22 APRILE, VENERDÌ

16:00 - 17:30
SALA A
CENTRO CONGRESSI PARTENOPE

ENV-2

PARTICIPATORY RESEARCH AND OPEN SCIENCE FOR MANAGING THE WATER-ENERGY-FOOD-ECOSYSTEM-SOCIETY (WEFES) NEXUS ACROSS THE GLOBAL SOUTH AND THE GLOBAL NORTH

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CONTRIBUTI

Transition management towards Water-Energy-Food-Ecosystem Nexus Through Responsible Research and Innovation – preliminary results from four Mediterranean Countries

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A participatory approach to map and assess Cultural Ecosystem Services provided by Protected Areas in Albania

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Agricultural production in Egypt: between sustainability and increasing demand

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Water, energy, food and environment nexus in six irrigation schemes of the Spanish Duero basin

I. Naroua, Université Boubakar Bâ de Tillabéri; L. Rodriguez Sinobas, Research group "Hydraulic for Irrigation", Agricultural Engineering School, Technical University of Madrid (UPM)

Potential of biochar derived from food industries as a sustainable adsorbent material for clean water provision in developing countries

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Modelling the impacts of water harvesting and climate change on rainfed maize yields in Senegal

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Rainwater harvesting techniques to support food security and climate adaptation in African drylands

P. Tamagnone, T. Pacetti, E.Caporali, Dipartimento di Ingegneria Civile, Ambientale, Università degli Studi di Firenze

Methods and indicators for the operationalization of the Water-Energy-Food-Ecosystem Nexus in the Mediterranean, with a focus on policy

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ABSTRACTS

TRANSITION MANAGEMENT TOWARDS WATER-ENERGY-FOOD ECOSYSTEM NEXUS THROUGH RESPONSIBLE RESEARCH AND INNOVATION - PRELIMINARY RESULTS FROM FOUR MEDITERRANEAN COUNTRIES

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The Nexus approach aims to make visible complex trade-offs among the natural resource dependencies of energy, food and water systems, and environmental threats including biodiversity loss, climate change and localized air and water pollution. The nexus between water, energy, and food has recently evolved as a resource-management concept to deal with this interwoven set of resources,their complex interactions and their effect on the natural, innovation and social ecosystems. FortransitioningtowardstheWater-Energy-Food-Ecosystem (WEFE) Nexus it is necessary to manage the change that the WEFE-Nexus brings. WEFE-Nexus requires reflexive transformation and innovation in collaboration among sectors, stakeholders, and their mental paradigms and practices. For such WEFE-NEXUS transformation and adoption, it is necessary for actors and stakeholders to actively participate in the WEFE-NEXUS transition process and to take ownership of this transition. Moreover, when transition concerns the most important societal goods of water, energy, and food security and at the same time preserving the natural ecosystem and environment, a carefully planned transition process is even more critical to secure successful adoption by all concerned stakeholders and actors. In this respect, the concept of Responsible Research and Innovation (RRI) is very suitable for facilitating the transition towards WEFE-Nexus. RRI aims at an interactive process, where societal factors, researchers and innovators actively cooperate to together co-define, co-design and co-construct solutions, services and products that are socially acceptable, sustainable and resolve important societal issues. In the EU PRIMA-funded project NEXUS-NESS, all these concepts and elements have been brought together into the NEXUS Ecosystem Innovation Labs Methodology. In this paper, this methodology of transitioning towards WEFE-Nexus is presented together with the first preliminary results of its application in four locations where the Nexus Ecosystem is being formed to transition towards WEFE-Nexus. The four locations are: a)Cornia watershed, in coastal Tuscany, Italy; b) Duero watershed, Spain; c)Wadi Jir watershed in Tunisia; and d)Wadi Naghamish watershed, Egypt. Innovation occurs at the intersection of collaborative activities among all these actors, by allowing them to exchange knowledge, learn from each other and to innovate horizontally.

A PARTICIPATORY APPROACH TO MAP AND ASSESS CULTURAL ECOSYSTEM SERVICES PROVIDED BY PROTECTED AREAS IN ALBANIA

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Natural resources are increasingly at risk because of climate change, demographic and economic growth, political instability, and forced migration. Globalization places additional pressure on resources, biodiversity and ecosystems, and, consequently, on the economies and well-being of local and neighboring populations of affected countries. In this context, International Cooperation for Development faces the urgency to work within the Water–Energy–Food–Ecosystems (WEFE) Nexus, aiming to increase water, energy, and food security without compromising ecosystem services and properly adapting to different operating social contexts. Propaedeutic to the WEFE Nexus framework, Mapping and Assessment of Ecosystem Services (MAES) is needed. Although MAES importance is firmly recognized, it is not yet a commonly widespread practice in emerging and developing countries. This is mainly due to the absence of a proper policy and operational framework, with several open issues related to data scarcity, lack of monitoring resources, absence of long-term management plans, and uncertainties in the administrative structures. Among others, river corridors and wetlands produce high-value ecosystem services, providing key habitat diversity for wildlife, but also water and sediments suitable for different human uses. Such ecosystems also supply cultural services, defined as the non-material benefits people obtain from ecosystems, which are deeply interconnected with other ecosystem services. The Balkan region is one of the last areas of Europe in terms of wilderness and integrity of fresh and coastal waters. In this context Albania emerges emphatically, with its nearly 384 Protected Areas (PAs), established due to the biological diversity of natural and cultural assets they offer. Although some PAs are officially recognized since 1940, the National Agency for Protected Areas (NAPA) faces several challenges in ensuring continuous and effective monitoring, management and conservation. Indeed, the abrupt socio-economic change in the Country and the massive emigration produced a lacking institutional and management framework within a paucity of resources. In this context, the Italian Agency for Development Cooperation (AICS) has identified Natural Capital as one of its priorities in the Environment and Nature sector and thus has concentrated its action in the last years in enhancing and supporting the capacities of NAPA for the responsible management of the Albanian PAs. This long-term AICS approach, which encompasses as key pillars the enhancement of the natural and cultural heritage present in the territory in an eco-touristic perspective, the protection of biodiversity and the socio-economic development of local communities, is expressed by the ongoing initiative NaturAlbania: capitalization and promotion actions in the territorial and environmental framework. NaturAlbania is indeed the project in which our work is framed, within one of its pilot actions, implemented by a heterogeneous network composed of the University of Trento, AICS Tirana, and three project partners, namely the local NGOs VIS, CELIM, CESVI. We hereby present the implementation of a socio-cultural participatory approach to map and assess Cultural Ecosystem Services (CES) in selected Protected Areas in Albania. Selected study areas are i)Shkodra Lake Nature Reserve (26,5 ha), ii) Buna-Velipoje Protected Landscape (23 ha), Divjaka-Karavasta National Park (22 ha), and iv) the Vjosa river corridor. The participatory activity was developed firstly by identifying and selecting stakeholders and relevant ecosystem services. Secondly, a test phase of the core participatory activity and final reformulation of the semi-structured survey and the supporting maps

was done. Then, after survey activity conduction, data analysis and the final sharing and communication of results were proposed. Globally, 40 stakeholders were actively involved among Public Administration (n.17), Environmental NGOs (n.8), local associations (n.8), eco-tourism operators (n.5), independent contractors involved in local planning and development (n.2). Per each study area, a local subset of stakeholders was considered. During the survey, each respondent was asked to indicate and draw on a paper map the existence, in terms of supply, of a set of CES out of a given set including 1) Sport and Recreation, 2) Tourism, 3) Contact with Nature, 4) Scientific Research, 5) Learn, Education, 6) Belonging/Identity, 7) Sense of Place and attachment to Nature, 8) Symbolic and Sacred, 9) Existence / Bequest. Apart from the existence and qualitative mapping of the above-mentioned CES, respondents were asked to rank the relevance of indicated CES on a 5-point scale.In this outlook, we provide a detailed description of used methodologies, adaptation to the specific Albanian context strategies, collected data analysis, main results discussion, framed within the wider NaturAlbania project. Our work represents the integration of available local and science-based strategies to optimize data collection and accountability with an inclusive approach. We suggest this low-cost replicable methodology in data-scarce contexts to provide a reference MAES baseline WEFENexus, as a potentially decisive tool for decision-makers to properly evaluate the socio-economic value of a determined area.

AGRICULTURAL PRODUCTION IN EGYPT: BETWEEN SUSTAINABILITY AND INCREASING DEMAND

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Achieving food security while approaching a sustainable self-sufficiency is one of the major challenges of this century. High gaps between demand and production of agricultural items and the reduced freshwater availability affect resilience of the water-food system in the arid countries of the Mediterranean region, making countries dependent on trade and food imports. A resilient agricultural system can better respond to drought, extreme water events and rising temperatures, which are expected to increase in the future due to climate change. In the coming decades a further decline in the natural availability of fresh water is expected in the Mediterranean, due to rising temperatures and reduced rainfall. Furthermore, future demographic projections show a major population increase that is putting increasing pressure on agricultural and water systems, due to the growing demand for agricultural products. For this reason, it is crucial to explore sustainable agricultural strategies that preserve consumption of irrigation water, maintain crop diversity and land use efficiency. In arid regions, approaching self-sufficiency, while preserving local water resources and, at the same time, ensuring a balanced nutritional supply and economic benefits, is an

urgent challenge. An emblematic case study is represented by Egypt. Since ancient times, Egyptian agriculture has developed along the banks of the Nile River and in the Delta, and today it represents the main contribution to the national economy, covering about 13% of the national GDP. The Nile River is the main source of water and 80% of the region's water consumption is for the agricultural sector. Currently, the available water resources in Egypt are already overexploited, and the current water is expected to furtherly increase in the future. Egypt is also affected by malnutrition issues, including iron deficiency-induced anemia, diabetes, and overweight issues. The analysis aims to evaluate an alternative sustainable crop distribution that enhances self-sufficiency in Egypt, optimizing crop productivity. We assessed the benefits obtained with an optimal crop distribution coupled with sustainable agricultural intensification. We adopt a spatially explicit approach to assess the crop water needs and the amount of irrigation water used for agriculture. Our agro-hydrological model is able to quantify spatially distributed crop water requirements, -namely blue and green water requirements -which are the volumes of water needed to compensate crop water losses through evapotranspiration. We first evaluated crop water needs and crop production related to the current crop distribution and second, we identified potential differences in food production and water consumption between the current and optimized crop distributions. The total currently cultivated area in Egypt's 5,467,880 hectares. The most extensively cultivated crops are cereals and forage grasses, followed by vegetables. The total annual volume of water required by the 17 crops is around 30.14km³, which is mainly covered by the volume of blue water (28.06km3), while the volume of green water was only 2,16km³, due to the low precipitation rate that characterizes the Egyptian climate.The results confirm that the contribution of irrigation is essential to support agricultural production as it provides 95% of the total crop water needs for the area. Our results show that domestic production cannot meet the food demand of the population for crops that are mainly present in the current diet(e.g.,cereals,soy,sugarcane,sunflowers and sugar beet). On the contrary,through the reallocation the production of these crops has been increased, reaching productive self-sufficiency for almost all of them. In particular, the reallocation of cultivated land increases the areas of cultivation of crops that have high production gaps, namely wheat, corn, soybean and sunflower. Our results show that, with an optimal crop redistribution, it is possible to feed a higher portion of the Egyptian population, using the agricultural resources of the country, without increasing the pressure on the currently available renewable freshwater resources of the Nile River.

WATER, ENERGY, FOOD AND ENVIRONMENT NEXUS IN SIX IRRIGATION SCHEMES OF THE SPANISH DUERO BASIN

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Irrigated agriculture is a key factor to foster crop production and the agribusiness sector. It also contributes to develop rural areas and maintain the population in rural villages in Spain. However, water resources are not always available to fulfill plant water requirements when needed. In addition, the Plan for modernization of hydraulic irrigation infrastructures (2000) has increased energy consumption and drastically raised the energetic cost in the last five years. Irrigated areas modify the natural environment thus, the application of agrochemicals and pesticides, together with an important aquifer overexploitation, have resulted in groundwater quality degradation and river fishes' extinction. On the one hand, the European, National and Regional Normative, regarding ecosystems requirements and services, must be met. On the other hand, farmers want to leave in the rural areas as long as their gross income is higher than expenses. Likewise, climate change predictions foresee an increase in temperature, which will increase crop water needs, and more droughts in semi and arid areas. Duero is the second largest river in Spain and supplies water to a larger and depopulated area where agriculture is the most important economic sector. The irrigated area has doubled in the last fifteen years and consumed 85% of total water resources at present. In the near future, in order to foster rural development and settle the population, it will be necessary to maintain irrigation but we have to tackle with the issues: water scarcity, energy prices and fertilizer cost. This work is aimed at providing some clues on the water-energy-food-ecosystem nexus in rural areas of Duero basin. Hence, six Duero irrigation schemes (Adaja, Tordesillas, Aranda-Tordesillas, Tordesillas-Zamora, Villalar de los Comuneros and Carracillo) have been selected. The study focuses on the evolution of water and energy consumption, as well as main crops production and ecosystems' status, from 2010 to 2020. The results would be a valuable tool to develop sustainable solutions (at regional scale) for fair and sustainable sharing of food production resources including energy, water, food and ecosystem.

POTENTIAL OF BIOCHAR DERIVED FROM FOOD INDUSTRIES AS A SUSTAINABLE ADSORBENT MATERIAL FOR CLEAN WATER PROVISION IN DEVELOPING COUNTRIES

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Geothermal contaminants and inadequate sanitation systems in poor and rural communities generate unsafe drinking water sources that increase public health risk and spread of diseases.

Waterborne diseases are endemic to these regions due to poor sanitation systems and unsafe water sources (Pandit & Kumar, 2015). Around 600 million people suffer from a shortage of safe drinking water facilities, therefore rapid transformation of existing knowledge and technologies into practical levels is needed to achieve the Sustainable Development Goals (SDG) 6 (Ensuring Water and Sanitation and Sustainable Management for All by 2030), and it is necessary to implement solutions frugally through policy formulation over the next 8 years. In particular, parts of Asia, Africa and South America are lagging far behind during this time frame due to poor scientific research and lack of funding.

Biomass generated from agricultural waste has been recognized as a rich source of feedstock for the production of biochar, but currently, farmers and other stakeholders like millers are practicing open field burning or open dumping processes to get released from these by-products. This causes great pollution and adverse health effects to humans as well as animals. Therefore, it seems that the potential of these by-products of agricultural industries has not been fully utilized yet in both developed and developing countries. The integration of biochar into water purification and sanitation systems will be enabled to create a circular material flow instead of a linear material flow. Therefore, the object of the current study is divided into two parts: 1. to draw the attention of scientific communities and policymakers to the potential of biochar in the water treatment sector to the provision of safe and clean drinking water; 2. to identify research gaps and future outlook in biochar-based water treatment.

Biochar has an admirable ability to remove several contaminants from aqueous solutions and is related to technology not been used for drinking water treatment yet (Figure 1). Biochar adsorbent has several positive impacts compared to low-cost conventional treatment methods (boiling, chlorination, sand filtration, solar disinfection). Due to its abundance, low cost, and simple technology, it is appropriate for low-income countries. Conventional low-cost methods primarily eliminate pathogens, but biochar has the potential to remove many contaminants from drinking water. Existing technologies, such as chlorination produce carcinogenic by-products, and boiling increases the concentration of chemical pollutants.

Biochar production is based on temperature and vapor residence time (Figure 1). Therefore, the physical and chemical properties of biochar are dependent on the production process, as well as adsorption capacities are depend on several characteristics of biochar, the main factors being the biological source, pyrolysis temperature, type of modification, pH value of the solution, reaction temperature, amount of dosage, initial concentration of contaminant, and presence of competitive ions in the solution. Also, the interaction between adsorbent and adsorbate and the physical and chemical properties of the biochar are the governing factors for the removal of contaminants from water.

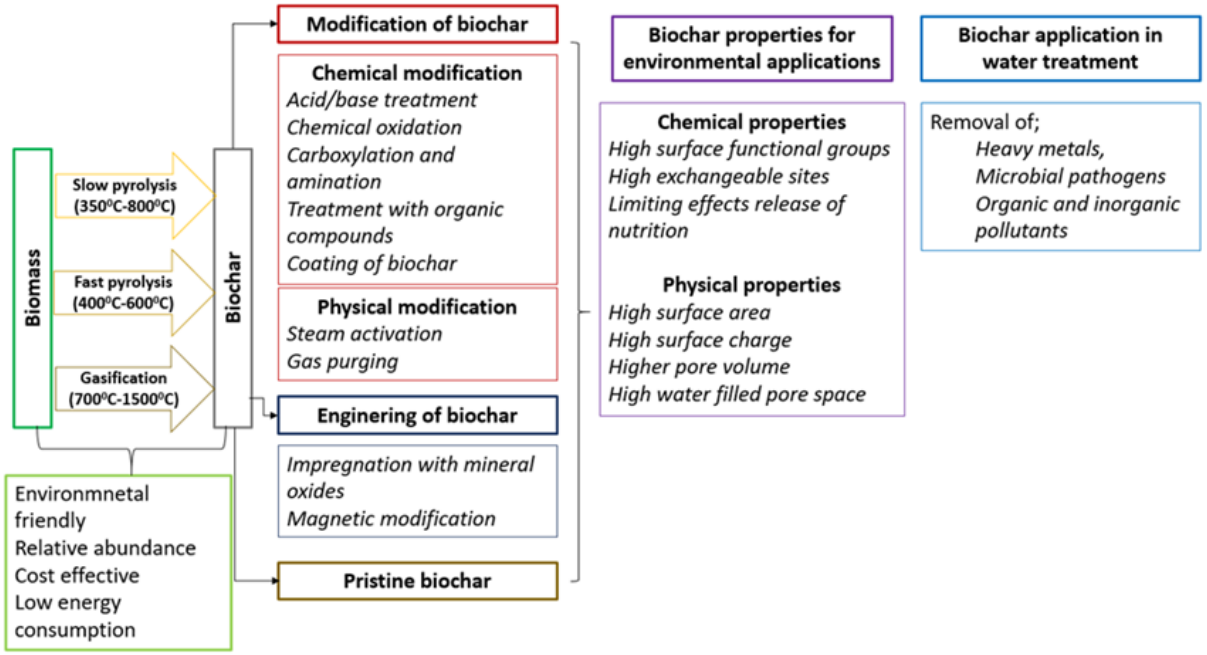

Figure 1. Strategic schematic diagram for biochar production, modification/engineering, characteristics, and water treatment applications

Using biochar as an absorbent material in water treatment and other life areas may have some positive economic benefits. In the case of biochar-based products, their price mostly depends on raw material, pyrolysis, storage, and transportation. Some data has been reported on the fact that the net present value of biochar production has shown positive effects on economic viability. To minimize the production cost, it is necessary to implement new technologies and selection of cheaper and sustainable raw materials like agricultural waste. The use of agricultural by-products to produce biochar is in line with achieving SDGs and the circular economy concept.

The recent studies have been focused on different types of biochar for the adsorbent of pollutants in aqueous solutions and not much effort is given for the practical feasibility, applicability, scalability, and efficacy. Figure 2 describes the schematic diagram of existing research findings and research gaps that should be overcome in the future. At last, certainly, the use of biochar in drinking water treatment makes a positive impact on the environment and economy, and it results necessary to ensure the safety and reproducibility of the adsorbent and to comply with international standards European EN 12915-1:2009 (Products used for the treatment of water intended for human consumption).

This study has been developed under the Ph.D. Program in Civil, Environmental, International Cooperation, and Mathematical Engineering, under the curriculum of appropriate methodologies and techniques in international development cooperation. Currently, the authors are working on the possibility to use biochar obtained from rice waste for the purification of water from arsenic and fluorine.

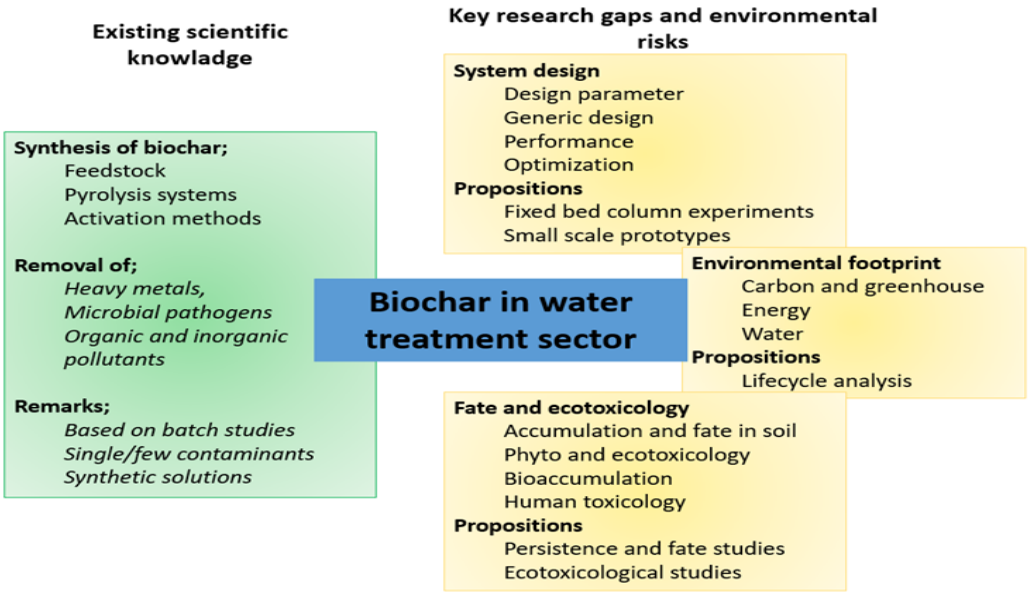

Figure2. Summary of existing information on biochar application as an adsorbent and key research gaps.

MODELLING THE IMPACTS OF WATER HARVESTING AND CLIMATE CHANGE ON RAINFED MAIZE YIELDS IN SENEGAL

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The agricultural sector of Senegal is prone to drought and climate change impacts. Despite this,the country counts less than 5% of irrigated lands,suggesting that its national agriculture is still strictly dependent on the rainy season. Moreover, rainfall is characterized by the presence of great variability,both on interannual and interdecadal timescales. In this framework, a research gap is represented by the lack of analyses on how much the current agricultural practices can be resilient,and on what water management strategies can be effective against climate change. Using FAO's AquaCrop crop-growth model, made up of a set of four sub-model components(climate,crop, soil, and management) to simulate a crop cycle, we simulated plausible climate change scenarios at different fertility levels, testing the efficiency of tied ridges water harvesting for the maize crop in the Fatick region, Senegal. Non-conservative parameters were adjusted with crop data collected within the project "Rain, Forest and People" of the International Rainwater Harvesting Alliance

(IRHA,https://www.irha-h2o.org/en/projects/la-pluie-la-foret-et-les-hommes) while calibration and validation were performed with regional yield data.Considering the current climatic scenario and soil fertility, tied ridges did not significantly impact the maize yields. Rainfall amount was enough for maize production and to avoid high water stresses along the cropping season. Under climate change scenarios, high reductions in yield were registered up to70% in optimally fertilized soil and 50% in conditions of fertility stress. Tied ridges only slightly increased yields up to 3.8% when a high reduction of rainfall occurred. When also considering the occurrence of dry spells in addition to climate change, maximum yield reductions do not exceed the values found without dry spells. However, in such context, tied ridges water harvesting performed better against climate change, especially under full fertilization management.Our results highlighted how the current maize production in the Fatick region of Senegal sustainable the current climate scenario, while it could be potentially impacted by climate change in the near future. In a pessimistic climate change scenario with dry spells occurring in the rainy season, in-situ water harvesting has the potentiality to avoid excessive crop losses.

RAINWATER HARVESTING TECHNIQUES TO SUPPORT FOOD SECURITY AND CLIMATE ADAPTATION IN AFRICAN DRYLANDS

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Sub-Saharan countries are the poorest regions in the world, with extremely fast population growth,and increasing demand for local agricultural production in scarcely fertile lands, naturally poor inorganic matter. Moreover, these countries are experiencing an exacerbation of extreme weather phenomena and climate change. Catastrophic rainstorms with intensities exceeding hundreds of mm per hour that in combination with land-use changes can often provoke severe flood events, from one side. The intensification of the hydrological cycle processes, with longer and severe drought periods that are compromising the reliability of local agricultural practices, from the other side. As consequence, especially in developing countries, damages to agricultural areas and food production undermine food security.To deal with drought-related threats to food security, a possible improvement can consider various rainwater harvesting techniques (RWHT) aiming to capture rainfall, increase the water use efficiency,reduce crop water stress, and increase the crop survival expectation.The Farming practices, by catching surface runoff, reducing erosion of fertile topsoil, and increasing infiltration can effectively contrast the ongoing desertification that affects drought-prone areas.The present study provides a comprehensive investigation concerning the benefits induced using indigenous RWHT against hydrometeorological threats affecting the Sahelian areas.The RWHT have been tested in term of runoff retention, infiltration increase into the root zone and the benefits on the crops induced by the water stress mitigation.To achieve these purposes, a series of

ecohydrological analyses are carried out and the hydrological processes at the field scale are evaluated computing the entire hydrological balance over the growing season of typical crops that are at the base of the Sahelianfarmer's diet. To make the study representative of the whole Sahelianbelt, a series of simulations were carried out using a wide range of input parameter sets generated for being representative of conventional values of those areas.The assessment takes into consideration also how the rainwater harvesting techniques are affected by the site characteristics in terms of land use, morphology and soil properties. Moreover,a comprehensive assessment of the ecological benefits which account for the crop life cycle jointed with the water cycle is also implemented.The results show the remarkable benefits induced by the use of specific farming practices dedicated to the improvement of rainwater harvesting.The enhanced infiltration provides a faster recharge of groundwater, which is available early for crops and later represents a precious storage for plants with a deeper root system. In terms of water management, this means an increase in green water availability for the benefit of a reduction in bluewater consumption (the amount of groundwater extracted for irrigation purposes).The effects of RWHTin green/blue water partitioning is evaluated by means of water footprint indicators of the crops produced highlighting the soil water content increment which prevents crops from reaching the condition of being water-stressed, maximising the yield while reducing the impact on bluesources. Upscaling the diffusion of these simple and affordable techniques would represent the first step towards the enactment of adaptation strategies to cope with climate changes and food scarcity.

METHODS AND INDICATORS FOR THE OPERATIONALIZATION OF THE WATER-ENERGY-FOOD ECOSYSTEM NEXUS IN THE MEDITERRANEAN, WITH A FOCUS ON POLICY

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Over the last years, the water-energy-food-ecosystem (WEFE) Nexus has received the attention of scientists and policy makers as a management approach to achieve water, food and energy security while preserving the environment. Implementing such an integrated approach is crucial for the Mediterranean, a region characterized by increasing demand for food and energy, and vulnerable to water scarcity, the impact of climate change and the degradation of natural resources. Yet, technical and non-technical barriers exist in the operationalization of the nexus approach, including lack of scalable modelling frameworks and limited means to demonstrate the benefits of the WEFE nexus on resources management. Through an extensive literature review, existing methods, tools and indicators used to operationalize the Nexus in the Mediterranean regions were identified and analyzed. The reviewed methods were assessed based on the location of application, their geographical scale (i.e.farm, basin, region, national), the part of the Nexus they focus on (e.g. water-food, energy-water,ecosystem) and the typology of the methods they utilize (e.g. system

dynamic modelling, index-based approach, LCA). It is clear from this review that the majority of methods, tools and indicators have been developed with siloed aims and they focus on a specific issue, sector, scale or country. Whereas Studies proposing a singular framework with applicability to the wider Mediterranean regions are few. In addition, methods and tools for the evaluation and integration of the impact on ecosystem services in Nexus assessments were also found to be limited.

PHYSICO-CHEMICAL ASSESSMENT OF WATER QUALITY IN THE WETLAND ARE OF THE TECHNOPOLE IN DAKAR, SENEGAL

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The preservation of wetlands is an important ecological issue, because these natural areas are home to an essential part of biodiversity and provide many services to the environment and to humans. Wetland ecosystems play important socio-economic functions for the development of the Dakar area and its inhabitants. The Technopole is a wetland very rich in biodiversity with a groundwater that practically flush the ground. The superficial groundwater, the discharge of wastewater treated by the wastewater treatment plant (WWTP), the drainage channels for rainwater and wastewater from neighboring districts, rainwater during wintering have reinforced the waters of the area which has become a lake. It is an area very suitable for agriculture, therefore the water treated by the WWTP is reused by market gardeners to cultivate all kinds of agricultural products.However, the high concentration of the population in the Senegalese capital Dakar, the significant discharges of wastewater, excreta, solid waste in areas sensitive to pollution, the occupation of the area by market gardeners using natural fertilizers organic materials, pesticides without respecting the standards, the large quantity of wastewater received by the wastewater treatment plant (WWTP) which exceeds its treatment capacities (WWTP undersized), the clandestine canals connected directly to the lake pose a serious problem in the management of the environment of the Technopole. As a result, the site is currently being attacked by the pollution of its water reserves (groundwater and lake)and the management of the quantities of wastewater that exceed its admissibility limits.Therefore, we focus our study in a physicochemical assessment of the quality of treated wastewater,the lake and groundwater in the Technopole area of Dakar, the capital of Senegal, in order to know the most polluted areas and provide a solution. This work was carried out by measuring the following water pollution parameters: temperature, pH, conductivity, dissolved oxygen, total dissolved solidsTDS, salinity which were measured in situ and nitrates NO3-, nitrites NO2-, total suspended solids TSS,total Kjeldahl nitrogen, total phosphorus measured in the laboratory of the Senegalese National Sanitation Office (ONAS in French) in Cambérène. A total of twenty-seven sampling sites including tenon the lake, eleven in the groundwater and six on treated wastewater from the Niayes treatment

plant were selected. The salinity analyzes showed that the lake is very salty with an average value of 21g/ L. The overall results revealed that the area surrounding the wastewater treatment plant is the most polluted part of the Technopole with values exceeding Senegal's wastewater discharge limits NS 05-016 July 2001, and the standards of wastewater reuse in agriculture from FAO, WHO. Our results confirmed our hypotheses during our investigations.Thus,the environment of the wastewater treatment plant represents the most polluted area of the Technopole. The leaching of chemical fertilizers such as NPK 10-10-20 used practically by all market gardeners, animal and poultry manure and mud have contaminated the groundwater table with nitrates, total nitrogen and total phosphorus. The lake is polluted in its northern and southern areas. The northern zone is more polluted by the installation of the wastewater treatment plant and the intensive fertilization of the market gardening fields, the southern zone of the lake by the clandestine canals and rainwater drainage canals. Wastewater treated and reused in market gardening in the area is dangerous to health and even destroys the quality of the soil. The mud used as fertilizer does not undergo adequate treatment, thus it constitutes a threat to the health of the populations who consume the products harvested from the area.

WATER-ENERGY-FOOD (WEF) NEXUS: A CASE STUDY OF RAICHUR DISTRICT OF KARNATAKA, INDIA

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Water security has become the primary concern among policymakers around the world. The water footprint is spread over different sectors,viz, agriculture, power production, etc. along with domestic needs, which often requires prioritization in water allocation. To arrive at an optimal strategy, anexus study is inevitable. The study aims to quantify the interaction between sectors (Agriculture,Power, Water, Ecosystem), with a focus to minimize water consumption in each sector. The study area, the Raichur District lies in the semi-arid region of Karnataka State with annual water deficit of 1.66 Billion Cubic Meters (BCM), and it accounts annual rainfall of less than 500 mm. The main water source of the district is Krishna and Tungabhadra rivers, which marks the northern and southern borders of the district. The district shows high water demand for power generation, crop production and livestock.The total land coverage of the district is about 8000 sq.km, with cultivable land area of around 6512sq.km. But the net irrigated area accounts only 33% of total cultivable area, i.e., 2161 sq.km. The research findings indicate that the water consumption in agriculture has reduced over the decades in the district. Further, the research reflects that, even though major irrigation canals are constructed, gross irrigated area is showing a declining trend. The study will find out the extent to which thermal power plants and other industries have limited the availability of water for irrigation. The research provide a glimpse of whether the cropping patterns/ choices has shifted with respect to

water availability.There are two thermal power plants in the study area, namely Raichur Thermal Power Plant (RTPS)and Yermarus Thermal Power plant (YTPS) with respective capacities of 1750 MW and 1600 MWrespectively. The cumulative annual requirement of freshwater for the thermal power plant comes around 100 MillionCubic Meters (Mm3).The paper will assess the scope of potential improvements in technologies and practices to optimize usage of water in thermal power. As per the Tariff Policy of 2016, it is mandatory for power plants inIndia to use treated waste water, if available within 50 km radius. The power plants need to make necessary arrangements with urban local bodies to utilize treated wastewater from SewageTreatment Plants (STP). The Raichur city has three STP's with a total capacity to treat 33 million litres of sewage water a day. The study will also focus on the possibilities of using STP reclaimed water after appropriate treatment in thermal power plants, mainly for ash handling, coal dust suppression etc. A detailed cost and benefit analysis will be done for the same. Often nexus studies fall short of implementation on the ground, hence this study will try to close such gaps by understanding the dynamics that influence nexus including political and cognitive factors. Further, the paper will project different water demand scenarios till 2050, to understand the dynamics of water demand for respective sectors in Raichur District. Subsequently, "water needs" for important sectors in addition to current water demand will be assessed to understand when and where water shortage could occur if adequate water management strategies are not put in place. A rapid assessment of such management strategies will be identified,and evaluated based on water quantity, reliability and financial cost, impacts to the environment etc.

FOSTERING EURO-MEDITERRANEAN INTERNATIONAL COOPERATION TO MAINSTREAM WEFE NEXUS APPROACHES: INSIGHTS FROM THE ITALIAN, SPANISH, TUNISIAN AND EGYPTIAN NEXUS ECOSYSTEM LABS OF THE PRIMA-FUNDEDNEXUS-NESS PROJECT

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Several academic studies have investigated the understanding, modelling and predicting Water, Energy, Food and Ecosystem (WEFE) Nexus scenarios for safe, fair and sustainable access to natural

resources. WEFE Nexus has been, and will increasingly be, a very actual and crucial topic across the earth and environmental sciences as well as social sciences and humanities. Available interdisciplinary research provide validated information on the crucial interlinkages that govern the WEFE interfacing dynamics.It is proven that managing natural and urban ecosystems without considering WEFE interlinkages may determine undesirable consequences in terms of safety and sustainability from multiple perspectives (e.g. environmental, social, economic). From short to long term, science provides evidence of the pivotal importance and multiple benefits of implementing WEFE Nexus approaches. Nonetheless,while research and technological breakthrough repaving the way to WEFE Nexus approaches,major technical and non-technical barriers still avoid the uptake oftheNexusparadigmin operational terms. WEFE-related Multi-Sector, Multi-Disciplinary and Multi-Actor cross-cooperation and mutual trust are still lacking in actual water and land management strategies. Moreover, stakeholders and citizens are not adequately informed and involved. While several guidelines and procedures are available, WEFE Nexus policies are falling behind and generally missing from the continental (e.g. EU Directive) to the regional scale. As a result, it is of fundamental importance to support projects, platforms and programs sharing experiences, best practices and failures, at the international level. In the international cooperation sector WEFE Nexus is emerging as pivotal topic in the scientific and geopolitical debate and strategies. The NEXUS Nature Ecosystem Society Solution or NEXUS-NESS project-funded by the PRIMAProgramme under the 2020 Nexus Innovation Action-seeks to tackle the barriers that avoid WEFE Nexus transitioning, an issue of paramount importance for the Mediterranean regions, from the Global North to the Global South. NEXUS-NESS aims to co-produce and co-test with stakeholders WEFE Nexus management plans for fair and sustainable allocation of resources. At the same time a technological solution and tailored procedures are co-tested to provide actionable information and easy-to-follow guidelines for WEFE Nexus operators and stakeholders in selected case studies.The NEXUS-NESS solution transdisciplinary datasets and tools seek to interlink the WEFE Nexus Components with a three-fold conceptualization of the Ecosystem component (Environment,Economy, Engagement/Society).The social sciences and humanities components are an important asset of NEXUS-NESSsupporting the production and use of an extended set of actions that are designed to foster the behavioral change needed to mainstream the Nexus approach.This contribution aims to specifically focus on the international cooperation between European and north African regions that are involved in the NEXUS-NESS project. NEXUS-NESS efforts are working to operationalize the adoption of a WEFE Nexus bottom-up approach in four different case studies employing Living Lab and Responsible Research And Innovation (RRI) principles. Results from the first year of project development are illustrated in this contribution with specific focus on the Val di Cornia (Italy), Duero basin (Spain), Wadi Naghamish (Egypt) and Wadi Jir basin (Tunisia) Nexus Ecosystem Labs (NELs).

A TRANS-DISCIPLINARY APPROACH TOWARDS THE CLIMATE CHANGE, WATER, LAND, AND FOOD SECURITY NEXUS IN SUB-SAHARAN AFRICA

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The 5th Assessment Report of the IPCCprojected that by the end of the 21st century, the global surface temperature will likely exceed 1.5oC with higher frequencies and longer durations of heatwaves based on RCP4.5, RCP6.0, and RCP8.5 scenarios.Changes in precipitation will, however, be experienced differently across the different regions of the globe.In Africa, the Sub-Saharan region is identified as the most vulnerable to the changing climate. This is due to the region's very low adaptive capacity in connection to the acute levels of poverty and the limited facilities needed to mitigate and/or adapt to the changing climate. Sub-Saharan Africa (SSA) is a region that greatly depends on precipitation to be able to provide the water, food, and energy needs of its people. For instance, the prevalence of rain-fed agriculture in most of the region makes its food systems highly sensitive to the changing patterns in temperature and precipitation. In the past decade, scientists and policymakers have come to realize that the relationship between climate change and water, land, and food resources are not unidimensional but multidimensional. This situation therefore calls for a nexus approach that addresses the inter-connectedness, synergies, and trade-offs existing between climate change and the water, land, and food (WLF) resources, which in early times were considered independently. While studies have sought to present the climate change and WLF security nexus in Africa, efforts in realizing it in the policymaking process is less pronounced in SSA.Our study sought to bring to light the current and future impacts of climate change on WLF resources, as well as the relationship between climate change and the WLF security nexus in SSA, and further suggested strategies needed to address these issues from a multidimensional perspective in the policymaking process.The Climate Change and WLF security is a very complex system, and therefore calls for a trans-disciplinary team which is a diverse group of professionals and experts from the sectors of climate change, water resource management, natural resource management, biodiversity and ecosystem conservation, sustainable agricultural production, environmental protection, economics, sociology,and local communities, working together across their disciplines to tackle the issues relating to climate change and the WLF security nexus. The decision-making process among stakeholders must however be complemented by using models of systems approach.

AN INTEGRATED EDUCATIONAL AND RESEARCH ACTIVITY WITH RWANDAN UNIVERSITIES IN THE FIELD OF WATER-FOOD-ECOSYSTEM NEXUS

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Managing the so-called Water-Energy-Food-Ecosystem-Society (WEFES) Nexus, across the Global South and the Global North,means building small "pieces" of a mosaic that will take a long time to complete and often includes only parts of a"complex"environment. Moreover, it means not only implementing international cooperation activities, but also supporting developing countries modernising, internationalising and increasing their access to higher education,to address the challenge of their higher education institutions,and to promote contact with people, intercultural awareness, and understanding.This note deals with the experience of a project concerning theWater-Food-Ecosystem Nexus in the Rwandan context from the point of view of higher education. Strengthening multilateral partnerships between institutions active in the field of higher education is the precise objective of the Erasmus+ "Capacity Building in Higher Education" (CBHE) programme funded by the European Union. Within this framework,the project"EnRHEd"- Enhancement of Rwandan higher education in strategic fields for sustainable growth–was recently awarded,and it is currently in the full implementation phase, with a duration of 3 years,which began in January 2020. The EnRHEd project has opened up privileged relationships between four higher education institutions in Rwanda, on the one hand, and three European Universities,on the other. Namely, the Project partners are: University of Rwanda, Institute of Applied Sciences INES-Ruhengeri (Rwanda),RwandaPolytechnic–College of Musanze (Rwanda), University of Technologyand Artsof Byumba (Rwanda), Rheinische Fachhochschule University of Applied Science Cologne-RFH (Germany),University of Liège (Belgium), and University of Parma (Italy), which is the coordinating institution.The selected strategic fields for sustainable growth are: (1) Food Science and Technology, and (2)Environmental Protection, Safety and Management.These two main topics have been chosen taking into consideration the current social and economic problems in Rwanda and taking into account the synergistic effects between these two fields in terms of both education and action. In fact, the relationships between water,food and ecosystem are complex and multidimensional. The pursuit of food security through increased agricultural production may include changes in land use, soil protection, management practices and agricultural inputs, water management, and may represent a key driver of landscape change, even in connection with urban growth. From the Rwandan standpoint, the economy is based on agricultural production and almost all the food comes from local rural activities. On the other hand, Rwanda has to cope with the problems deriving from natural disasters (floods, landslides), population growth linked to the increase of urban areas, adequate water supply and sanitation services, waste management and treatment. It is evident that the lack of basic environmental policies and good practices in land planning leads to poverty and

underdevelopment.The specific actions that EnRHEd project implements are oriented to respond to these real needs through the development of innovative higher education programme that will last beyond the timespan of the project. Involving about 30 European academics, EnRHEd is expected to train a total of 46 Rwandan lecturers,35 Rwandan and 6 European students, 9 Rwandan administrative staff members.The specific objectives of the EnRHEd project are:1.revision of 9 current programmes and improvement of didactic approach;2.set up of news programmes (3 Advanced Diploma, 1 undergraduate, 6 mastersand 2 PhD);3.introduction of e-learning and digital methods;4.internationalization of education (9 trained staff members).Enhanced curricula will help the growth of the skills of experts at different levels:lecturers,researchers, professionals, trade, crafts and technicians.Specific actionsconcernmobilityflows:they aim to improve international relations capacities of the Rwandan partner institutions. The project also supports the improvement of the so-called "knowledge triangle",as a plethora of actions are geared towards strengthening the links between education, research and business.The introduction of innovative teaching/learning methods, internationalisation and connection between education and production concern the two aforementioned main fields, which are considered strategic for sustainable growth and strictly interconnected.Considering Rwanda's current problems and national development policies, it is clear that the Water-Food-Ecosystem Nexus can be effectively pursued and implemented if based on solid higher education, involving technicians and professionals working at various levels. Therefore,the EnRHEd project intends to "act" on the traditional university curricula already activated (or in the process of being activated) in the Rwandan partner institutions.These programmes cover a wide range of different but interconnected disciplines,ranging from civil engineering to urban planning, with particular reference to water resources, irrigation and drainage technology, water and sanitation technology, construction technology, environmental and land management,and from biotechnology to food safety and quality management, through agricultural techniques, postharvest technology, food science and technology.

PRELIMINARY ANALYSIS OF THE AGROS-SMART EXPLORATIVE SURVEY ON SMALL-HOLDER FARMERS ACROSS THE GLOBE

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Small holder farmers are one of the most vulnerable subjects of the effects of climate change. Due to their attitude to plan and to follow natural rhythms, they are strongly affected by the increase in variability due to the changing climate. On this issue technology can help to increase resilience realising climate smart agriculture. Standing to FAO, climate smart agriculture helps to guide actions needed to transform and reorient the agricultural system to effectively support development and ensure food security in a changing climate.With AGROS-SMART we want support small holder farmers in better adapt crop management to the changing environment due to climate change, to

offer a platform where exchange best practices and ideas and to build farmer resilience by applying the principle of Climate Smart Agriculture.With this work we want to report the results and analysis of the preliminary survey launched to assess the basic needs of small holder farmers in order to design the AGROS.SMART strategy. The survey collected over 50 responses from different countries and an exploratory data analysis has been performed on the obtained data to extract information about connectivity, digital divide and concrete application of climate smart agriculture.