PhD School on Agriculture, Environment and Bioenergy

(http://sites.unimi.it/dottorato_aab/)

(XXXVI cycle, 2020-23)

Project draft

1.Field of interest

AGR/08

2.Project title

Exploring effectiveness of nature-based solutions in managing and reclaiming stormwater runoff

3.Tutor (membro del Collegio dei Docenti)

Tutor: Claudio Gandolfi

Co-Tutor: Daniele Masseroni

4.Relevance of the topic and state of the art:

Nature-based solutions (NbS) provides viable techniques and approaches to face socio-environmental challenges such as climate change, water risk, water pollution, food safety (Cohen-Shacham et al. 2016). In particular, solutions which exploit the combination of soil proprieties and vegetation characteristics can reduce stormwater runoff generation in urban and peri-urban areas, improving its quality (Rodrigo-Comino et al. 2016). A compendium of more than 1000 examples of Soil-Vegetation solutions from across 100 European cities can be found in the naturvation.eu website and in Seddon et al. (2020). In the last thirty years, several innovate nature-based approaches (e.g. water retention measures, blue-green infrastructures) have been designed and adopted in urban- and agro-ecosystems (Keesstra et al. 2018) for mitigating stormwater negative effects. However, the evaluation of their real effectiveness and impacts on the environment is still deeply investigated. Soil parameters related to soil structure (porosity, aggregate stability, organic matter content, water holding capacity) and vegetation behaviors related to soil-vegetation-atmosphere interconnections (vegetation cover, evapotranspiration) allow to create more resilient ecosystems achieving a buffer against future impacts of climate change and creating better life conditions for citizen (Muñoz-Rojas et al. 2015). As climate policy turns increasingly towards greenhouse gas removal approaches such as afforestation, scientific community recognizes the urgent need to understand how NbSs can achieve their potential to tackle both the climate and biodiversity crisis while also contributing to sustainable development (Munang et al. 2014). In light of these concerns, the main objectives of the PhD are (i) exploring new integrated approaches of blue-green infrastructures for stormwater mitigation and remediation in high-density anthropized areas (ii) modelling NbS behavior in reducing the impact of quantity and pollution of stormwater in urban and peri-urban areas arising through increased precipitation; (iii) identifying appropriate indicators and metrics for the social–ecological effectiveness of nature-based interventions; (iv) evaluating benefits of NbS to outweigh the costs of implementation and maintenance in a range of contexts and respect to traditional engineered alternatives.

5.Layout of the project (draft)

5.1.Materials & Methods:

The objectives of the project will be reached through (i) collection of literature data, (ii) on-field measurements and (iii) modelling experiments. Specifically, measures of hydraulic proprieties of urban soils, water flux exchanges in soil-plant-atmosphere systems, rainfall interception by plant, water quality, phytoremediation capacity will be carried out on NbS already implemented in different urban and peri-urban contexts in Italy and elsewhere in accordance with the possibility to spend a period abroad in specialized research institutes which deal with these subjects. Collaborations with water managers and reclamation consortia will get started and their support will be valuable for transferring the project results to the territory. Laboratory or scale model experiments might be implemented where necessary, especially for reproducing environmental controlled situations and separating the effects of external variables. The results of measures and monitoring activities will allow to calibrate and parametrize models which will be implemented in order to describe the behavior of single and combined NbSs at local and basin scale both for designing and planning purposes. Performances of NbS will be evaluated through indexes based on hydrologic efficiencies, water quality assurance, cost-benefits analysis, also in prospective of future climate changes and land use transformations. Activities takes advantage by experiences developed by agr/08 group in the last five years in the contexts of Flood-Hide, Smart-Green and Monalisa projects.

5.2.Schedule and major steps (3 years):

I year	Measures	Measures of (i) hydraulic proprieties of urban soils, (ii) water flux exchanges in soil-plant-atmosphere systems, (iii) rainfall interception by plant, (iv) water quality, (v) phytoremediation capacity will be carried out on NbSs in different contexts (with a focus on Mediterranean areas). Laboratory and scale model experiments will be implemented, where necessary, to cope with the necessity to evaluate separately variables such as meteorological conditions, vegetation species, substrate types. Flow and water quality measures will be carried out on already implemented NbSs to understand their impact on reducing and reclaiming stormwater runoff in collaboration with other research institute, water manager and reclamation consortia as well.
II year	Modelling	A modelling framework able to capture key processes, interrelationship and feedback between hydrology and water quality processes in single and combined NbSs at different spatial scales will be implemented with the aim to design the best NbS configurations and planning their location on urban and peri-urban areas also in light of future climate changes and land use transformation.
III year	Metrics	Indicators will be defined and refined by the selection of specific metrics in collaboration with the main stakeholders (e.g. water managers and irrigation consortia). Meetings between the PhD student and other experts will be organized to identify the most suitable metrics for assessing the key indicators of NBS performance and impact based on specific objectives, project duration, and available resources. There are typically several different metrics that could potentially be used to quantify each indicator. Potential metrics and indicators could be: *Flood vulnerability*: (i)flood peak heigh, (ii) time to flood peak, (iii) runoff in relation to the precipitation quantity, (iv) infiltration capacity, (v) evapotranspiration. *Drought vulnerability*: (i)r ainwater or

		graywater used for irrigation purposes, (ii) water exploitation index. *Water quality:* (i) basic water quality (pH, temperature, EC, DO, flow rate), (ii) nitrogen and phosphorus in surface water, (iii) metal pollutants in surface water, (iv) total suspended solids (TSS), (vi) pollutant discharge to local waterbodies. *Green space management*: (i) distribution of public green space , (ii) accessibility of urban green spaces. *Urban regenerations*: (i) reclamation of contaminated land, (ii) ratio of open spaces to built form, (iii) incorporation of environmental design in buildings, (iv) preservation of cultural heritage. *Partecipatory planning & governance*: (i) openness of participatory processes, (ii) climate resilience strategy development.

6. Available funds

Monalisa – Fondazione Cariplo (UniMI budget ca. 120.000 €)

6. Literature:

Cohen-Shacham, E., Walters, G., Janzen, C., & Maginnis, S. (2016). Nature-based solutions to address global societal challenges. IUCN: Gland, Switzerland, 97.

Rodrigo-Comino, J., Seeger, M., Senciales, J.M., Ruiz-Sinoga, J.D., Ries, J.B., 2016a. Spatial and temporal variation of soil hydrological processes on steep slope vineyards (Ruwel-Mosel Valley, Gemany). Cuadernos De Investigacion Geografica 42 (1), 281–306

Keesstra, S., Nunes, J., Novara, A., Finger, D., Avelar, D., Kalantari, Z., & Cerdà, A. (2018). The superior effect of nature based solutions in land management for enhancing ecosystem services. Science of the Total Environment, 610, 997-1009.

Seddon, N., Chausson, A., Berry, P., Girardin, C. A., Smith, A., & Turner, B. (2020). Understanding the value and limits of nature-based solutions to climate change and other global challenges. Philosophical Transactions of the Royal Society B, 375(1794), 20190120.

Muñoz-Rojas, M., Jordán, A., Zavala, L.M., De la Rosa, D., Abd-Elmabod, S.K., AnayaRomero, M., 2015. Impact of land use and land cover changes on organic carbon stocks in Mediterranean soils (1956–2007). Land Degrad. Dev. 26, 168–179.

Munang R, Andrews J, Alverson K, Mebratu D. 2014 Harnessing ecosystem-based adaptation to address the social dimensions of climate change. Environ. Sci. Policy Sustain. Dev. 56, 18–24. (doi:10.1080/ 00139157.2014.861676)