environmental sciences proceedings

MDPI

Proceeding Paper

Multi-Actor Working Groups as Fora for WEF Nexus Innovation and Resilience †

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† Presented at the ICSD 2021: 9th International Conference on Sustainable Development, Virtual, 20–21 September 2021.

Abstract: This paper presents a stakeholder engagement framework, which is built on the systems innovation approach (SIA). The framework is developed to facilitate a decision-analytic platform, structured on a multi-level integrated WEF (water-energy-food) model in order to better understand the multi-sectoral WEF trade-offs, capitalize on potential synergies, and explore the interdependencies as well as feedback across a hierarchy of three spatial scales: (i) micro level, the demonstration site, (ii) meso level, the Nile River basin, (iii) macro level, the Mediterranean region. Operating in the space of multi-actor working groups (MAWGs), stakeholders are guided to identify and examine the WEF Nexus drivers of change, while considering the local ecosystem services and validating project findings.

Keywords: multi-actor working groups (MAWGs); systems innovation approach; multi-sectoral WEF trade-offs

Citation: Akinsete, E.; Stergiopoulou, L.; El Said, N.; Koundouri, P. Multi-Actor Working Groups as Fora for WEF Nexus Innovation and Resilience. *Environ. Sci. Proc.* **2022**, *15*, 69. https://doi.org/10.3390/environsciproc2022015069

Academic Editors: Cheyenne Maddox and Lauren Barredo

Published: 1 June 2022

1. Introduction

The WEF Nexus is a conceptualization of the inextricable linkage between water, energy, and food. It examines the relationship between the three components; how the demand for one resource can drive demand for another, and similarly how an increase in the cost of one affects the other's efficiency of production [1]. The WEF Nexus approach has proven particularly useful in addressing water, energy, and food insecurities in Sub-Saharan Africa, by providing insight to support regional development [2]. The WEF Nexus approach is further developed in the context of the EU PRIMA-funded project, AWESOME (the AWESOME project (mAnaging Water, Ecosystems and food across sectors and Scales in the sOuth MEditerranean) is funded by the Partnership for Research and Innovation in the Mediterranean Area Programme (PRIMA), grant agreement number 1942), to include the dependency of water, energy, and food on ecosystems (e.g., freshwater, forests, scrublands, grasslands, and wetlands)—the Water, Energy, Food, Ecosystems (WEFE) Nexus. These four aspects are directly linked to human well-being and poverty reduction [3]. The approach focuses on assessing and quantifying interactions in a complex system between multiple goals, and the influence of achieving one goal on the fulfillment of others [4]. The method uses an integrated approach in order to analyze the synergies and trade-offs between sectors, aiming to maximize the efficiency of using resources, while adapting policies and institutional interventions [5].

The WEF Nexus has entered the governance discourse, aiming to present the complexity of systems, such as agriculture, through demonstrating physical and institutional connections. In terms of policy, the WEF Nexus aids work towards achieving security for water, food, and energy simultaneously [6], while it is also used in order to identify

potential trade-offs during policy design, and the development of solutions benefiting multiple SDGs [7]. Therefore, the WEF Nexus concept plays a crucial role in achieving the goals of the Paris Agreement and the SDGs [7].

The application of the WEF Nexus is particularly significant in the Mediterranean region as well as in transboundary river basins, such as the Nile basin, where resources are closely tied to existing socio-economic concerns. The Mediterranean region is a geographical area with diverse socio-political, economic, and environmental conditions, where the policies and interventions affecting water, energy, and food have been managed separately [5]. In addition, the problems affecting these critical resources render the area vulnerable within the context of climate variability and change, population growth, and other developmental pressures, such as pollution issues and water scarcity [8], imbalanced water allocation among sectoral users, high demand for food and energy [5], food loss and waste, as well as changing dietary habits.

At 6650 km in length, the River Nile is the world's longest river. It flows from Central Africa to the Mediterranean Sea, with a river basin of 3,500,000 km^2. The Nile basin is experiencing rapid population and economic growth, which is putting pressure on shared resources. At the same time, international cooperation is further challenged by discussions about the Grand Ethiopian Renaissance Dam management. To tackle the hydro-political conflicts among the riparian countries, the Nexus approach has the potential to address trade-offs among the stakeholders in competition for water, energy, and food resources, whilst promoting a deeper understanding of shared benefits [9].

The current water demand for irrigation along the Nile is estimated at 83 BCM; meaning 80% of the entire water demand. This figure is projected to be more than 140 BCM by 2050 if the current level of water management technology continues (https://nilebasin.org/index.php/new-and-events/313-study-aimed-at-addressing-growing-water-demand-in-the-nile-basin-at-final-stage, last accessed on 31 May 2022). This, in combination with demographic projections developed in the framework of AWESOME (https://awesome-prima.eu/wp-content/uploads/2021/06/AWESOME_D21_AUEB_WP2_F_Demographic_scenarios.pdf, last accessed on 31 May 2022) indicates a population of 1.2 billion people in the Mediterranean by 2100, and explains how the demand for water, food, and energy are set to escalate rapidly. In addition, the total current evaporation from dams of 17.2 BCM is constantly on the increase, further contributing to reducing the amount of water available to meet rising demands. The planned growth in installed energy generation capacity is 21,000 MW, while the storage capacity of the planned dams will reach 200 BCM. At the current rate, water demand will soon outstrip the available resources if suitable measures are not put in place, which takes into account the WEF Nexus in order to balance the use of resources between these four sectors, as well as between the upstream and downstream uses.

Spanning 11 countries (Burundi, Democratic Republic of Congo, Egypt, Eritrea, Ethiopia, Kenya, Rwanda, South Sudan, Sudan, Tanzania, and Uganda), one of the most prevalent problems within the Nile basin is the very different degree of water-use efficiency among countries. Egypt, for example, has relatively well-performing irrigation systems with one of the highest water-use efficiencies internationally for crops, such as cotton and wheat [10]. On the other hand, Sudan's poor irrigation systems are causing poor yields due to water inefficiency, poor canal maintenance, and lack of water. Sudan's irrigated agriculture is stagnating with only 1% of its arable land currently irrigated [11]. The application of the WEF Nexus approach is particularly significant as there is a need to consider the Nile basin as a resource basin where all water values (whether direct or indirect) are analyzed; and natural resources, such as land and energy connected to the basin are considered for the cooperation of all water users and the development of the basin as a whole [12].

Water use for food production is a priority within the Egyptian WEF Nexus, and the agricultural sector is the largest user of water resources based on total water needs. Egypt faces water security problems due to inefficient irrigation techniques and over-exploitation of groundwater. In addition, the Grand Ethiopian Renaissance Dam, being 73% complete

as of May 2020, has placed additional pressure on the availability of water [13]. Moreover, food self-sufficiency in Egypt is limited by scarce water resources, thus, 50–60% of food is imported (despite a 20% increase in overall crop production since 2010). In 2017, winter crops' production reached up to 89.8 million tonnes (Mt) while summer crops reached 48.1 Mt tonnes, due in part to land reclamation and sustainable water usage [14]. Although 33% of international trade volumes dropped due to the COVID-19 pandemic, exports rose up to 8.4 Mt in 2020 (in comparison to a mere 5.4 Mt of agricultural products exported in 2019). Another key area of concern is energy use for water treatment and conveyance in the form of fuel-powered and energy-intensive water lifting plants. These aspects are addressed by projects shedding light on the importance of directing efforts to increase water supply through desalination units and wastewater reuse. While this will entail even more energy use, the current surplus in energy generation and the expansion in the renewables sector would make it a viable trade-off. By promoting desalination to increase the national water supply, reusing treated wastewater to recycle nutrients and reduce energy-intensive fertilizers, promoting renewable energy for irrigation systems, e.g., solar pumping, and considering the energy potential of agricultural waste, the WEF Nexus approaches aim to increase water efficiency in Egypt in the agricultural sector by 60% [13,15].

In light of the importance of the WEF Nexus approach within the region, this paper aims to present a stakeholder engagement methodology developed in the framework of the EU PRIMA-funded project, AWESOME, that identifies and examines the relationships between the core drivers of change within the WEF Nexus concept, taking into consideration their interactions with local key ecosystem services. As a multi-tier method, it is designed to support a bottom-up approach towards the scaling-up of innovative solutions, taking into consideration the macroeconomic WEF Nexus development at national and Mediterranean scales; therefore, making it an effective tool to support activities from regional planning at the Nile basin scale, down to a single farm. AWESOME's significance lies not only in its ability to integrate stakeholders' perspectives in order to develop local capacity but also provides assistance to national and regional policies in the Nile river basin and the Mediterranean to go beyond the implementation of the usual WEF Nexus practices in order to ensure a discernible impact in the implementation of Agenda 2030 (https://sdgs.un.org/2030agenda, last accessed on 31 May 2022) and the revival of economies around the Nile.

2. Materials and Methods

2.1. Case Study Approach

The AWESOME project analyzes the WEFE Nexus (water-energy-food-ecosystems) across three special scales, namely: (i) the macro level, which is represented by the macro-scale processes and policies that influence the dynamics of water, energy, food supply, and demand as well as the ecosystem services in the Mediterranean; (ii) the meso level which corresponds to the river basin scale, where the strategic planning needs to take place based on realistic projection and focuses on three main countries crossed by the Nile (Egypt, Ethiopia, Sudan); (iii) the micro level, which is represented by the demonstration site, where experiments on soilless agriculture (hydroponics and aquaponics) take place. The stakeholder engagement approach aims to leverage stakeholders' perspectives to produce a detailed intra-basin analysis at the case study level (micro and meso levels), with the potential to scale up to the extra-basin regional spatial scale with macro-level modelling (Figure 1).

The above approach allows for a better characterization of different technological solutions to produce water and food, as demonstrated at the micro level, while producing a realistic representation of macro-scale processes and policies influencing critical resources and ecosystem services.

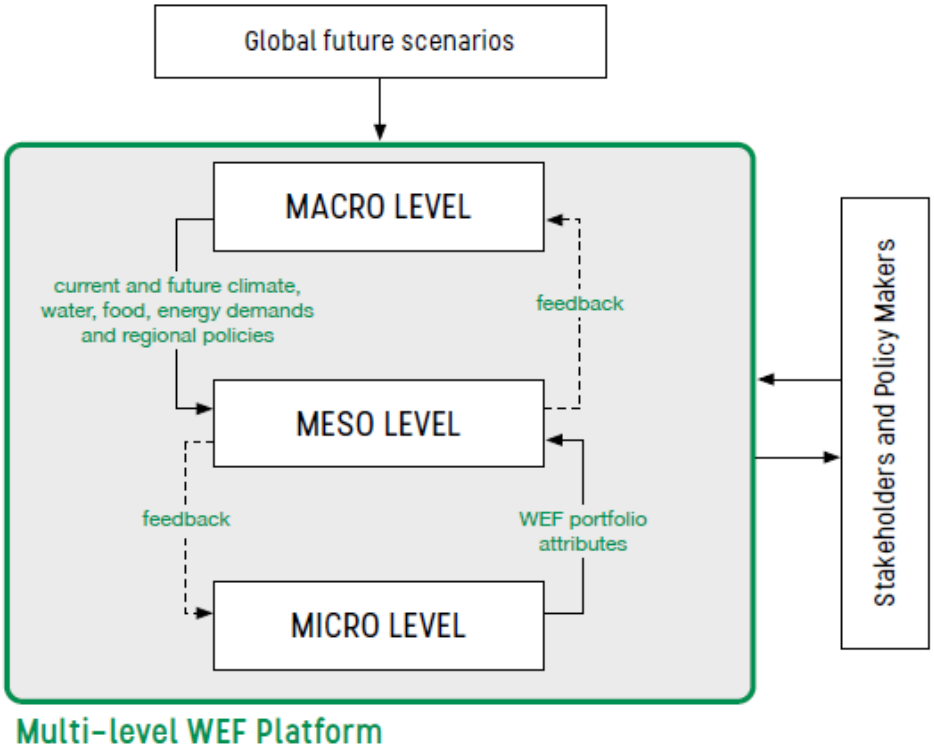

Figure 1. The AWESOME multi-level WEF platform.

2.2. Multi-Actor Working Groups Methodology

The project capitalizes on stakeholder knowledge via structured multi-actor working groups (MAWGs), which engage key local, national, and regional actors from a variety of sectors as "citizen scientists" within the project. These stakeholders support the identification of key WEFE Nexus issues and drivers, as well as provide validation of outputs to ensure results are grounded in the real world and relevant for end-users. A systems innovation approach (SIA) is adopted as the basis of the development and implementation of the MAWGs, as it is particularly suited to addressing the growing complexity and interconnectedness of modern societies and economies by focusing on the functions of a cross-sectoral system as a whole; analyzing challenges, opportunities and designing solutions [16]. Through SIA, it is possible to understand and evaluate the interconnectedness within and among the systems' components that signify decisions, decision-makers, resources, organizational setups, drivers of change, services, and time frames [17].

Among the mechanisms to be used in the framework of SIA are: (i) participatory mapping techniques which will assist the joint examination of the current situation in the river basin, and in the case study area, the identification of actions and management initiatives, existing and hypothetical, that affect WEFE Nexus; (ii) collaborative problem framing and then co-designation of future scenarios with the stakeholders; (iii) validation and analysis of projects outputs; (iv) assessment of the gap to reach future scenarios in terms of local labor skills.

2.2.1. Stakeholders Listing

The first step toward establishing the MAWGs is the identification of appropriate stakeholders to constitute the working group. To do so, a long list of potential MAWG members in the form of sector actors is drafted. This process places emphasis on:

(i) Representation: from all WEFE sectors and sub-sectors as water supply, water quality, water management, hydropower, desalination, traditional agriculture, hydroponics, etc. In addition to sectoral thematic representation, consideration is given to representation within the different categories of the Quadruple Helix model, i.e., public institutions (government agencies, ministries, etc.), private organizations (agri-business, SMEs, etc.),

academia (universities, research centers, etc.) and non-governmental organizations (think tanks, unions, multilateral organizations, activist groups, etc.).

(ii) Alignment: and consistency with the tri-level structure of the AWESOME model in terms of the micro, meso, and macro levels of analysis. The MAWGs are focused on the micro and meso levels, with stakeholders on the micro level being those active within the Egyptian national context, where the demonstration site is located. They are directly relevant to the innovative technological solutions of the demonstration and pilot sites located in Egypt and are engaged in the MAWGs to facilitate the participatory development of mental maps to visualize the key drivers of WEFE change, identification, prioritization, and the valuation of key ecosystem services, capacity building and upskilling. Stakeholders on the meso level come from the three river basin countries (Egypt, Sudan, and Ethiopia), and are engaged to develop the equivalent mental maps from the meso perspective and allowing transferability and adaptability of the WEFE innovations' results, from the micro level to the meso level.

2.2.2. Stakeholders Analysis and Mapping

Stakeholder analysis is crucial in order to gain a deeper understanding, not only of who the key actors are within the WEFE Nexus context but also their perspectives, interests, the relationships to one another, and their relevance to the needs and requirements of the research. The stakeholders identified within the long list are analyzed based on two key criteria:

(i) Influence: the degree to which the stakeholder has the power to effect change, in terms of WEFE Nexus activities in the area of focus.

(ii) Interest: how likely they are to engage in activities and initiatives relevant to the WEFE Nexus and the degree to which they are directly impacted by WEFE Nexus activities.

The stakeholder mapping involves the visualization of the relationships between the stakeholders and the WEFE Nexus, based on their positioning on a graph that plots influence against interest. Such mapping allows the research team to clearly identify where each actor stands when evaluated against the same two key criteria and to compare them to one another. The map is formulated via a participatory process within the case study team and visualized using Miro, an online collaborative working tool. The initial map is then validated by WEFE sector experts, such as members of the project advisory board. Figure 2 represents a sample of the mapping illustrating Interest along the x-axis from low (left side) to high (right side) and Influence on the y-axis from the least influence at the bottom, to the greatest influence at the top.

At present, one year after the project's initiation, 76 stakeholders have been identified at the micro level using the above methodology. Following analysis, they have been grouped based on the four created quadrants, as illustrated in Figure 2.

Monitor/Minimum effort: this is a group of 13 stakeholders characterized by Low Interest/Low Influence, that is useful to be informed only about the big steps of the project and can have a low level of engagement.

Keep satisfied: this is a group of 12 stakeholders characterized by Low Interest/High Influence, which means they should be kept satisfied and updated regularly on projects' output, as their feedback is important.

Keep informed: this is a group of 30 stakeholders with High Interest/Low Influence, that needs to be updated and engaged regularly. While not seemingly as crucial as the Manage Closely or Keep satisfied groups, it is important to solicit input from this group, as it tends to include those who are often marginalized.

Manage closely: this is a group of 16 stakeholders with High Interest/High Influence, that need to participate with a higher level of engagement, as their feedback is critical to any decision-making. This quadrant will serve as a key focal point for the recruitment of MAWG members.

Figure 2. Stakeholders mapping on Miro.

AWESOME's stakeholder mapping process helps mitigate the risk of oversight when selecting potential MAWG members and provides a clear basis for the justification of recruited members.

3. Discussion

The application of the WEFE approach in drought areas, such as the Nile basin, becomes even more significant in the context of COVID-19, as the region faces disproportionate impacts with trends showing over-dependence on energy [18]. COVID-19 has exacerbated the food insecurity that existed in the region in the context of climate change, geopolitical conflict, and economic crises; putting additional pressure on the energy access challenges. Threats, such as reduced access to nutritious food and an increased vulnerability of people with weaker immune systems, mean increased exposure for groups, such as the elderly or people with underlying health conditions [19]. The most prevalent problem that the Nile basin faces boils down to disruptions within the context of the WEFE Nexus; whether caused by a change in demand patterns or changes and shortages in supply [20]. Demand-induced disruption can be linked with a high demand for water for sanitation purposes (such as for hand washing) and increased medical waste (protection materials, such as gloves and masks), both affecting the water sector and consequently the energy demand for water [21], while supply-induced disruptions can be caused by mortality or morbidity impacting the supply of labor in industries, such as food and by a lack of sufficient infrastructure [18]. The Pan African University Institute of Water and Energy Sciences, in a recent study based on an online survey (842 respondents from Uganda, Tanzania, and Nigeria), reports that lockdown policies have already had a negative impact on the production of food since the basic actors in the food supply chain are unable to work; resulting in food prices increasing by more than half [22]. At the same time, declining resources due to climate change and demographic conditions can cause WEFE instability

and impact public health directly or via economic repercussions [18]. Such a situation can jeopardize not only human health and well-being but also key developmental goals (e.g., the Sustainable Development Goals (SDGs)) on the African continent [2].

These recent changes in the context of COVID-19 are incorporated into AWESOME's methodology as an attempt to redefine the notion of WEFE resource security in periods of the pandemic; considering in particular, rural areas suffering from virus-related disruptions and workforce reduction. This is especially vital, given that current research focuses on urban-related impacts from pandemics due to their population density and importance to the economy.

4. Conclusions

Global challenges, such as population growth, demands for increased food production, and the pressures on resources (in addition to issues, such as climate change, soil degradation, water scarcity, and environmental pollution) are on the rise. There is an urgent need to find alternative, sustainable, and reliable ways to secure food supply. Innovative agriculture techniques, such as hydroponics, could provide part of the solution to these problems. This article provides a description of a state-of-the-art methodology for convening MAWGs and its linkage with the research toward smart agriculture and food security policy. The results from the first MAWGs will be produced in January 2022 in the form of mental maps, while the next steps will focus on the realization of workshops on two different levels, a case study and the river basin level.

Author Contributions: Conceptualization, L.S. and E.A.; methodology, E.A.; software, L.S. and E.A.; validation, N.E.S.; formal analysis, L.S. and E.A.; investigation, N.E.S.; resources, N.E.S.; data curation, L.S.; writing—original draft preparation, L.S.; writing—review and editing, E.A.; visualization, L.S.; supervision, P.K. All authors have read and agreed to the published version of the manuscript.

Funding: This research is funded by the Partnership for Research and Innovation in the Mediterranean Area Programme (PRIMA), grant agreement number, 1942.

Informed Consent Statement: Informed consent is obtained from all subjects involved in the multi-actor working groups of the study.

Data Availability Statement: AWESOME project's future results and the consortium is available online: https://awesome-prima.eu/, Last accessed on 31 May 2022.

Conflicts of Interest: The authors declare no conflict of interest.

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