**MUFFIN**

**MULTI-SCALE URBAN FLOOD FORECASTING: FROM LOCAL TAILORED SYSTEMS TO A PAN-EUROPEAN SERVICE**

Pluvial urban flooding, caused by extreme rainfall intensities in combination with a large fraction of impervious surface and a limited capacity of storm water sewer systems, is a major societal hazard already today. The problems are further anticipated to increase in the future, when higher intensities are expected in a warmer atmosphere containing more precipitable water. Developing systems for urban flood forecasting and early warning is therefore a key requirement for keeping cities secure and sustainable with respect to flooding hazards and mitigating their impacts. Accurate urban flood simulation and forecasting require a very short time step (minutes) and a very high spatial resolution of both rainfall input (hundreds of meters) and the description of the urban environment (meters). Designing, constructing and maintaining such locally tailored urban flood forecasting systems is very resource-demanding and difficult to achieve in many parts of Europe and the world. A potential way to generate meaningful flood forecasts in cities without local systems may be to develop large-scale hydrological forecasting systems towards higher resolutions and better descriptions of the urban environment. Even with less accuracy than in local systems, urban flood forecasts from largesystems may be useful for end-users if well interpreted and presented. In this project, we will perform development and hindcast experiments of urban flood forecasting systems in three European cities: Rotterdam, Aalborg and Helsinki. These cities fulfil the requirements in terms of highresolution observations and urban models (3Di, Robek-Urban, MIKE, SWMM) for state-of-the-art local urban flood forecasting systems. Meteorological observations and forecasting systems will be developed to obtain the most accurate description possible of high-intensity rainfall and its evolution. An existing Pan-European hydrological forecasting model, EHYPE, will be developed for improved performance in urban areas by using a new model structure based on new land-use data sources as well as increased resolutions in time and space. Coordinated experiments with model versions representing different resolutions and data types will be performed and analyzed. A key aspect of the project is active end-user involvement. Eight endusers, representing three key categories (national authorities, local managers and commercial users), have committed to the project and will be involved from start to finish in order to ensure the most useful outcome possible. Key issues concern the forecast lead time and spatial resolution. How early in advance must a flood alert be issued and with what spatial level of detail in order to be useful for different end-user categories? To which degree are these requirements attainable in different forecasting systems? What is the value of larger-scale forecasts in cities without local system? Innovative means of interpreting, processing and communicating the forecasts to provide an added value from the end-users? Perspective will be developed. Key scientific outcomes are new knowledge about small-scale precipitation extremes and their predictability and about the limitations of urban flood forecasting at different scales. In terms of practical solutions, new and improved operational tools for urban flood forecasting in Europe will be developed.

**ACWAPUR**

**ACCELERATED WATER PURIFICATION DURING ARTIFICIAL RECHARGE OF AQUIFERS - A TOOL TO RESTORE DRINKING WATER RESOURCES**

Water is essential for life, not only for direct consumption, but also for sanitary requirements, and for agricultural and industrial production. Pure drinking water is a limited resource and the demand for water is increasing globally due to human population growth, increased wealth, and climate change. Development of efficient and cost-effective techniques for water purification and reuse is therefore urgent. Artificial recharge of aquifers is an often used technique to replenish deficient water resources. Water being insufficient for drinking water is infiltrated via basins or surface spreading through soils and aquifer sediment thereby improving the water quality. Although artificial recharge has been used for decades, the technique is often operated as a black box without knowledge of the microorganisms and the metabolic processes and pathways involved. ACWAPUR aims at developing techniques, steering tools and management guidelines to prevent leaching of pathogens, inorganic nutrients and organic pollutants to underlying aquifers during artificial recharge processes. This will be achieved by the construction of advanced treatment membranes with a porosity that prevent leaching of pathogens and at the same time provide optimal conditions for microbial degradation processes. The membranes will consist of organic layers which on the one hand, promote sorption of contaminants and on the other hand, facilitate the creation of different redox conditions, to accelerate different contaminant degradation processes. ACWAPUR will also provide fundamental knowledge about pathogen transport and microbial degradation of nutrients and contaminants to be used for the development of steering tools and management guidelines for artificial recharge of aquifers. Examples of steering tools to be investigated includes 1) stimulation of ammonium oxidizing bacteria which are known to facilitate co-metabolic degradation of contaminants 2) supply of specific degrading bacteria or nutrients to treatment membranes 3) addition of easily degradable organic carbon to facilitate nitrogen removal by denitrification, and 4) coating of membrane sediments by e.g. iron oxides to facilitate adhesion of pathogenic bacteria. In addition to bringing considerable advances to water treatment biotechnology, the main outcome of ACWAPUR will thus be prototype membrane systems, steering tools and management guidelines ready for commercialization and implementation in a number of artificial recharge applications.

**IMDROFLOOD**

**Improving Drought and Flood Early Warning, Forecasting and Mitigation using real-time hydroclimatic indicators**

Strengthen drought and flood forecasting and early warning is essential to improve adaptation to climate change. IMDROFLOOD plans different actions to improve the mitigation of the impact of droughts and floods at the catchment level. All these actions will be implemented in different catchments of Europe and South Africa, covering contrasted environmental conditions and specific problematic. IMDROFLOOD will make use of currently available information sources on meteorological, hydrological and remote sensing data to generate new information relevant for flood and drought risk management. New monitoring networks and Doppler radar images will be tested for the generation of more suitable and operative drought indices and the role of ecosystems and vegetation communities in the mitigation of the impact of floods and droughts will be assessed, while probabilistic flood forecasting systems will be developed, integrating all these tools to implement a powerful Early Warning System. IMDROFLOOD adapts to different research priorities, developing innovative tools, including nature-based solutions and using different sensor technologies monitoring networks with the purpose of mitigating the impact of extreme events. IMDROFLOOD will obtain drought indices for different sectors useful for drought monitoring and early warning and will integrate short and medium term meteorological predictions with eco-hydrological rainfall-runoff models and numerical simulations for better flood prediction. IMDROFLOOD will also assess the role of vegetation communities and ecosystems on drought and flood impacts and it will develop drought vulnerability curves for natural ecosystems. These tasks will allow designing efficient drought and flood early warning and forecasting systems and produce information for helping in planning for risk management at the catchment scale. IMDROFLOOD is organized in eight Work Packages and it uses a transdisciplinary approach that includes innovative in-depth studies that combine drought and flood analyses from local to river basin levels. The outcome of this project will be not only basic research. Besides, the projects aims at putting this knowledge into work and will develop information tools based on server-side technologies that are basic for asound management of flood and drought risk, and will do this in close collaboration with the stakeholders and end-users to ensure an adequate uptake of the new products developed.

**DOMINO**

**Dikes and Debris Flows Monitoring by Novel Optical Fiber Sensors**

With more than 5 million people affected, more than 1000 killed, and with estimated total damages exceeding 4.5 billion Euros just in Europe and during the last decade, floods are among the most disruptive natural events threatening our Society. Due to increase in extreme weather events and rapid socio-economic developments in vulnerable locations, the risks connected to floods in general are growing rapidly, and the awareness of these risks and of the need to face them efficiently with an integrated approach is well testified in the "7th Environment Action Programme" of the European Commission. Strategies for adaptation and protection can range from reinforcing civil structures, such as dikes and drainage channels, to careful planning of land use and definition of apt evacuation plans; in any case, these strategies would strongly benefit from effective monitoring tools and early warning systems. In this perspective, project DOMINO aims at developing novel fiber optic sensors (FOS) for the monitoring of dikes and debris flows, that could eventually be used to prevent disasters and manage the related emergency. DOMINO will pursue this goal along two main research lines: the development of a distributed FOS for ground vibration measurement, to be employed in debris-flows monitoring, and the development of distributed and quasi-distributed FOSs for pressure measurement, to be employed mainly in the monitoring of dikes.

FOSs are experiencing ever increasing interest and diffusion as they offer several advantages over traditional sensors. Their small form factor allows to easily include them in the structures to be monitored, while the easiness of remote operation, together with their intrinsic robustness to extreme conditions, make them befitted to hostile environments. Most of all, however, FOSs can be easily concatenated and are the only technology enabling continuous distributed sensing, over distances of several kilometers. These very unique characteristics make FOSs the sensors of choice when large structures or sites have to be monitored, just like for dikes and for the channels and ravines along which debris flows may develop.

To date, dikes stability is typically monitored by measuring parameters such as displacement, temperature and water pressure at specific positions. The use of FOSs has started recently, and it is mainly focused on the distributed measurement of temperature and deformations; nondistributed pressure FOSs are being investigated too. Results are encouraging, but the technology is not mature yet, in particular for what concerns pressure measurement. Differently, the monitoring of debris flows by means of FOS is still a largely unexplored field. Traditional monitoring is performed by means of geophones, inclinometers and trip wires. So far, the few reported examples of FOSs for debris-flow monitoring are mainly mimicking those devices, without exploiting the full potential of FOS technology.

Project DOMINO will go beyond the state of the art by developing a novel distributed ground vibration sensor, tailored to the monitoring of debris flows, and novel distributed and quasi-distributed pressure sensors, to monitor dike stability and to investigate more in details the rheological and mechanical properties of debris flows. The complementary competences needed to succeed in this goal are well represented by the proponent Team, made of two units with experience in FOSs (University of Padova, Italy, and University of Alcala, Spain) and two units with experience in geohydrology (Delft University of Technology, The Netherlands, and Research Institute for Geo-Hydrological Protection, CNR, Italy). Moreover, the Team will constantly involve stakeholders and relevant authorities. Eventually, DOMINO will not be limited to provide new tools for the monitoring and prevention of floods, but will also establish a new multi-disciplinary research group in Europe with specific expertise in dike and debris-flow monitoring.

**PROGNOS**

**PREDICTING IN-LAKE RESPONSES TO CHANGE USING NEAR**

**REAL TIME MODELS**

Lakes and reservoirs represent important resources that are critical for ensuring European water security. Many are under continuous pressure from urbanization and agricultural intensification, and from changes in climate, including increases in the occurrence of extreme events. These pressures can reduce water quality through, for example, the occurrence of nuisance algal blooms or higher levels of dissolved organic carbon (DOC), and therefore increase the costs for water treatment. Increasingly, automated high frequency (HF) water quality monitoring systems are being adopted for lake and reservoir management across Europe. Generally, these HF data are still used only to inform on the present lake state, and their full potential to guide water quality management is not realized. We propose to develop an integrated approach that couples HF data to dynamic models to forecast short-term changes in lake state, and thus inform management decisions to safeguard the ecosystem services that lakes provide. The project consortium includes expertise from European sites that have been involved in the forefront of HF monitoring systems since the late 1990s, a state-of-the-art mesocosm system which can test scenarios for adaptive management, expertise in modelling algal blooms and DOC levels, and expertise in assessing societal benefits from changes in water management.

This project will promote innovative solutions for water-related challenges across Europe. It will develop, demonstrate and disseminate forecast based adaptive management solutions for two specific water quality threats: nuisance algal blooms and the production disinfection by-products from DOC. The technology demonstrated here has the potential to transform water management and foster the growth of European companies that specialize in adaptive water management and water quality forecasting systems.

**Watintech**

**Smart decentralized water management through a dynamic integration of tecnologies.**

The WATINTECH project proposes a combination of concepts of sewer mining with urban run-off treatment in decentralized treatment facilities to enhance the recovery of valuable resources including water, methane (heat, energy) and value-added chemicals, either extracting or producing them from the fluxes inside a sewage pipe. It is also postulated that this combination improves the management of centralized wastewater infrastructures under variable weather events (such as heavy rain episodes combined with long dry periods). The impact of sewer mining and wastewater characteristics on downstream wastewater treatment plants (WWTP) will also be analysed. In an ideal scenario, besides generating the value-added products for local reuse, decentralized treatment will also impact positively on the existing centralized sewage collection and treatment facilities, an aspect rarely taken into account in the design of decentralized infrastructure.

WATINTECH summons an inter-disciplinary consortium offering capabilities that cover the whole R&D value chain - from fundamental research to market uptake. The project will advance the state-of-the-art of novel technologies to achieve five main objectives in four experimental work packages (WP 1-4) employing different size laboratory and pilot-plants and one theoretical work package modelling process innovations and providing system wide optimization (WP 5). A brief description of these five WPs follows:

WP 1 Decentralized water reclamation: Forward Osmosis (FO) filtration, preconcentrating raw wastewater for anaerobic treatment (WP2), production of reclaimed water, and the use of constructed wetlands (CW) for treating alternatively urban run-off and nutrient rich waste streams from the anaerobic process. Evaluating the medium and long-term performance of the technologies, draw solution selection and regeneration, and the impact of evapotranspiration rates, salinity and nutrients in the CW plants.

WP 2 Decentralized energy recovery from sewage: use of a lab scale anaerobic membrane bioreactor (anMBR) to maximise the energy recovery from concentrated wastewater from the FO unit (WP1); study of temperature variations and hydraulic retention time on methane production and membrane fouling; insertion of an electrochemical cell via a recirculation loop to oxidise sulphide at the anode to avoid methanogenesis inhibition.

WP 3 Value-added products from sewage to control sewer corrosion: study of the production of caustic soda at the cathode and oxygen at the anode during its regeneration of the electrochemical unit applied in WP2; long-term evaluation of the use of these products to minimize sulphide production in a labscale sewer rising main.

WP 4 Impact of sewer mining on WWTP optimization: study of the impact of sewer mining on downstream wastewater treatment processes and in particular the nitritation/ denitritation pathway for N and P removal under low COD loading, high pH etc; optimize energy efficiency and reduce greenhouse gas emissions.

WP 5 Mathematical modelling and system-wide planning: develop novel dynamic mathematical models of the novel processes. These models, together with different criteria (environmental, technical, economic and social) will be integrated in a decision support system for planning centralized/decentralized urban water systems under different scenarios. Prof Rodríguez-Roda will lead WP 6 (project management and exploitation) with strong support of his institution s administrative team dealing with all financial, administrative, and legal aspects of the project including intellectual property management. A scientific board will be constituted by including a senior scientist of each institution. The scientific board will be the main decision-making group to keep the project on track and manage any risks. An advisory and stakeholder board will be constituted to guide and advise upon technical challenges and appropriate dissemination and exploitation strategies.

**Pioneer\_STP**

**The Potential of Innovative Technologies to Improve Sustainability of Sewage Treatment Plants**

Pioneer\_STP addresses the challenges related to wastewater treatment (WWT) from a holistic perspective. Concepts such as resource recovery, sludge management, energy balance optimization, new effluent quality requirements (Emerging Pollutants, EP) and emission of greenhouse gases (GHGs) are compulsory to drive the European water sector to be more innovative, productive and competitive. The project aims at assessing the impact of the integration of (4) innovative Unit Technological Solutions (UTS) (comprising in total 9 technologies), nowadays developed at lab- or pilot-scale, targeted to energy recovery and nutrients removal/recovery, into a Sewage Treatment Plant (STP). Each UTS will be characterised not only in terms of efficiency but also concerning their environmental (LCA, Risk), economic (LCC) and energetic impacts.

Pioneer \_STP considers the cross effects (positive and negative) between the different units, in a strategy that goes beyond a focus on a particular unit to a global focus (the entire STP). A number of different layouts including the innovative units will be assessed under a multi-criteria analysis by using a superstructure-based optimization framework. The optimal process design solutions (novel plant flow schemes) will be further optimized by using a dynamic plant wide modelling platform (PWM).

The consortium includes 5 skilled teams from Denmark, Italy, Spain and Sweden, from Academy and Industry, providing a multi-disciplinary approach: Development and full Characterisation of each UTS for Wastewater (Aqualia, KTH, USC), Centrate (UNIVR, Aqualia) and Sludge treatment (USC), Life Cycle and Risk Assessment (USC), Life Cycle Costs Assessment (DTU, USC) and Superstructure-based optimization and Simulation of mass and energy fluxes in the water, sludge and gas streams by means of PWM (DTU). Cooperation is enhanced by a mobility plan focusing on complementary skills. Research results can be transferred in a relative short time period to full scale STPs, an important added value for the stakeholders that support this proposal, including Companies and Water Authorities.

**WE-NEED**

**WatEr NEEDs, availability, quality and sustainability**

Groundwater (GW) is a major source of water supply in Europe. This natural resource is endangered by several factors, such as improper water management policies, including over-exploitation, and contamination by anthropogenic activities. Ignoring the profound consequences of GW depletion and quality deterioration is the foundation on which unsustainable water policies are built. The goal of this project is to develop new management strategies to assist in the sustainable use of two key components of the GW resource: pumping wells, used to obtain water for drinking purposes, and natural springs, typically employed for crop irrigation as well as for recreational use. We ground our activities on observations linked to two field sites in Italy. These sites are archetypal of two distinct realities and can be considered representative of diverse environmental settings and conditions of Europe-wide interest. As such, key features of our approach and techniques are resilience and adaptability, so that the approach can be readily adapted and employed in other European aquifer systems. We will (i) build conceptual models to describe groundwater system functioning under the influence of uncertain parameters and processes defined at diverse spatial-temporal scales; (ii) characterize the fate of emerging contaminants (ECs) such as pharmaceuticals, personal care products and engineered nanomaterials, as well as agricultural and industrial chemicals, in aquifers and the way they may threaten the quality of GW; and (iii) quantify the effect of multiple sources of uncertainty on sustainable management and protection of groundwater, here including hydrogeological settings, well abstraction rates, sources of contamination, anthropogenic actions, EC loads, natural attenuation processes, spatial and temporal distribution of redox conditions and ecotoxicological concerns. Because geological media are heterogeneous and exhibit spatial variations on many scales, prediction of subsurface flow and transport are formidable challenges. These tasks can only be rigorously tackled within a probabilistic framework. We apply and extend a recently developed scaling framework able to explain a wide range of observations about the way main statistics and probability distributions of environmental variables change with (space-time) scale. We adopt a Probabilistic Risk Assessment (PRA) approach aimed at increasing confidence in decision making through quantification of risk. Our approach to PRA involves considering information of various origins and synthesizing them in a descriptive and simplified set of indicators, easily transferable to decision makers. Casting the work in a Bayesian framework will enable updating risk indices by conditioning on data obtained in the experimentallyoriented parts of the project. Risk analysis will be based on assessing exposure of a given organism to concentrations of ECs, combined with ecotoxicological studies, as well as consideration of social implications. Ecotoxicity tools (bioassays) will allow quantitative assessment of potential deleterious effects to the environment of the ECs that may be present in the system. Relevant and application-oriented pilot scenarios jointly identified with the stakeholders involved in the project will be analyzed. This will lead to (i) assessment of the contaminant-specific vulnerability of the aquifer systems, and (ii) improved, physically-based risk assessment and water management protocols. As such, PRA provides an umbrella under which knowledge of diverse nature can be blended so that a comprehensive decision can be taken by properly considering risk (Decision Making Under Risk). As a concrete and applicable product, we will provide a decision-making procedure and associated decision matrix for the sustainable use and management of groundwater for civil, agricultural and industrial activities and ecosystem preservation in the pilot scenarios.

**IRIDA**

**Innovative remote and ground sensors, data and tools into a decision support system for agriculture water management**

Efficient agriculture water use is of crucial importance for water resources management. Consequently, accurately determining evapotranspiration (ET) is the first step for improving irrigation efficiency and productivity and for quantifying the ecosystem water balance. Several approaches for determining ET have been proposed in literature, but the relation between high and low spatial resolution methods still remains unresolved in irrigation studies and water management planning. The present proposal will create a mixed model where isolated actual ET and soil moisture measurements, obtained in the representative areas within a plot, can be correlated with actual ET results obtained by means of low-resolution methods. In this sense, the combination of on-the-ground high-resolution ET methods with the analysis of thermal and hyperspectral imagery provided by unmanned aerial vehicle (UAV/RPAS/UAS) (at plot scale), manned vehicles and satellites (at catchment scale) should ease the mixing performance and solve the upscaling. The proposal will integrate the methodologies and routines into a decision support system (DSS) that will serve to manage the large amount of inputs (Big Data Analysis) and to provide simple irrigation recommendation to the end-users. At a single plot level, IRIDA will set, by means of the analysis of high-resolution thermal and hyperspectral imagery provided by UAVs, the range of variability to detect water stressed zones within. This information will be used to decide the exact location for installing on-ground sensors to increase the spatial representativeness of the ET. At a catchment scale, and under conditions of varying land use as in northern Europe, the evaluation of satellite remote sensing will allow increasing the accuracy of the ecosystem water balance determination, improving flood predictions and the water footprint assessment. The obtained results will be disseminated at a scientific level and an initial market exploitation study will be carried out by the publicprivate partnership from 4 different countries representing the great diversity of agro-systems and their water management in Europe.

**DESERT**

**Low-cost water DEsalination and SEnsoR Technology compact Module**

Irrigated agriculture is the primary user of water in Europe and is a very competitive economic sector of the European Union. Almost the 46% of the region’s population lives in places (almost nine European countries), which are water-stressed. Moreover, in Europe also the problem of water quality degradation of surface and groundwater bodies has received great interest because of the excessive use of mineral fertilizers in agriculture. Nowadays, water scarcity regions require innovative and sustainable research approaches, to enhance the use of non-conventional water sources in agriculture as a component of effective water conservation strategies. Nevertheless, irrigated agriculture in many areas in the world operates with complete disregard to the basic principles of resource conservation and sustainability practices. In this contest, implementing such a strategy is a key factor for sustainable use of limited water resources.

The use of non-conventional water resources means that it is necessary to take into account some critical aspects. In the Mediterranean Region, these sources usually may contain essential nutrients, beneficial for crop growth, but also salts, toxics ions and compounds, which can accumulate in soil and crops over time, compromising soil quality and reducing yields. Effective technologies for reducing salt concentrations in these water sources and for monitoring of nutrient concentrations, to be taken into account into fertilizer plans, represent crucial points to enable the reuse in agriculture.

The present project proposal, with participating partners from Italy, Spain and Belgium, addresses these issues and is in line with the topics of this call, by proposing an innovative water desalination and sensor technology compact module for continuously monitoring water quality and nutrient content. The effectiveness of these solutions will be tested by means of sustainability assessment, energy and cost efficiency of the system. DESERT technology, in order to contrast water scarcity and increase the water quality, looks for increase energy savings keeping part of the nutrients and using solar energy to treat the non-conventional water. The water value as a scarce resource will be evaluated by combining water characteristics, soil and climate features with environmental impacts and energy efficiency indicators in the crop-water function model.

**MEPROWARE**

**NOVEL METHODOLOGY FOR THE PROMOTION OF TREATED**

**WASTEWATER REUSE FOR MEDITERRANEAN CROPS**

**IMPROVEMENT**

With the decreasing availability of fresh water resources, particularly for the agricultural sector, the use of treated wastewater has gained popularity over the last decades. Wastewater treatment and reuse have reached extremely high levels of technological advancement and flexibility, providing multipurpose uses of treated water ranging from safe restoration of natural water bodies up to drinking standards. However, reuse still encounters resistance as users at different levels are not well informed about the potential of such waters, the benefits when it comes to nutrient recovery for agriculture, and most importantly the range of suitable methodologies for treated wastewater applications. To address this issue and in order to promote the reuse of treated wastewater, an integrated innovative methodology will be developed and applied in three demo sites cultivated with olives and grapevines. The core of the proposed methodology is the evaluation of the yield and quality of crops under variable levels of water and nutrient supply, by adapting the nutrient quantities to the phenological needs and coupling it with crops water requirements under three different local climate conditions. Activities will include monitoring wastewater quality, modeling water use and needs as well as economic feasibility/benefits. The participation of different stakeholders in the activities and all phases of the project will be promoted by their direct involvement, starting by their support to the experimental activities with a focus on the transfer of know-how, to the dissemination and building of technical and social acceptance towards treated wastewater reuse and finally dissemination and communication of results. The present proposal introduces an innovative methodological approach to treated wastewater reuse specifically addressing well-defined types of crops, agronomic practices, and water constraints that are typical of Mediterranean countries. The underlying idea is to provide evidence of the positive relationships between treated wastewater reuse and plants growth and crops productivity with specific reference to the Mediterranean.

To obtain this, in a framework of water and nutrient use efficiency, reuse practices will be made more easily acceptable by stakeholders through their direct participation to the implementation of the proposed methodology.

**INXCES**

**INnovations for eXtreme Climatic EventS**

INXCES will develop new innovative technological methods for risk assessment and mitigation of extreme hydroclimatic events and optimization of urban water-dependent ecosystem services at the catchment level, for a spectrum of rainfall events. It is widely acknowledged that extreme events such as floods and droughts are an increasing challenge, particularly in urban areas. The frequency and intensity of floods and droughts pose challenges for economic and social development, negatively affecting the quality of life of urban populations.

Prevention and mitigation of the consequences of hydroclimatic extreme events are dependent on the time scale. Floods are typically a consequence of intense rainfall events with short duration. In relation to prolonged droughts however, a much slower timescale needs to be considered, connected to groundwater level reductions, desiccation and negative consequences for growing conditions and potential ground – and building stability. INXCES will take a holistic spatial and temporal approach to the urban water balance at a catchment scale and perform technical-scientific research to assess, mitigate and build resilience in cities against extreme hydroclimatic events with nature-based solutions.

INXCES will use and enhance innovative 3D terrain analysis and visualization technology coupled with state-of-the-art satellite remote sensing to develop cost-effective risk assessment tools for urban flooding, aquifer recharge, ground stability and subsidence. INXCES will develop quick scan tools that will help decision makers and other actors to improve the understanding of urban and peri-urban terrains and identify options for cost effective implementation of water management solutions that reduce the negative impacts of extreme events, maximize beneficial uses of rainwater and stormwater for small to intermediate events and provide long-term resilience in light of future climate changes. The INXCES approach optimizes the multiple benefits of urban ecosystems, thereby stimulating widespread implementation of nature-based solutions on the urban catchment scale.

**SIM**

**SMART IRRIGATION FROM SOIL MOISTURE FORECAST USING SATELLITE AND HYDRO METEOROLOGICAL MODELLING**

The work aims at developing an operational tool for real-time forecast of irrigation water requirements to support parsimonious water management in case of actual or forecasted drought period. The system will be a prototype version of a world wide web platform (smart device), that will support users in parsimonious irrigation water management from basin authority to single farm. In particular in water limited period: i) farmers to maintain soil moisture in an optimum value interval allowing water saving and reducing plant stress, ii) irrigation consortiums to manage the water among users, according to the actual and forecasted water need; iii) water authorities to manage at basin scale the water withdraw of reservoirs respect to the actual and forecasted water request, and quantitative meteorological forecast. The system combines satellite monitoring of soil moisture and of evaporative fluxes, quantitative meteorological forecast and detailed distributed hydrological modelling of soil water balance and crop water needs. It provides real-time and forecasted soil moisture behaviour at high spatial and temporal resolutions (from 10 m to 250 m, from 1 hour to daily) with forecast horizons from few up to fifteen days. This compared to water stress thresholds defined for each specific crop and its growth stage will determine the correct timing of irrigation and the amount of water. Economic impacts at basin scale of the developed technology will be evaluated starting from single farm to larger irrigation districts considering not only the role of water and energy saved in financial terms based on the local cost of the water and crop production, but also the environmental benefit due to a parsimonious use of the water .

The proposed methodology will be applied in different case studies in Italy, in the Netherlands, in China and Spain, characterised by different climatic conditions, water availability, crop types and irrigation schemes. The proposed system, for its versatility, can be easily exported for applications to the other case studies worldwide. The presence of Chinese partner will help in demonstrating this.

Water authorities, farmers consortium and single farms will be involved for the validation of the product and the analysis of its economic impacts for the demonstration area. The expected innovative tool will have impact both on the scientific community, as well as on operative farms and water authorities. These results will be guarantee from the work team, that represents a good compromise between research institutes and small enterprises which can implement advance research tools into an operative industrial product.

**Biorg4WasteWaterVal+**

**Bioorganic novel approaches for food processing waste water treatment and valorisation: Lupanine case study**

Food processing industry uses a large volume of fresh water to deliver safe food for humanity, which is obtained from public water providers or ground and spring water sources. The resulting brackish wastewater is often disposed of in public sewers or using different suboptimal solutions. The food processing industry is comprised of several factories of small/medium size, calling for a modular technological solution able to be quickly implemented at the companies´ site. In this project, novel separation processes using low energy and chemicals at low cost will be developed based on novel membrane processes and adsorbers capable of purifying the water for *in-situ* recycling at zero cost for the company. A far reaching concept is suggested in which alkaloids are isolated and converted into building blocks of value for pharmaceutical and chemical industries, compensating for water detoxification costs. New biological and chemical tools will be developed for conversion of alkaloids into such added value compounds. Lupanine is used as a particular example to illustrate this case.

**TH.E.R.BIO.R**

**THERMAL ENERGY RECOVERY FROM A NOVEL SEQUENCING**

**BATCH BIOFILTER GRANULAR REACTOR**

THERBIOR focuses on the development, implementation and diffusion of technologies to improve energy efficiency in wastewater treatment plants (WWTPs) using a fully off-grid solar-assisted heat pump (SHP) system, pplicable Europe-wide but centred on the Mediterranean region. The THERBIOR project aims to provide solution for the tourism sector, which is characterised by intense seasonal water demand and wastewater discharge. The integration of physical infrastructure such as a highly efficient tubular heat exchanger coupled to a fully off-grid reversible watersource heat pump with a pioneering, novel Sequencing Batch Biofilter Granular Reactor (SBBGR) already installed in the Water Research Institute (CNR-IRSA, Italy), which creates new value through reuse and repurposing. This technology may help to produce benefits for local populations in the form of wastewater management, giving people access to clean water, and thus contributing to societal well-being through better human health as a result of better water quality. Projections for future climate change point to increasing resource depletion and water scarcity, which will have a serious socio-economic and environmental impact.

Current global changes (such as climate change and urban sprawl) demand innovative practices to minimise the risks associated with water distribution and storage facilities in urban areas. Consequently, efforts are needed to strengthen public participation and imbue a sense of social responsibility concerning water and energy use, especially regarding freshwater resources, and adapting to the above-mentioned threats. Innovative technologies are required by the water industry to develop products and services fuelling the European economy. The main goal is to reuse the heat from the existing novel SBBGR reactor at CNR-IRSA into a low-temperature air conditioning system capable of covering the cooling/heating (CH) and domestic hot water (DHW) demand of an experimental test laboratory; this will be constructed during the project at the CNR-IRSA site. The system will be backed up by short-term storage based on Phase Change Materials (PCM) to ensure year-round coverage of the experimental lab's CH and DHW demand. After obtaining satisfactory results from the developed prototype, we will analyse this innovative application's viability for incorporation into Almeria's (Spain) and Bari's (Italy) tourist facility network. Our main goal will be to evaluate how much energy we can gain from a specific urban wastewater network to reduce energy consumption (coming from fossil fuels) for cooling/heating purposes in tourist buildings located in the cities. The project also intends to create new business opportunities, notably by supporting SME involvement in local water and solar-energy supply chains. THERBIOR comprises a consortium of 4 European organisations from Spain, Italy and Denmark, combining a wide range of technical, institutional and business expertise. THERBIOR aims to bring together all the specialists required to support and promote a novel technological solution to improve urban wastewater treatment process efficiency with an emphasis on model application under the European Water and Energy Directives.

**STEEP STREAMS**

**Solid Transport Evaluation and Efficiency in Prevention: Sustainable Techniques of Rational Engineering and Advanced MethodS**

The recent increase in intensity and frequency of meteorological and hydrological events in mountainous areas is recognized as one of the effects of climate change. Extreme meteorological events endorse hydrological extreme events in steep channels, like flash floods, intense bed load transport, debris flows, and driftwood. Conventional defence works and their design criteria currently in use are erratic to ensure sufficient protection to human life and urban settlements. For this reason, new approaches need to be studied. The STEEPS STREAMS project aims at researching structural innovative solutions and design criteria reliable to mitigate the impacts of flash floods and debris flows especially in presence of intense woody material transport, typical of mountain catchments. Given the growing increase of the risk conditions and the increase in urbanization of these areas in the European context, a rigorous study approach is needed. The study approach envisaged by this project is the following:

**Analysis** of the correlation between climate change and the increasing in intensity and frequency of extreme events on the small catchment in mountain areas, by highlighting the consequences for the environment, such as changing soil conditions, vegetation, the effects of frost and thawing, in order to define more certain design conditions as regards the liquid and solid flow and the driftwood.

**Development** of a mathematical model capable of simulating the transport of liquids and intense solids flows, even in the presence of plant material.

**Development** of rational criteria of the mitigation remedial and defence techniques for the prevention and risk management related to extreme events in mountains area, like debris flow and intense bed load transport, associated with the driftwood. In particular, the development of innovative rational approaches to the design of the defence structures, but with innovative solutions in order to operate a lamination of the solid material and of the wood material separately.

**Assessment of the tools** developed with physical model, mathematical model and at real scale. The outcome of the project is the application of innovative rational criteria for the mitigation, prevention and risk reduction against extreme events. Criteria are adapted to the particular conditions of mountain areas and account for the effects of climate change.

The output of STEEP STRREAMS will consist in scientific publications and in a guideline for the prevention, risk management and risk mapping against extreme events of solid transport in steep stream of mountain areas in Europe, developed accounting for the effect of climate change. The project also aims at starting a collaboration between researchers and practitioners also belonging to different disciplines, like meteorology, climatology hydrology, hydraulic engineering forestry engineering, including the research fields of sediment transport and of wooden transport in steep streams.