water points are recorded in Nubian sandstone aquifer, three of them are flowing with salinity varies from 1920 ppm and 2717 ppm, while the others are pumped with salinity ranges from about 986 ppm to 2381 ppm. The variation of salinity may due to the different sources of recharge. The main problems of WS are due implementation, random land reclamation, flood irrigation, bad maintenances, water logging and design. The solutions of these problems are re-design the irrigation system, connection between drains, excavate new drainage, excavate new tile drainage system, maintenances of irrigation and drainage systems, and decreasing the groundwater level.

8. WATER RESOURCES MANAGEMENT

INVESTIGATION OF SNOW COVERS DATA ON ANN AND ANFIS MODELS FOR STREAMFLOW FORECASTS

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In recent decades, population growth and increasing water demand, on one hand, and climate change and drought episodes, on the other, underline the importance and sensitivity of water resources management. Streamflow forecast is one of the fundamental tools in water resources management. Demand for increased accuracy of flow forecasts is particularly raised in large mountainous basins, such as Karoon basin in Iran. In this study, 1- to 3-months ahead forecasts of Karoon river flow were conducted using nonlinear and intelligent techniques including Artificial Neural Networks (ANNs) and Adaptive Neuro-Fuzzy Inference System (ANFIS) models. In addition, the effect of snow cover (SC) data, extracted from the National Oceanic and Atmospheric Administration (NOAA) images on the performance of these models was investigated. Relying on cross correlation and PCA techniques, three input patterns were constructed and their performances as inputs of ANN and ANFIS models were evaluated. Then, the most accurate model was considered as the selected pattern and the effect of SC data on the performance of the selected pattern was investigated. In order to investigate the effectiveness of SC data during both snowfall and snowmelt periods, the performance of selected patterns for the ANN and ANFIS models were further analyzed separately using SC data. Results showed that decreasing the number of input variables through the PCA technique proved efficient, while the effect of SC data on the performance of forecast models was positive. For ANN models, the improvements in streamflow forecasts for all lead times were about 7.8%, 5.1% and 7.9% in Root Mean Square Error (RMSE), determination coefficient (R^2) and mean absolute error (MAE) values, respectively. Inclusion of SC as input data also improved the performance of the selected model in both snowfall and snowmelt periods, but the degree of improvement in the snowmelt period was considerable.

DEVELOPMENT OF A SPATIAL MULTI-CRITERIA DECISION TOOL IN A SPATIAL DECISION SUPPORT SYSTEM FOR WATER RESOURCES PLANNING

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Problems involving the process of integrated water resources management (IWRM) such as finding the best solution on water allocation and conflict resolution are of significant challenges especially in case of the changing environment. This might be a challenging problem because of technical, economic, social, environmental as well as political aspects that may be in contrast with each other. Recently, development of information technology has improved the application of specific tools to be used through the complex process of an IWRM. Geographic Information Systems (GIS) and Multi-Criteria Decision- Making techniques (MCDM) are two common tools that could be employed to solve water resources problems. This paper presents a spatial MCDM (SMCDM) which is used through a GIS-based Spatial Decision Support System (SDSS) for the purpose of water resources planning and management. The algorithmic process of the developed SMCDM and its role as an important module of a new developed spatial decision support system is discussed. SDSS integrates various modules of water resources systems analysis and spatial multi-criteria decision making in a single system. Thus, the system is found to be very effective and user-friendly to get required outputs for an integrated water resources management process of a river basin. The developed SMCDM model is useful for prioritization water resources alternatives through different conditions. Application of the developed system in a great river basin in Iran, Karkheh river basin, is discussed thoroughly.

HYDROLOGICAL STUDY IN ORDER TO SUPPORT THE CONSTRUCTION PROJECT OF THE TWO HYDROPOWER PLANT ON THE GRABOVA RIVER

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The purpose of this study consists to obtain one of the computing method for achieving optimal results in the calculation of maximum flow depending on which will be relevant for dimensioning of hydropower plant components (hydraulic structures) .Since the distribution of water flow measured at the respective stations Grabova river having no real time measurements. So the only way to solve the problem is to assess hydrological parameters for Grabova River, especially at the point of join of its two branches, (Cuma and Valamara streams). Calculation of maximum flow by using rational method is actually enlarged. Maximum flow will actually be a size between the flow that is calculated by first method, based on measurements of flow, and the second method, based on rainfall. Exact solution of this problem, as well as some other problems addressed in this study, will become staging for a period of 1 or 2 years reliable measure of rainfall and flow. Unable to organize the measurements mentioned above, our recommendation to accept the results of calculating the maximum flow is the second method (rational method, based on rainfall), goes in favor of increasing the security of hydraulic structures and will not significantly affect the cost of hydropower plant.

VALUING INVESTMENTS TO REDUCE THE RISK OF HYDROLOGIC FAILURES IN HEADWORKS SYSTEMS

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With a wide portfolio available of different options (both on demand and supply side) for managing the supply-demand balance, water planners are faced with the task of correctly understanding the actual value and usefulness of such alternatives. Cost – benefit analysis (CBA) provides a straightforward and conceptually clear approach to the issue of assessing investments for system expansion by explicitly including the consumer's surplus among the benefits.

In many mature contexts, however, where most infrastructure for water supply has been already built and consumption levels are stable, such investments must be seen as a means to reduce the risk of not supplying the demanded water, rather than as a way to close the supply – demand balance in present or future conditions. Risks are also conditional on the present level of withdrawals from the sources that may be inflated due to high losses in both conveyance and distribution networks.

The paper introduces and applies a methodology to quantify the benefits of reducing water supply risks in headwork systems for municipal use, including regulated and unregulated resources, due to hydrologic failures. As risk includes both the occurrence probability of a failure and the related effect (damage), the methodology combines a simulation module of the system at yearly scale coupled with a stochastic hydrologic input to reproduce the probability distribution of the failures with a metric for supply failure damage provided by the price – demand relationship for municipal water.

This approach is then combined with the classic discounted cashflow approach of CBA to allow for the dynamics of both water supply and demand due to population growth and, above all, reduction of water losses in water distribution networks.

The methodology is applied to evaluate a number of different supply-side projects aimed at increasing the reliability of the headwork system for municipal uses of over 4,000,000 inhabitants in Apulia, in southern Italy, featuring multipurpose reservoirs, unregulated and groundwater resources as well as a network of major transfer facilities. The projects are focused on supply augmentation by transferring additional water to the system from other systems, or producing more water in the system by building additional weirs.

The above exercise allows ranking of individual projects by their economical performances and the economic evaluation of combinations of different projects.

DECISION SUPPORT SYSTEMS FOR SUSTAINABLE DEVELOPMENT OF RIVER BASINS

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According to the European Water Framework Directive 2000/60/EC, all member states must formulate and implement Integrated River Basin Management strategies. Water resources management is not a straightforward task. Its complexity isn't simply a result of any computational limit in modelling, but also comes from the multiple interdependent processes (physical, biochemical, ecological, social, legal and political) that govern the behaviour of water resource systems. These processes are affected by uncertainties and by the unpredictable actions of multiple individuals and institutions involved in the management and operation of such systems. The Decision Support Systems (DSS) for River Basin Management enable the comparison of water strategies for different scenarios based on the effects of multiple objectives. They can be used to support the planning and implementation of measures, as well as the communication between public authorities and other public or private stakeholders, since stakeholders' involvement in the decision making process for water resources is nowadays a necessity.

The present paper aims to present the role and the importance of the Decision Support Systems in River Basin Management. An effort to gain a deep insight in the different decision making procedures for the sustainable management of river basins, including simulation, optimization and multi-criteria analysis, is made. The Mediterranean river basins have been used more intensively in the last decades with man-imposed pressures often exceeding the sustainable resource limits. The difficulties and the challenges in modelling technologies and in the development and implementation of such a tool for the Mediterranean watersheds are identified. Finally, a characteristic example of the most common stresses exerted in Mediterranean river basins, owning a plethora of uses (domestic supply, irrigation, energy, recreation, etc.), and proposed goals/objectives for the development of a decision making procedure are included. Since the implementation of integrated and sustainable river basin management is a big challenge, a model of a Decision Support System that considers the special conditions (climatic conditions, the threat of the global climatic change, complexity of authority responsibilities, stakeholder conflicts) observed in Mediterranean watersheds along with human judgment could be a precious informative tool for an effective decision-making of the administration bodies.

RE-MODULATING WATER ALLOCATION IN A COMPLEX MULTI-RESERVOIR SYSTEM UNDER CURRENT AND CLIMATE CHANGE SCENARIOS

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Water resource planning and management at watershed scale should be aimed at guaranteeing soil and water conservation, together with the organization, use and management of water resources for protecting the environment and for the economic and social development. Nevertheless, often the appropriate approaches and tools for identifying the most efficient solutions are not adopted, and water resource is allocated for fulfilling water demands from different stakeholders with no clear rules, especially when complex water supply systems are managed.

In this study water demand for irrigation and hydropower is analyzed in a large-scale complex system located in Eastern Calabria (Southern Italy), i.e. the Neto-Tacina system involving 2 watersheds (total area about 1500 km²), 3 irrigation systems (about 235 km² of irrigable fields, more than 70 km² actually irrigated), 9 reservoirs, 3 intakes and a system of three consecutive hydropower plants. Specifically, current scenario is analyzed considering water concessions awarded to the companies managing the hydropower plants. Then, by means of statistical tools, a GIS-based distributed hydrological model and software tools for integrated water resources planning, three alternative and more efficient scenarios are proposed. Finally, the same analysis is repeated considering a number of future water availability scenarios, derived from the most recent high resolution climate change data for the analyzed region, provided by regional downscaling experiments with grid resolutions finer than 20 km.

MAPPING THE ANNUAL RUNOFF DATA IN SICILY USING A GEOSTATISTICAL APPROACH

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The availability of reliable and long time series of runoff data is fundamental for most of the hydrological analyses and for the assessment and the management of water resources even in condition of global climatic change. However, hydrologic data set are often characterized by a short duration and also suffer from missing data values, mainly due to malfunctioning of gauging stations for a specific period. In order to overcome this problem and obtain long and continuous runoff time series, different models and methods have been previously developed and proposed. While some models, used to extent the streamflow record, are conceptual, empirical, regressive models based on the rainfall input, other models are based on the derivation of runoff maps at different time scale; these maps allow the runoff estimation in gauged basins characterized by the absence of data or in ungauged basins.

Aim of this paper is the derivation of a map relative to the mean annual runoff at regional scale using a stochastic approach derived from the kriging interpolator. This approach can be assimilated to a kriging system, which considers explicitly the areal nature of runoff variable by imposing the constrain of the water balance; it allows to derive gridded annual runoff maps with finer and finer resolution.

The methodology has been applied to 23 main hydrographic basins of Sicily, Italy, using the mean annual runoff dataset provided by *Osservatorio delle Acque*. All these basins have been previously grouped in three homogeneous zones, as suggested by previous studies. A cross-validation procedure has been performed in order to validate the procedure for each homogeneous zone.

DYNAMIC NETWORKS OPTIMIZATION FOR WATER RESOURCE MANAGEMENT UNDER UNCERTAINTY

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The paper will contribute to the study of the modelling issues related to water network optimization under resource uncertainty and to define the robustness and efficiency of water system management. Infrastructures are seen as specialized and time varying dynamic networks. As described in Sechi and Zuddas (2008), the problem can be modelled as a multi-period dynamic network problem where, in the planning time-horizon, special nodes are defined at relevant decision points. A resolution approach to address this problem is to employ the Subjective Stochastic-Scenario Optimization (SS-SO) which describes uncertainty by finite number of scenarios assigning to them subjective probabilities. Aspects of stochastic optimization with uncertainty described by scenario trees can be found in Dembo et al. (1995), Rockafellar and Wets(1991), Römisch and Schultz, 2001. The SS-SO approach tries to obtain a "robust" decision policy that minimizes the risk of wrong decisions. It allows exploitation of the algebraic structure of the model such as those arising from dynamic networks and multi-scenario structures. In the paper we focus on the study of multi-period systems supported by dynamic networks, by integrating scenario optimisation and a subsequent re-optimisation phase. In the scenario optimisation phase we will represent data uncertainty by a multi-scenario model, obtaining a so-called "barycentric" value of some critical variables with respect to all scenarios. Multi-scenario solutions are then included in a successive re-optimisation model where the barycentric value is considered as a redefined target. This procedure gives rules planning the risk of wrong decision when defining emergency plan to face resource scarcity. In the paper a representative example related to the management of a water supply scheme in southern Italy will be illustrated.

USE OF HYDRAULIC, HYDROLOGIC AND WATER QUALITY MODELS IN THE INTEGRATED WATER RESOURCES MANAGEMENT: THE CASE STUDY OF LAKE IDRO

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A challenge for the next years is the improvement of the hydropower sustainability following the basic principles of the integrated water resources management issued by the WFD. Indeed, although WFD has been fully introduced within the national laws, a further period of experimentation and diffusion of best practice should be needed to put its basic principles into practice. In this frame a means to improve hydropower sustainability should pass through testing reservoirs operational modalities which take into account all the possible water needs at a wider scale. After having spent some years developing and applying tools to support hydroelectric reservoirs management issues, we decided to set up one case study where those tools could be used in combination, in an attempt to carry out an example of integrated approach to the river basin management. The selected site was Lake Idro, a natural lake regulated through an artificial weir for agricultural and hydropower use, whose inflowing water is regulated in turn by a number of hydroelectric upstream dams. Along with the quantitative aspect, water quality and ecological status of the lake are considered to have worsened in last years. Although the lake has been smoothly regulated for decades, conflicts among public and private stakeholders have arisen more recently, due to the increase in ecological requirements, public awareness of environmental issues and fragmentation of water exploiters and regulatory boards throughout the hydrographic basin. The project core is modelling water quality, hydrology and hydraulic of the watershed-lake system in order to identify firstly which changes of lake regulation could help to reduce nasty water conditions and then to study the consequences that such changes could have in relation to flood prevention, water availability and electrical production.

The following tools will be applied: a hydrological-hydraulic watershed modelling tool, a lake hydrodynamic and water quality model (using data from in-lake monitoring station), a simplified tool for the optimization of hydroelectric plant.

Prior to the start up, the project has been presented to the main stakeholders in order to share with them both the goal and the achievements of the research. Agreements have been reached with the main institutional subjects (Regione Lombardia and Provincia di Trento) for the sharing of data and information produced within each own institutional tasks. The present paper is aimed at the presentation of the start up of the Lake Idro project.

NEW CHANGES IN WATERSHEDS AND IWRM NEEDS, CASE STUDY: BAR WATERSHED

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Nowadays, water scarcity is the most important challenge facing sustainable development in the Middle East. It is expected that the Middle East governments, sooner or later, have no choice but to orient their development policies towards water resources sustainability. Establishment of this strategy is subject to an integrated approach to water resources management (IWRM).

One of the successful experiences on IWRM approach in Iran has been carried out in Bar basin, in the north-eastern region of Iran. Bar (Kharasfrud) River is one of the main branches of Kalshur large River, as the principle element of water supply and a basic source of water recharge to the Kalshur plain, flows between 2 different cities in Khorasan province, Iran, with more than 10 percentage of the province area occupying. Bar river originates from two separate Karstic sources, its average yearly run-off is more than 60 million of cubic meters, which in comparison with other rivers flowing at this region, is considered a huge quantity.

In the past, a significant part of Bar run-off reached to Kalshur, during a period of time, from March to May, and recharged the plain. The old regime of water operation rules between stakeholders had a traditional accepted aspect for all of them. Recently, from 10 years ago, the watershed has experienced new significant changes, population rising dramatically, water transfer project, dam construction, reconstruction of old barrages and channels, ... which have been resulted in changes in the behaviors of the stakeholders and consequently to agricultural pattern changes, expansion new gardens at upstream regions, drilling at least 1500 unauthorized wells in the riverbase at every summer.

Recently, all contributes of Kalshur (specially Bar river), suffer from these new challenges, so downstream activities are under new pressures like huge losses in groundwater resources, Qanats drying and upward moving of saline fronts.

Approaching to IWRM plan and sustainability in supplying water were subject to managing any contributes separately and use of local experiences. Therefore an action plan was designed and new relations with stakeholder groups developed to reach a new agreement relating to water rights and divisions. This action plan ended in construction of small reservoirs, with the storage capacity of according the water rights of the stakeholders in period of March-May. The experience of these pump-storage plans with the new operation rules is a successful one in joint exploitation of a complex river. In this paper, the details and procedures which led to formation of the related action plan will be reviewed.

Today, after successful construction and joint operation of reservoirs, upstream stakeholders are cared to act and use water according the accepted rules between them, authority and other users.

SUSTAINABILITY ISSUES IN WATER MANAGEMENT

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In the 1992 Rio World Summit on Environment and Development (UNCED), water resources are indicated to remain at the core of sustainable development and, thus, they are to be managed and developed on a sustainable basis. Agenda 21 of UNCED has officially stated the new outlook towards environmental and water resources management, namely that the environment should be managed by an integrated approach in respect of SUSTAINABILITY. Chapter 8 of Agenda 21 emphasizes that sustainability must be achieved in making decisions for overall development and resource management at regional and national scales. In that regard, decisions must seek for sustainability in 3 dimensions: *economic* (efficiency), *social* (equity) and *environmental* (compatibility). These three dimensions are the pillars of sustainability. If significant, a fourth dimension can be added to cover *institutional* issues. Sometimes, *information* is considered as the fourth dimension (basin information requirements).

The problem here is how to evaluate whether water management is sustainable or not and how to ensure sustainability in decision making for management. To be more specific, the question to be resolved is how to measure or quantify economic, social and environmental dimensions of sustainability. The first step towards quantification of these dimensions requires the identification of “indicators” for sustainability, i.e. economic indicators, social indicators, and environmental indicators. Chapter 40 of Agenda 21 on 6 “Informed Decision Making” (statements and 7) foresees the identification of sustainability indicators along the above three dimensions and requires that these indicators are updated regularly to be reported in regional or national studies. Accordingly, various international organizations have prescribed lists of indicators to be used in local, regional, national and global development and management plans. These indicators are also classified to represent system (e.g., basin) properties such as: P(stress on the system), S(state of the system) and R(system response). To infer on sustainability in water resources systems, such indicators have to be evaluated by the use of Decision Support Systems (DSS) comprising the integrated tools of databases, models, GIS, and expert systems. DSS allows comparing various water management scenarios where the values of indicators are varied to assess baseline, pessimistic and optimistic management conditions. The success of DSS applications is closely related to the quantity and quality of available information on economic, social and environmental aspects (indicators) of water resources.

The study presented attempts to define sustainability in water resources systems on a quantifiable basis and introduces sustainability indicators. It further demonstrates the assessment of indicators within a DSS system. These issues are considered in the case of the SMART (Sustainable Management of Scarce Resources in the Coastal Zone) and OPTIMA (Optimization for Sustainable Water Resources Management) projects funded respectively by the 5th and 6th Framework Programmes of the European Union. The basic issues discussed will further be demonstrated in the case of the Gediz River Basin in Turkey.

DIAGNOSING CAUSES OF WATER SCARCITY IN COMPLEX WATER RESOURCES SYSTEMS AND IDENTIFYING RISK MANAGEMENT ACTIONS

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Diagnosing the causes of water scarcity in complex water resources systems is a precondition to adopt effective drought risk management actions. From the water management perspective, water scarcity is an unacceptable risk of facing water shortages to serve water demands in the near future. Water scarcity may be temporary and related to drought conditions or other accidental situation, or may be permanent and due to deeper causes such as excessive demand growth, lack of infrastructure for water storage or transport or constraints in water management (water rights, floods). One of the objectives of river basin planning is effective management of the risk of water scarcity. Planning and management decisions depend on the reliability and vulnerability of water resources systems to confront water scarcity. Lack of reliability can be easily identified with water resources system models, but diagnosing its causes in a given system is a more complex task. In this paper we present four indices which have been developed to evaluate water scarcity: the Water scarcity index, the Demand reliability index, the Sustainability index, and the Management potential index. We propose a methodology for interpretation of index values that can lead to conclusions about the reliability and vulnerability of systems to water scarcity, as well as to diagnose their possible causes and to propose solutions. In cases where several systems are analysed, indices are also useful to make a comparative study between them and to prioritise actions. The described methodology was applied to the Ebro river basin, identifying existing or expected problems and possible solutions. System diagnostics, based exclusively on the analysis of index values, were compared with the known reality as perceived by system managers, validating the conclusions in all cases.

DETERMINATION OF POWER COEFFICIENT BY THE TRANSFER OF FLOWS TO PROJECT SECTION

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In the design of hydraulic structures which are leading tools in the development of water resources it is a basic rule to have the hydrometeorological data of the site where the water structure will be constructed. There is no or insufficient data on the design-section of the hydraulic structure generally. Therefore, it is a common way to obtain these data through transfer from closer upper and/or lower stations with measurements by using of drainage-areas ratio(s). In Türkiye's practice, the power of drainage-areas ratio is assumed to be taken as "one (=1)". But in fact this transfer is not linear and a defined power of drainage ratio may be utilized. In order to determine this power, the relevant studies have to be carried out in both river and basin scales.

Because of lacking of any convenient studies for Türkiye's basins by the determinations of this power, such studies have to be executed immediately. For time being, more than 1200 small HEPP's are mostly depended on this flow-transferring subject. Within the scope of this study, the way to do this transfer of flows to project axis, has been handled. The widespread data transfer method is based on the ratio of drainage-areas and considered as a defined power " n " of that ratio. In the literature, this value " n " are given between 0,8-1,2 depending on the proportions of the drainage-areas between axis and existing flow measurement stations (FMSs). In this study, for the determination of the power-value " n ", methods of experimental hydrology have been utilized. Using the data of three sequential FMSs in near vicinity with sufficient and no-disturbed flow measurements connected to each other with various intersection forms have been taken into consideration. Then it is assumed one of the FMS's data do not exist, where the other(s) has (have). By assuming different " n " values, the transfer has been realized from the other(s) FMS(s) utilizing the proportional drainage-areas. After realizing transfer, the transferred values are compared with measured values. Experimenting different " n " and using some fitting-formulae, the best-fitted " n " value has been determined. For that section of the study, the undisturbed data have been selected and analyzed.

As a result, it has been determined that data transfer from only "one" FMS is more appropriate. From the point of practical utilization, it is also studied whether any relation does exist between the elevation and the value of power " n ", and a second order polynomial correlation has given best result. Finally, it has been shown that the power " n " by the transferring of flow to the project-axis may not be taken always "1". It is more suitable to assign this value according to basins, sub-basins and/or regions and should be somewhat connected with elevation.

POLITICAL AND MANAGEMENT RULES OF WATER RESOURCES IN SCARCITY SCENARIOS

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The planning process of water resources management has been proved to need a multi-objective approach, aiming to take into account the different and often antithetic expectations of stakeholders and users. Of course, the overall process has to be based on equity, environmental safety and public welfare, beside the economic profit.

The planning process, moreover, and the decision makers have to cope with uncertainties and doubtful situations. That is the reason to welcome the use of Decision Support Systems (DSS) whose advantage consists in the possibility to compare different scenarios and political approaches to argue general managing rules.

The study case here presented is based on the Sinni river hydraulic system which has been proved to be representative of many Southern Italy complex schemes. In the specific view, the drought and scarcity of water resources has been investigated. The national directive (5 Agosto 1999, ex. art. 17 D.Lgs N°36/1994, Di Santo & Ranieri, 2000) aiming to define the agreement between Puglia and Basilicata regions in terms of transboundaries resources is the reference to quantify the water demand and supply.

Some of our findings put in evidence that proper managing flexible decisions are often sufficient to solve some conflictual dynamics between users in the near and middle term future.

WATER RESOURCES AVAILABILITY, A KEY FACTOR FOR THE DEVELOPMENT OF INDUSTRIAL AREAS: THE CASE-STUDY OF PATRAS (GREECE) INDUSTRIAL AREA

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The present paper discusses issues related to water problems in quality and quantity as a constraint for the increasing economic gain and sustainability of industrial parks. It is well known that industry is a large water consumer. Hence, in most industrial countries water shortages are becoming increasingly severe, acting as a key parameter for the arrest of growth in industrial sector. Even though this discussion started a long time ago, problems are still present. Nowadays, the climate change which leads to water resources decrease and the increasing consumption of goods and services, speed up even more the phenomenon of water resources contamination. Therefore, the industrial park managers have the challenge of satisfying the consuming needs in water, without preventing the economic growth of industries or the installation of additional ones in the parks and without degrading water resources of future generations. That's why they should take into account past experience and try to find new and flexible ideas in existing use patterns, in order to optimize the use of available water resources.

This paper presents as a case study the industrial park of Patras (I.P.P.) in Greece, which faces a lot of problems concerning water scarcity. IPP accommodates more than 100 companies and occupies more than 4000 employees, a fact that highlights IPP as one of the most important poles of growth and financial activity in the whole region. The new Port of Patras that will be connected with the northern Detour of Patras city, the operation of Rion-Antirion Bridge linking Peloponnese to mainland Greece and the construction of Ionian and Olympian Motorways create optimal conditions for development of existing businesses and are significant factors for the attraction of new investments. However, water scarcity and rising water prices act as restrictive factors for installation of industries. Hence, the decision tools for smart planning of water resources are much more necessary than ever. The goal of the present paper is to demonstrate that management policies/choices of integrated planning still exist to reduce the water scarcity in quality and quantity in IPP. It is implied that the settlement of water problem in the region provides a big precedence as it will contribute actively in the economic and sustainable development of the major area.

COMPARISON OF VARIOUS OPTIMIZATION METHODS FOR TRAINING OF ANN RIVER FLOW MODEL

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Artificial neural network (ANN) models provide huge potential for simulating the behavior of nonlinear physical systems e.g. hydrological systems. The training of an ANN is primarily a non-linear optimization problem in which the objective is to determine the values of decision variables (i.e. connection weights) such that the global error at the output layer (normally mean square error, MSE) is minimized. Most ANN applications in hydrology reported in literature have employed the popular back-propagation algorithm (BPA), which is a gradient search method, for training purposes. In this paper, the results from an investigation on the use of different optimization methods for the training of feed-forward neural network model structure are presented. Two classical and two evolutionary optimization methods were investigated for the training of the ANN hydrologic models. The classical optimization methods investigated include BPA and simplex search technique, and real coded genetic algorithm (RGA) and particle swarm optimization (PSO) were the two evolutionary optimization methods adopted for training in this study. In addition, a hybrid (RGA+BPA) training algorithm was explored in an attempt to improve the forecast accuracy. The daily river flow data derived from Godavari Basin @ Polavaram, Andhra Pradesh, India have been employed to develop all the models included here. A wide range of error statistics have been used to evaluate the performance of all the models developed in this study. It has been found that the evolutionary algorithms performed slightly better than the classical optimization methods, and the hybrid training algorithm performed the best amongst all other methods investigated. It is concluded that a hybrid approach capable of exploiting the advantages of individual methods is more appropriate in capturing the complex, dynamic, and non-linear nature inherent in the hydrological systems.

INTER COMPARISON OF GENERIC SIMULATION MODELS FOR MULTI-RESERVOIR WATER RESOURCES SYSTEMS

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Particularly under water scarcity conditions, simulation models provide an efficient way to predict the interaction and impacts, over time and space, of alternative operating rules in multipurpose multi-reservoir systems. Complex water systems can be seen as an aggregation of reservoirs in series and in parallel and many of these operating rules are combinations of derived operating rules for single-purpose reservoirs in series and in parallel.

There are a number of such generic models for simulating water resource systems. AQUATOOL (Valencia Polytechnic University), MODSIM (Colorado State University), RIBASIM (DELTAWARES), WARGI (University of Cagliari) and WEAP (Stockholm Environmental Institute) are representative of models used for preliminary analysis of alternative plans and policies. This paper is about modelling in practice more than in theory. The proposed inter comparison do not identify all the features of each model, but rather gives some general information on the identification and evaluation of operating policies in single-purpose reservoirs in series and in parallel with the aid of these simulation models. In particular, the emphasis is on the flexibility and effectiveness of these simulation models that use different techniques to reproduce traditional operating rules. The application to reservoirs in series and in parallel (a classic in the literature) gives the user control over the operations of each of the model components and help users select the model that best satisfies their needs in managing particular complex water systems.

SIMULATION OF VARIABLE-DENSITY GROUNDWATER FLOW AND TRANSPORT IN THE COASTAL AQUIFER OF THE PYRGOS AREA (GREECE)

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This study presents an application of the SEAWAT code, which is a combined version of MODFLOW and MT3D codes, to simulate three-dimensional, variable-density groundwater flow and transport in the coastal unconfined aquifer, developed in the alluvial deposits of Alfeios River in the Pyrgos area. The study area is located on the north bank of the Alfeios River estuary and is between the NW-SE trending fault south of Pyrgos town, which appears as the hydraulic boundary of the aquifer to the north, and the coastline. The recharge of the aquifer is mainly owing to the infiltrated rainfall water and to the lateral seepage from Alfeios River. The low-lying area along the coast, with soil surface elevation below the sea level, is the area of the former Mouria Lake, which has been drained in 1960's after the construction of a system of drainage canals and land drainage pumping stations, to provide land for agriculture. Measurements of piezometric head in the low-lying area after the drainage of the Mouria Lake show severe drawdown of the water table, negative hydraulic gradients and salt water intrusion. The groundwater quality has been deteriorated not only because of salt water intrusion but also due to anthropogenic contamination. The SEAWAT code simulated the complex behaviour of the density contrast between the fresh groundwater and the salt water under the existing hydrologic stresses for a period of four decades and showed that the computed water table heights and salt concentration were in good agreement with the monitored data. The SEAWAT code was also employed to predict the long term future development of the aquifer and the area under scenarios which include restoration of the Mouria Lake in part of its original area or nearly complete restoration of the lake. The results showed that a coupled variable-density flow and transport modeling is essential in planning a sustainable water resources management and development of the area.

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