A SOCIO-ECOLOGICAL APPROACH TO COMBAT DESERTIFICATION FOR SUSTAINABLE FUTURE

EcoFuture

Work Package 1

Deliverable 1.2 Causal Loop Diagram of the JV

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Executive Summary

The objective of this task is to develop a Causal Loop Diagram (CLD) for the Jordan Valley (JV) including all three involved territories in order to compare and contrast priorities. The CLD identifies the WEFE Nexus challenges faced in the area and the key leverage point/actions that one can take to affect them as well as their interconnections and the interdependence between the challenges and the actions. Mapping of the WEFE system for the three territories in the JV can identify the differences in the key priorities between the stakeholders of the territories as well as common ground and conflict points. The following steps were followed for the CLD creation:

Conceptualization - The main purpose of this step is to set the context of the analysis and to preliminarily identify the main challenges for the area. It mainly relies on background information, which include evidence from previous projects and research activities, as well as feedbacks from policy implementation in the past.

Mapping - This step is to map the complex web of connections among the different elements affecting the dynamic evolution of the WEFE Nexus system. The CLD captures how elements in the system are interrelated.

Behavior analysis - This step is to understand the dynamic behavior of the WEFE Nexus system and to support the definition of Nexus policies. To this aim, the CLD developed in the previous step can be analyzed using a combination of descriptive and structural analysis. This will allow the identification of "Nexus challenges", and the selection of leverage points, i.e., points in the system where local intervention could have large impacts at system scale. Kumu is calculating a series of centrality measures (degree centrality, betweenness centrality, closeness centrality and eigenvector centrality).

In this research, we used a 3-prong approach to develop and analyze the CLD for the JV. The process was to first create a draft CLD for the JV based on literature review and expert knowledge, then validated it through EcoFuture partners. In particular, we asked the partners to confirm the draft Nexus challenges, add challenges if missing and rank/prioritize the challenges in each area (Stage I). Once the feedback was received, the revised CLD can accommodate all the changes and weights can be applied so the statistics reflect the priorities of the challenges ranked by the partners. The next step was to validate the CLD with key stakeholders involved in the National living labs and revise it according to stakeholder feedback if necessary and rank the challenges. Once this process was completed in the three territories, a unified CLD for the JV was created (Stage II). The third stage (Stage III) was to analyze the unified CLD and compare and contrast the prioritization of the challenges in each of the three territories. The final step was to present the unified CLD to the WEFE prioritization workshop. This methodology allowed to identify the priorities regarding the Nexus challenges of the three territories and conflicting actions within and between territories as well as achieving a common understanding of the challenges, problems and impacts to the WEFE Nexus for the JV.

Through this analysis, the challenges that face JV were identified and prioritized. Water demand for irrigation, Water quality, Agricultural development, Renewable energy availability, Biodiversity, Climate change, Population growth, was the initial list of identified challenges in the area according to the scientific

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experts. The Jordanian partners added two more challenges in the initial list of challenges: soil quality and governance, while Israeli partners added competition between development and land conservation and sanitation services (wastewater & solid waste).

The ranking of the challenges of the Jordanian stakeholders was the same as identified by the EcoFuture Jordanian partners indicating the importance of close collaboration between the National Agricultural Research Center and the JV stakeholders in understanding stakeholder needs and priorities.

There are similarities and differences in priorities for the three territories according to the Israeli, Jordanian, Palestinian stakeholders. The top four challenges according to the Jordanian and Palestinian stakeholders are mainly related to agriculture: water quality, water demand for irrigation, and agricultural development. Soil quality is included in the list of the top challenges from Jordanian perspective, while renewable energy availability is included in the list from Palestinian perspective. On the other hand, for Israeli stakeholders, climate change, competition between development and land conservation, biodiversity and renewable energy availability are of high priority. The next (lesser) priorities for Jordanian and Palestinian stakeholders are biodiversity and climate change. Jordanian stakeholders included among the list of challenges of lesser priorities the renewable energy availability and governance. For Israeli stakeholders, population growth, sanitation services, agricultural development and water quality constitute the next (lesser) priorities. The last priority for Jordanian and Palestinian stakeholders is population growth while for Israeli stakeholders is water demand for irrigation. From the results of the prioritization of challenges, it is concluded that the priorities for Palestinian and Jordanian stakeholders are similar while Israeli stakeholders have other priorities.

The CLD created by the experts and the Israeli, Jordanian and Palestinian partners, was used as a first level of engagement of stakeholders in JV and the results validated its effectiveness as a tool for engagement. The usability of this analysis for leading decision-makers and stakeholders in the co-design of WEFE Nexus policies will be evaluated at the second Work Package of the EcoFuture project.

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1. Introduction

1.1 Introduction

The objective of this deliverable is to develop a common understanding between the various stakeholders in the three territories in the Jordan Valley (Jordan, Israel and Palestine) on what are the challenges that the region faces, and what are the drivers of the WEFE Nexus, the interrelationships, and impacts. An innovative methodology that could accomplish this goal is developing a Causal Loop Diagram (CLD) developed bottom-up by the stakeholders. We used our experience obtained from the PRIMA Lenses project where CLD were developed for seven pilots in six countries including Jordan, Israel, Türkiye, Greece, Italy and Spain (Giordano et al., 2023). One of the outcomes of the CLD development in the LENSES project was that the challenges and leverage points were for the most part common in all pilots in the different countries, highlighting the notion that rural areas have very similar problems all around the Mediterranean. Based on this experience we adapted and developed a CLD that responds to the peculiarities of the Jordan Valley (JV.)

While developing an approach to analyze the main components of the WEFE Nexus for the EcoFuture project, it is essential to map the challenges faced by the stakeholders as well as all the actions that can be taken impacting them. The CLD was chosen as the best visual tool through which stakeholders and experts could give their input and investigate the connections between the main variables and which of these variables are considered of most significance. To create the CLD, a visualization platform for mapping systems 'Kumu Docs' was used.

In recent years, researchers are implementing integrated social and ecological approaches to investigate WEFE requirements through System Dynamic Models and CLDs. CLDs are often a precursor to System Dynamics models; used to begin the modelling process in an intuitive way, before the conversion to stock and flow diagrams and differential equations (Barbrook and Penn, 2022). This methodology provides an active push from intellectual research to accomplishing policy interventions for nature-based solutions (NBS). The participation of stakeholders is crucial in establishing action-based results (Giordano et al., 2023). The system dynamics approach intends to connect the various complexities which are innate in all systems and sectors to create successful, "high-leverage" policies (Sterman, 2002).

An ecosystem services (ES) assessment of attitudes of Jordanian and Israeli locals towards the efficiency of ES in the Arabah Valley, indicated the significance of including social perspectives in ecological and economic research to support policy implementation (Orenstein and Groner, 2014). Providing evidence of the holistic approach and its utility in a large spectrum of sectors, the system dynamics model has been used to elucidate the efficiency of policy implementations concerning the "Danish housing stock and building energy performance," by exploring various scenarios and analyzing behavioral aspects (Fazeli and Davidsdott, 2015). Additionally, a system dynamics approach was used to investigate the socioeconomic and environmental patterns of the electricity sector relating to low carbon development in Mauritius, a Small Island Developing State of the Indian Ocean. After collecting background information, the calibrated model was successful in forecasting scenarios representative of the power sector of Mauritius (Deenapanray and Bassi, 2015). Another example of the impact of the systems dynamic model for

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environmental research is the one conducted by Groundstroem and Juhola (2020). Their study implemented systems thinking and CLDs to explore the effect of wood pellets importation on climate change, including the sociopolitical, ecological and economic dynamics.

More recent research illuminating the importance of stakeholder involvement in systems dynamic research has been done by Tiller et al (2021). Through workshops in six different locations across Europe, this study reflected on the complexity and similarities of several environmental sectors amongst the case areas. Using CLDs and a focus on stakeholder input, this study presented the necessity of participatory research in safeguarding successful policy application. A study exemplifying the usefulness of the systems dynamic approach and CLDs in policy-making, is the research done by Gudlaugsson et al (2022) in Tees Valley of North East England concerning the energy transition towards decarbonization. Due to the complicated nature of policy planning and application regarding energy transition, CLDs and stakeholder participation facilitated the investigation of scenarios involving socioeconomical and environmental impacts on these policies. The system dynamics theory aligns exceptionally with the requirements of the WEFE Nexus goals. A case study in Pinios River Basin demonstrates this connection by using substantial stakeholder involvement concerning attitudes towards nexus challenges (Malamataris et al., 2023).

Similarly, a systems dynamic methodology was used in the case study for Koiliaris River in Crete, Greece. The river basin is part of the Critical Zone Observatory and the European LTER Network and the principal investigators of the Technical University of Crete have conducted years of detailed bio-physical and chemical measurements and developed models of the watershed and the surrounding region. This facilitated the development of a CLD by collecting the information necessary for the qualitative and quantitative components included in the CLD. The verification of the CLD was based on stakeholder participation with the first Learning and Action Alliances (LAA) being a semi- structured interview with local farmers and the second a workshop aimed to investigate the attitudes and behaviors of the stakeholders of the area (Giordano et al., 2023). The main obstacle decided among stakeholders and experts is inadequate effectiveness of water management.

The objective of this task (Task 1.2) is to develop a CLD for the Jordan Valley including all three involved territories in order to compare and contrast priorities. The CLD identifies the WEFE Nexus challenges faced in the area and the key leverage points/actions that one can take to affect them, their interconnections and the interdependence between them andwmeasures towards their resolution. Mapping of the WEFE system for the three territories in the Jordan valley is essential in identifying the differences in the key priorities between the stakeholders of the territories as well as common ground and conflict points.

1.2 CLD theory

CLDs provide a snapshot of key variables and how they are interconnected. Both the structure of CLD and the ‘narrative’ behind it can help the understanding of the system’s state and its evolution. The core building blocks of CLD are variables and their direct causal relationships, which can be either positive or negative).

Another key element of CLDs is represented by feedback loops. A feedback loop consists of two or more causal links between elements connected in a cyclical form. The behavior of a variable is therefore (partly)

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caused by its past behavior. There are two different types of feedback loops: positive and negative. A positive (or reinforcing) feedback loop is self-enhancing and generates exponentially escalating behavior which could be (extremely) beneficial or (extremely) detrimental. A negative (or balancing) feedback loop generates balancing or goal-seeking behavior, being sources of stability as well as resistance to change.

A weight (typically between 0 and 1) can be also assigned to each link of the CLD, representing the strength of the interconnection between variables. It can be either defined by the analyst (based on the available knowledge) or directly by the stakeholders through specific participatory exercises.

The Kumu (www.kumu.io) Social Network Analysis module was used for the creation of the CLD in this Task (Task 1.2). Kumu is a popular (open source) platform which provides a web-based interface for building and analyzing system maps.

1.3 Overall process of stakeholder engagement

Stakeholder engagement is an issue of great importance within the framework of EcoFuture and most of the deliverables are directly related to this issue. Stakeholder engagement in EcoFuture consists of three phases depicted in Figure 1 (Phase A) and Figure 2 (Phase B and C).

The objective of stakeholder engagement of Phase A was to identify and prioritize the challenges and priorities in each territory of the JV. In this Deliverable (1.2), the development and analysis of CLD is the result of the input obtained from the mapping of WEFE resources (D1.1), socioecological mapping (D2.1) and governance mapping (D5.1) (Figure 1). The Living Labs/interviews conducted in each of the three countries gave feedback to the prioritization of challenges facing the JV.

Based on the mapping of the WEFE resources (supply and demand), the CLD developed for the JV, and hydrologic analysis (D3.1), water allocation (D3.2) and energy analysis (D3.3) of the region, we will conduct transnational living lab workshop (D1.3) with the stakeholders to identify the priorities for each country and for the JV as a whole. We will follow a methodology such as the capacity factor analysis where the stakeholders will rank the challenges, issues and problems and thus set priorities to the problems that need to be addressed in the region. The results of the workshop will be used as feedback for the gap analysis (D5.2).

The objective of Phase B stakeholder engagement is to co-design with stakeholders potential alternatives to address the challenges and issues faced by the JV. The results and feedbacks of the second phase of stakeholder engagement will be included in D2.3 and D2.4 (Figure 2a). The objective of D2.3 is to derive a stakeholder understanding and engagement to the suggested NBS bundles and to devise efficient management strategies to minimize the costs and externalities within a participatory framework. Evaluation of alternatives will integrate a wide range of (often conflicting) objectives and criteria of different nature in the presence of several groups of the stakeholders involved in the decision-making process (D2.4). The final phase of stakeholder engagement will include a transnational living Lab (Figure 2b) where co-design processes will be taken place. Since the stakeholders may require evidence to justify the suggestions, techno-economical models will be used for evidence-based policies. D5.3 involves the development and application of WEFE related models, which will be used for analysing policies based on scenario simulations. Following discussions with the stakeholders' final suggestions for short-term and

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long-term governance setups will be provided to the policy makers. These will analyze the process of crafting strategies to navigate a sustainable transition towards selected efficient WEFE alternatives at the catchment level (D5.4).

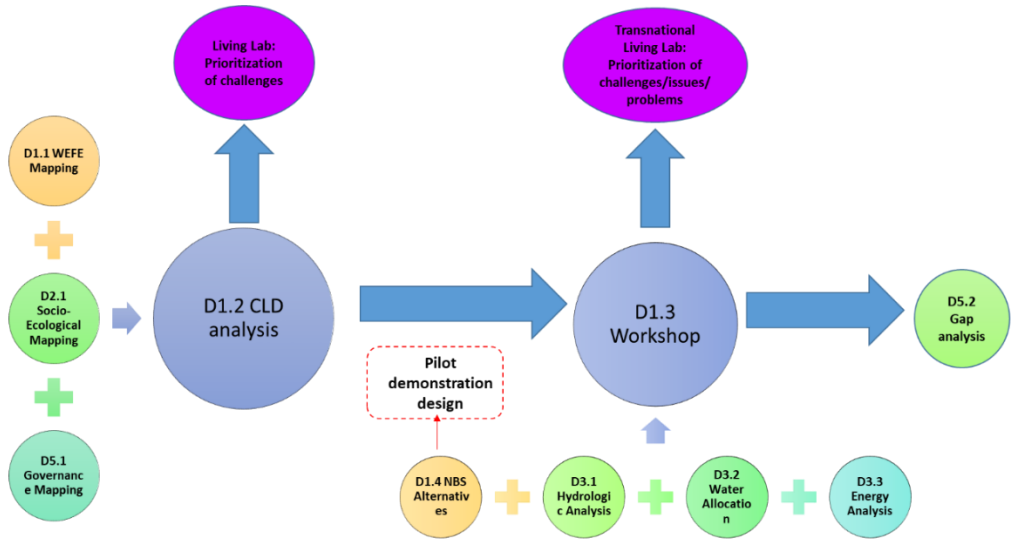

Figure 1. Phase A of stakeholder engagement within EcoFuture

Figure 2. Phase B (a.) and C (b.) of stakeholder engagement within EcoFuture

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2. Methodology

2.1 Methodological approach for CLD development in JV

In this research, we used a 3-prong approach to develop and analyze the CLD for the Jordan Valley as they are depicted in Figure 3. The process was to first create a draft CLD for the Jordan Valley based on literature review and expert knowledge (derived from the LENSES-PRIMA project), then validated it through EcoFuture partners. In particular, we asked the partners to confirm the draft Nexus challenges, add challenges if missing and rank/prioritize the challenges in each area (Stage I). Once the feedback was received, the revised CLD can accommodate all the changes and weights can be applied so the statistics reflect the priorities of the challenges ranked by the partners. The next step was to validate the CLD with key stakeholders involved in the National living labs and revise it according to stakeholder feedback if necessary and rank the challenges. Once this process was completed in the three territories, a unified CLD for the JV was created (Stage II). The third stage (Stage III) was to analyze the unified CLD and compare and contrast the prioritization of the challenges in each of the three territories. The final step was to present the unified CLD to the WEFE prioritization workshop. This methodology allowed to identify the priorities regarding the Nexus challenges of the three territories and conflicting actions within and between territories as well as achieving a common understanding of the challenges, problems and impacts to the WEFE Nexus for the JV (Figure 3).

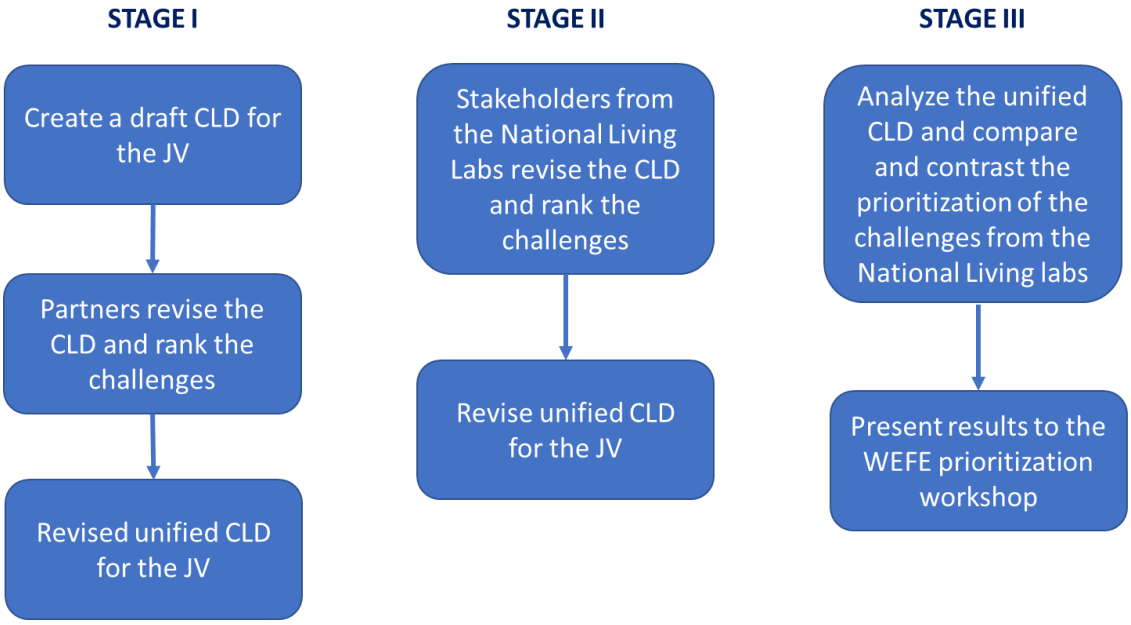

Figure 3. The three stages of development of the CLD for the Jordan Valley

2.2 Steps followed for CLD creation

The following steps were followed for the CLD creation:

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Conceptualization - The main purpose of this step is to set the analysis's context and identify the main challenges for the area. It mainly relies on background information, which include evidence from previous projects and research activities, as well as feedbacks from policy implementation in the past.

Mapping - This step is to map the complex web of connections among the different elements affecting the dynamic evolution of the WEFE Nexus system. The CLD captures how elements in the system are interrelated.

Behavior analysis - This step is to understand the dynamic behavior of the WEFE Nexus system and to support the definition of Nexus policies. To this aim, the CLD developed in the previous step can be analyzed using a combination of descriptive and structural analysis. This will allow the identification of "Nexus challenges", and the selection of leverage points, i.e., points in the system where local intervention could have large impacts at system scale. Kumu is able to calculate a series of centrality measures (degree centrality, betweenness centrality, closeness centrality and eigenvector centrality) whose definitions can be found in Table 1.

In other words, Kumu platform can conduct a behavioral analysis based on the interconnection between the variables and thus ascertain their degree of significance. In addition, in the case where stakeholders have identified priorities in the Nexus challenges and leverage points, then one can assign weights to signify the degree of importance given to each variable. A weight between 0 and 1 can be assigned to each link of the CLD based on the ranking of the stakeholders obtained through the participatory process (Giordano et al., 2023). By assigning weights to the variables, the analysis of the interconnections can more accurately represent stakeholder perspectives.

Table 1. Definition of the centrality measures of a CLD calculated by Kumu.

Centrality measure	Definition	Description
Degree Centrality	Counts the number of connections an element has.	Elements with high degree are the local connectors / hubs.
Betweenness centrality	Measures how many times an element lies on the shortest path between two other elements.	Elements with high betweenness have more control over the flow of information and act as key bridges within the network. They can also be potential single points of failure.
Closeness centrality	Measures the distance each element is from all other elements.	Elements with high closeness can spread information to the rest of the network most easily and usually have high visibility into what is happening across the network.
Eigenvector centrality	Measures how well connected an element is to other well connected elements.	Elements with high eigenvector centrality are the leaders of the network, though they may not have the strongest local influence.

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3. Results

3.1 Initial identified challenges and leverage points in JV

Figure A.1. (Appendix) presents the initial version of the CLD produced for the JV. The main challenges for the area were determined after an extensive literature review, evidence from previous projects and research activities, as well as feedback from policy implementation. Moreover, D1.1, D2.1 and D5.1 provided input for a detailed 'narrative' description of area, which helped the understanding of the systems state and its evolution and the identification of the challenges and the connected issues. The initial challenges identified were the following seven: Water demand for irrigation, Water quality, Agricultural development, Renewable energy availability, Biodiversity, Climate change and Population growth. The leverage points for the challenge of "Water demand for irrigation" were the following: financial incentives, farmers training, information and awareness, wastewater treatment effectiveness, aquaculture, innovative irrigation techniques, intensive agriculture. The leverage points for the challenge of "Water quality" were the following: Wastewater treatment effectiveness, Reduction of Water salinity, Reduction of Diffuse sources of pollution, Reduction of Point sources of pollution, Protection zones, Water monitoring and Water diversion. The leverage points for the challenge of "Agricultural development" were the following: Nature-based Solutions, Farmers training, Financial incentives, Reduction of unsustainable agricultural practices, Reduction of soil erosion, Reduction of the use of fertilizers, pesticides, herbicides. The leverage points for the challenge of "Renewable energy availability" were the following: Wastewater treatment effectiveness, Hydro power, Solar power, Wind power. The leverage points for the challenge of "Biodiversity" were the following: Nature-based Solutions, Urbanization, Climate change, Reduction of the use of fertilizers, pesticides, herbicides, Reduction of livestock grazing, State of natural areas. The leverage points for the challenge of "Climate change" were the following: Nature-based Solutions, Hydro power, Solar power, Wind power. The leverage points for the challenge of "Population growth" were the following: Urbanization, Tourism and Migration.

3.2 Changes in challenges and leverage points from EcoFuture partners

The second step of the first stage of the process was the revision of the initial CLD by the EcoFuture partners (from Jordanian, Israeli and Palestinian perspectives) by adding/removing challenges and leverage points. Specifically, once the CLD was created based on expert understanding of the WEFE Nexus issues faced by the JV, the Ecofuture Jordanian, Israeli and Palestinian partners were asked to confirm the challenges, add new challenges if missing and rank/prioritize the nexus challenges. The purpose of the prioritization is to conduct an initial analysis of the CLD before it is confirmed by the stakeholders, which will be the final depictions of their beliefs and attitudes towards the challenges they encounter in JV.

The main nexus challenges, as identified by the Jordanian researchers, influencing the overall sustainability of the WEFE Nexus of the Jordan Valley are water quality, water demand for irrigation, soil quality, agricultural development, biodiversity, climate change, renewable energy availability, governance, and population growth. As it is observed, the Jordanian partners added two more challenges (soil quality and governance). These challenges were decided during the conceptualization process which included literature review and local partner input. The Jordanian partners also ranked the challenges in

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the following order from the most important to the less important: 1) Water quality, 2) Water demand for irrigation, 3) Soil quality, 4) Agricultural development, 5) Biodiversity, 6) Climate change, 7) Renewable energy availability, 8) Governance, 9) Population growth. It is important to notice that the top four challenges according to the Jordanian partners relate to agriculture: water quality, water demand for irrigation, soil quality and agricultural development. The next four challenges are biodiversity, climate change, renewable energy and governance. The least priority challenge is population growth.

Appendix B presents the results from the behavioral analysis of the CLD. The degree centrality ranking after applying weights, according to the ranking of the partners, was a fairly accurate representation of the main challenges prioritized by the Jordanian partners (Table B.1). Betweenness centrality (Table B.2.) and eigenvector centrality (Table B.3.) values also depict the validity of the representation of the main challenges.

Table 2 presents the list of leverage points, which are variables/actions that affect the main challenges as revised by Jordanian partners. Examples of leverage points which are identified action variables are: network modernization and rehabilitation, wastewater treatment effectiveness, information and awareness, innovative technologies, water use efficiency, capacity building, financial incentives, water monitoring, Jordan river restoration, development of cooperatives, wind, solar and hydro power and NBS. The assignment of variables and their direct causal relationships identified three feedback loops, which is when variables connect in a cyclic form, were developed (Figure 4). The first loop relates to water availability for irrigation and agricultural aspects, reinforcing the relationship between water availability for irrigation and agricultural productivity, profitability and innovative technologies. In turn, the variable innovative technologies demonstrate a balancing relationship to water demand for irrigation since the use of innovative technologies could result in decreasing demand for water. Furthermore, water demand for irrigation, also, has a balancing relationship to water availability for irrigation because decreases in water demand imporoves water availability for irrigation. The second feedback loop is relevant to water quality which has a beneficial relationship with the state of natural areas, which in turn reinforces the variable tourism. Tourism has a balancing effect on wastewater treatment effectiveness, a variable which establishes a negative (balancing) relationship with point sources of pollution. An improved degree of effectiveness of the wastewater treatment will decrease point sources of pollution. Point sources of pollution has a balancing relationship with water quality. The final feedback loop is positive indicating that the relationship between variables is behaviorally significant and thus should be investigated in more depth. This loop has positive relationship between soil and water quality. The analysis of loops can be coupled with the results of graph theory measures computation, supporting the leverage analysis. In particular, we focused on the closeness centrality, which identifies elements that can easily affect the rest of the network and usually have a high impact on what is happening across the system. The variables characterized by high closeness centrality values are some of the variables that experts consider as important in understanding the system mapping (Table B.4.).

Table 2. Nexus challenges versus leverage points assessed in the CLD from the Jordanian perspective

Nexus challenges	Leverage points

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Water quality	Reduction of Water salinity, Wastewater treatment effectiveness, Water monitoring, Reduction of Point sources of pollution, Socioeconomic conditions and community culture, Reduction of Diffused sources of pollution, Water diversion, Protection zones
Water demand for irrigation	Wastewater treatment effectiveness, Financial incentives, Innovative technologies, Farmers capacity building, Intensive agriculture, Socioeconomic conditions and community culture
Soil quality	Intensive agriculture, Use of fertilizers, pesticides, herbicides, Soil salinization, Sterilization of soil, Crop rotation, Water quality, Soil erosion
Agricultural development	Innovative technologies, Market conditions, Water demand and quality, Financial incentives, Improving soil quality, Reduction of unsustainable agricultural practices, Farmers capacity building, NBS
Biodiversity	State of natural areas, Use of fertilizers, pesticides, herbicides, NBS, Climate change, Urbanization, Indigenous and Local Community Involvement, Livestock grazing, Deforestation and fire events
Climate change	Livestock grazing, Unsustainable agricultural practices, Financial incentives, Solar power, NBS, Farmers capacity building, Information and awareness, Socioeconomic conditions and community culture, Hydropower
Renewable energy availability	Reformulating polices and regulations, Solar power, Innovative technologies, Financial incentives, Wind power, Hydro power
Governance	Enforcement of laws, bylaws, and regulations, Reformulating polices and regulations, Enhancing of the Public-Private Partnership
Population growth	Socioeconomic conditions and community culture, Foreign Labor, Human Health & Well-Being, Migration, Tourism, Urbanization

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Figure 4. The 3 feedback loops in the JV CLD relating to water availability and agricultural development, water quality and the soil .

The main nexus challenges, as identified by the Israeli researchers, influencing the overall sustainability of the WEFE Nexus of the Jordan Valley are water quality, water demand for irrigation, agricultural development, biodiversity, climate change, renewable energy availability, Competition between development and land conservation, Sanitation services (wastewater and solid waste) and population growth. As it is observed, the Israeli partners added two more challenges (Competition between development and land conservation, and Sanitation services (wastewater and solid waste)). These challenges were decided during the conceptualization process which included literature review and local partner input. The Israeli partners also ranked the challenges in the following order from the most important to the less important: 1) Population growth, 2) Climate change, 3) Agricultural development, 4) Water demand for irrigation, 5) Competition between development and land conservation, 6) Biodiversity, 7) Water quality, 8) Renewable energy availability, 9) Sanitation services (wastewater and solid waste). Table 3 presents the list of leverage points that relate to the nexus challenges revised by the Israeli partners.

Appendix C presents the results from the behavioral analysis of the CLD. The degree centrality ranking, after applying weights, according to the ranking of the partners, was a fairly accurate representation of

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the main challenges prioritized by the Israeli partners (Table C.1). Betweenness centrality (Table C.2.) and eigenvector centrality (Table C.3.) values also depict the validity of the representation of the main challenges.

Table 3. Nexus challenges versus leverage points assessed in the CLD from the Israeli perspective

Nexus challenges	Leverage points
Water quality	Reduction of Water salinity, Wastewater treatment effectiveness, Water monitoring, Reduction of Point sources of pollution, Socioeconomic conditions and community culture, Reduction of Diffused sources of pollution, Water diversion, Protection zones
Water demand for irrigation	Wastewater treatment effectiveness, Financial incentives, Innovative technologies, Farmers capacity building, Intensive agriculture, Information and awareness, Aquaculture
Sanitation services	Land planning, population growth, urbanization, wastewater treatment effectiveness
Agricultural development	Financial incentives, Reduction of unsustainable agricultural practices, Farmers capacity building, NBS, Reduction of soil erosion, Reduction of the use of fertilizers, pesticides, herbicides
Biodiversity	State of natural areas, Use of fertilizers, pesticides, herbicides, NBS, Climate change, Urbanization, Livestock grazing
Climate change	Solar power, NBS, Wind power, Climate adapted building, EV adoption
Renewable energy availability	Wastewater treatment effectiveness, Solar power, Wind power, Hydro power, state of grid, Land availability
Competition between development and land conservation	Land planning, population growth, Financial incentives, urbanization
Population growth	Migration, Financial incentives, women's education, religious leadership

EcoFuture Palestinian partners did not modify the first seven identified challenges, as they thought that they were representative for the region. The Palestinian partners also ranked the challenges in the following order from the most important to the less important: 1) Water demand for irrigation 2) Climate change, 3) Population growth, 4) Agricultural development, 5) Water quality, 6) Renewable energy availability, 7) Biodiversity. Table 4 presents the list of leverage points as they relate to the Nexus challenges and as they revised by Palestinian partners.

Appendix D presents the results from the behavioral analysis of the CLD. The degree centrality ranking, after applying weights, according to the ranking of the partners, was a fairly accurate representation of the main challenges prioritized by the Palestinian partners (Table D.1). Betweenness centrality (Table D.2.) and eigenvector centrality (Table D.3.) values also depict the validity of the representation of the main challenges.

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Table 4. Nexus challenges versus leverage points assessed in the CLD from the Palestinian perspective

Nexus challenges	Leverage points
Water quality	Reduction of Water salinity, Wastewater treatment effectiveness, Water monitoring, Reduction of Point sources of pollution, Reduction of Diffused sources of pollution, Water diversion, Protection zones
Water demand for irrigation	Wastewater treatment effectiveness, Financial incentives, Innovative technologies, Farmers capacity building, Intensive agriculture, Information and awareness, Aquaculture
Agricultural development	Financial incentives, Reduction of unsustainable agricultural practices, Farmers capacity building, NBS, Reduction of soil erosion, Reduction of the use of fertilizers, pesticides, herbicides
Biodiversity	State of natural areas, Use of fertilizers, pesticides, herbicides, NBS, Climate change, Urbanization, Livestock grazing
Climate change	Solar power, NBS, Wind power
Renewable energy availability	Wastewater treatment effectiveness, Solar power, Wind power, Hydro power
Population growth	Migration

3.3 Comparison of partner prioritization of challenges and unified CLD

Table 5 presents the results of the CLD analysis regarding the Nexus challenges as they have revised by EcoFuture partners and ranked. The Jordanian partners added two more challenges in the initial list of challenges: soil quality and governance, while Israeli partners added competition between development and land conservation and sanitation services (wastewater & solid waste). There are similarities and differences in priorities for the three territories. The top four challenges according to the Jordanian partners are related to agriculture: water quality, water demand for irrigation, soil quality and agricultural development. For Israeli partners, except for agriculture, population growth, climate change and competition between development and land conservation are also of high priority. For Palestinian partners, the highest priorities are also the same (water demand for irrigation, climate change, population growth, agricultural development) but they do not think that competition between development and land conservation is of high importance.

The next (lesser) priorities for Jordanian partners are biodiversity, climate change, renewable energy availability and governance. Biodiversity and renewable energy availability ranked also from Israeli partners in the same order, but they think also that water quality is one of the lesser priorities. For Palestinian partners, renewable energy availability and water quality are the next set of priorities.

The last priority is different among three territories. For Jordanian partners is population growth, for Israeli is sanitation services and for Palestinians is biodiversity.

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Table 5. Priorities regarding the Nexus challenges of the 3 territories according to EcoFuture partners' opinion

	Jordan	Israel	Palestine
Highest priorities	1) water quality 2) water demand for irrigation 3) soil quality 4) agricultural development	1) population growth 2) climate change 3) agricultural development 4) water demand for irrigation 5) competition between development and land conservation	1) water demand for irrigation 2) climate change 3) population growth 4) agricultural development
Lesser priorities	5) biodiversity 6) climate change 7) renewable energy availability 8) governance	6) biodiversity 7) water quality 8) renewable energy availability	5) renewable energy availability 6) water quality
Last priority	9) population growth	9) sanitation services (wastewater & solid waste)	7) biodiversity

Figure 5 presents the conceptualization and mapping of the unified CLD for JV as it has been changed and confirmed by the EcoFuture partners. All changes, additions in challenges and leverage points were incorporated.

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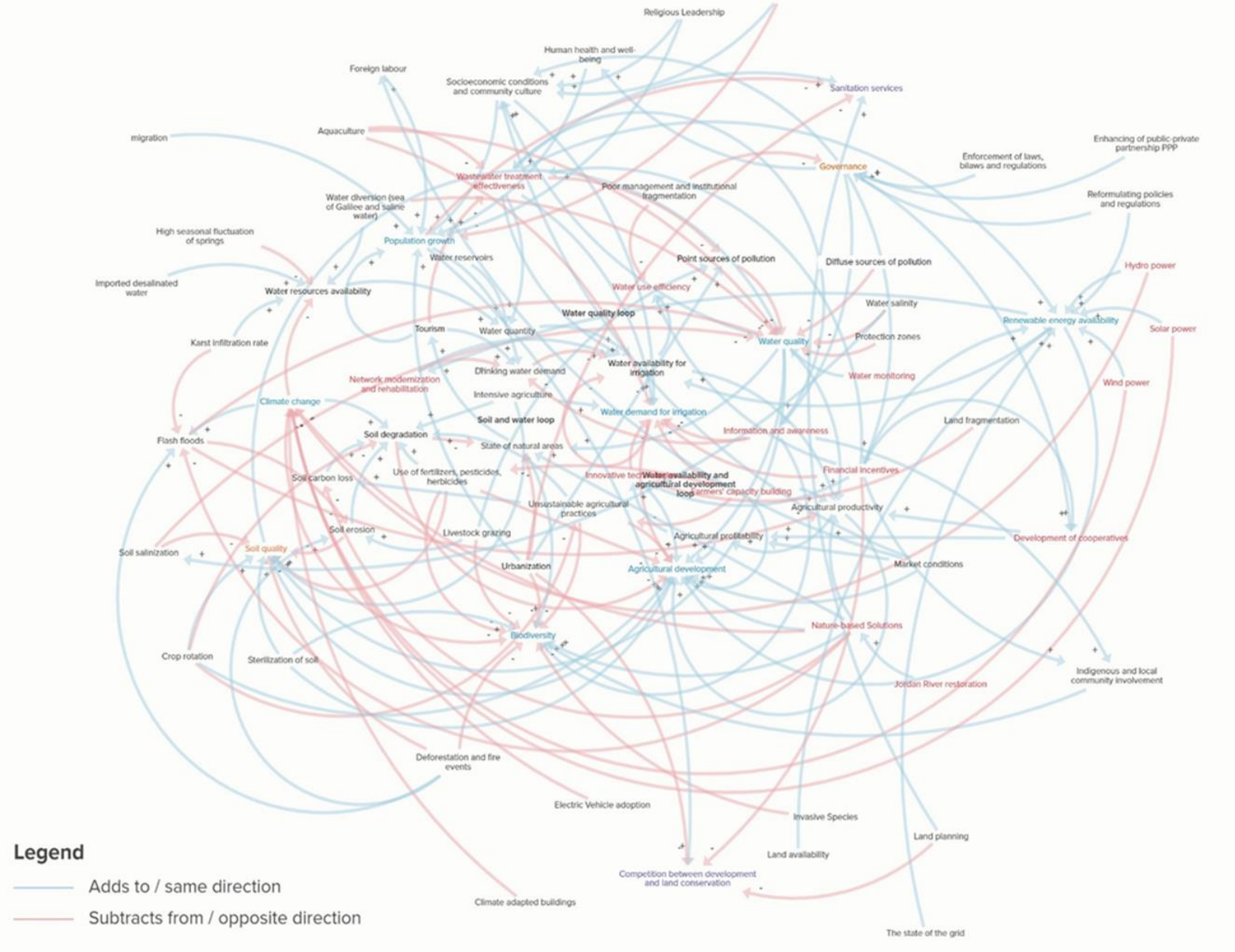

Figure 5. Conceptualization and mapping of the unified CLD for JV

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3.4 Description of components of the Unified CLD of the JV

Figures 6 to 14 present the direct connections between each challenge to the key variables/leverage points affecting it. Figure 6 presents the direct connection of the challenge of population growth with the key variables affecting it. Population growth is affected by migration, foreign labor, tourism, urbanization, socioeconomic conditions, human health and well-being and religious leadership, and women's education, and impacts sanitation services and competition between development and land conservation. Figure 7 presents the direct connection of the challenge of climate change with the key variables affecting it. Climate change is affected by NBS, climate adapted buildings, electric vehicle adaptation, hydro power, wind power and solar power. Climate change also impacts water resources availability, flush floods, soil degradation and biodiversity. Similarly, Figure 8 presents the direct connection of the challenge of biodiversity with the key variables affecting it. Biodiversity is affected by climate change, NBS, use of fertilizer, pesticides and herbicides, livestock grazing, urbanization, unsustainable agricultural practices, sterilization of soils, deforestation and fires, invasive species, community involvement and information and awareness. Figure 9 presents the direct connection of the challenge of agricultural development with the key variables affecting it. Agricultural development is affected by water quality, water demand for irrigation, renewable energy availability, market conditions, agricultural productivity, crop rotation, soil quality, soil degradation, use of fertilizers, pesticides and herbicides, farmer's capacity to adapt, innovative technologies. Agricultural development impacts agricultural profitability. Figure 10 presents the direct connection of the challenge of water demand for irrigation with the key variables affecting it. Water demand for irrigation is affected by aquaculture, socioeconomic conditions, financial incentives, farmer's capacity to adapt, innovative technologies and wastewater treatment effectiveness, and impacts agricultural development. Figure 11 presents the direct connection of the challenge of water quality with the key variables affecting it. Water quality is affected by soil salinization, flush floods, water diversion, aquaculture, point sources, diffuse sources, water salinity, protection zones and water monitoring. Water quality impacts agricultural development, agricultural productivity, state of natural areas and soil quality. Figure 12 presents the direct connection of the challenge of renewable energy availability with some key variables affecting it. Renewable energy availability is affected by hydro power, wind power, solar power, state of the grid, land availability, financial incentives, reformulating policies and regulations, wastewater treatment effectiveness, network modernization and rehabilitation. Renewable energy availability impacts water availability for irrigation and agricultural development. Figure 13 presents the direct connection of the challenge of competition between development and land conservation with some key variables affecting it. This challenge is affected by population growth, urbanization, land planning, financial incentives and impacts water availability for irrigation. Finally, Figure 14 presents the direct connection of the challenge of sanitation services with some key variables affecting it. This challenge is affected by wastewater treatment effectiveness, land planning and population growth.

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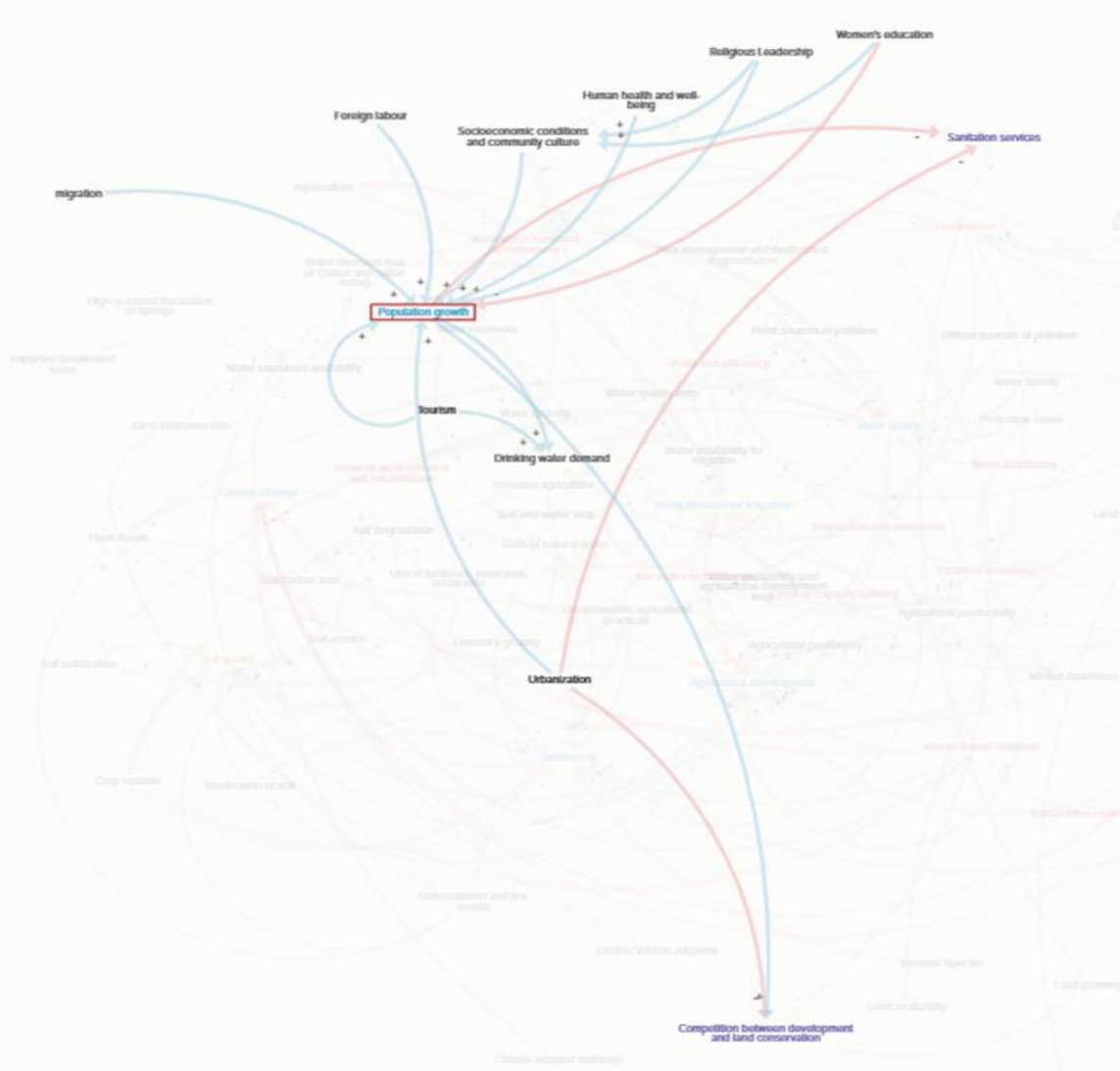

Figure 6. Variables affecting population growth

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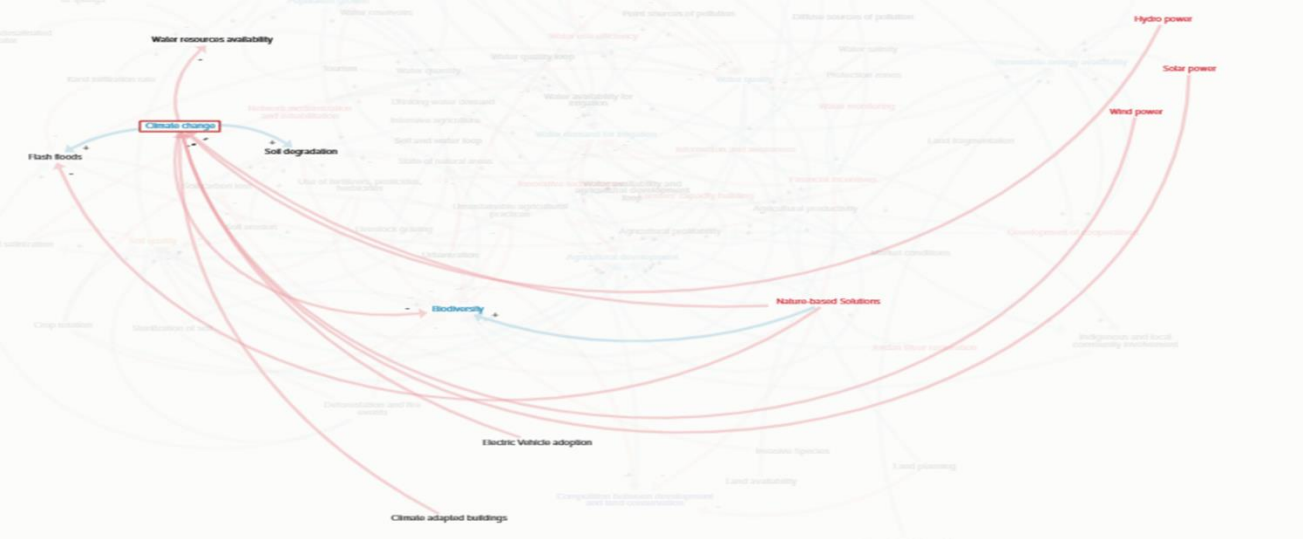

Figure 7. Variables affecting climate change

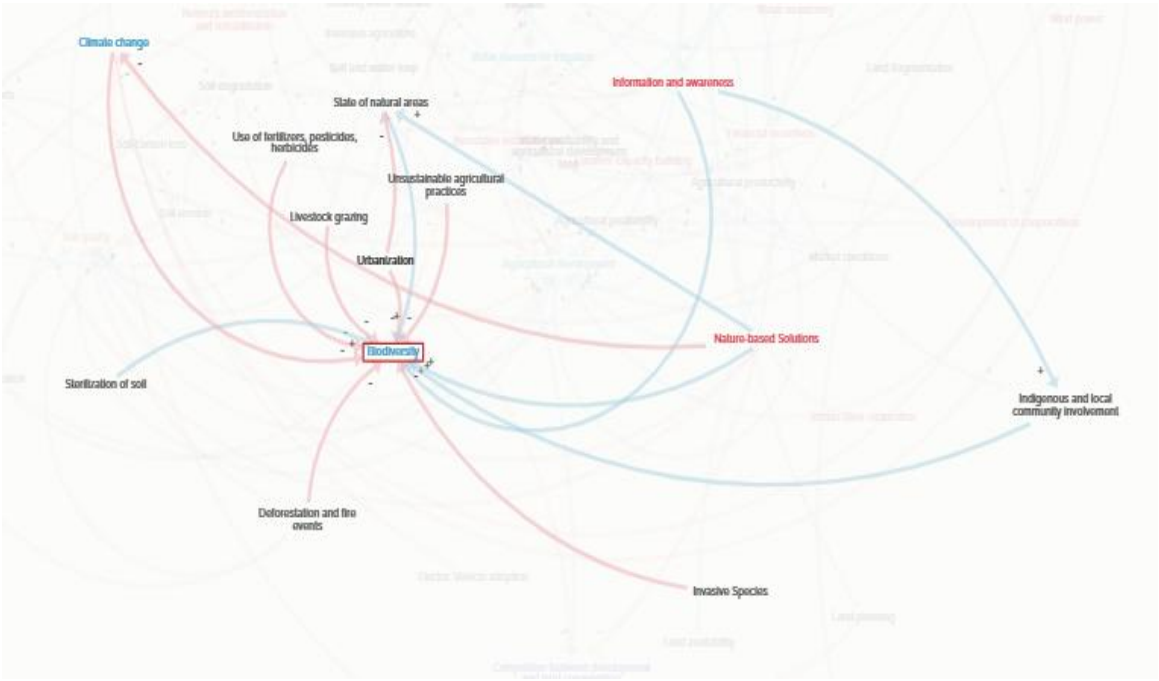

Figure 8. Variables affecting biodiversity

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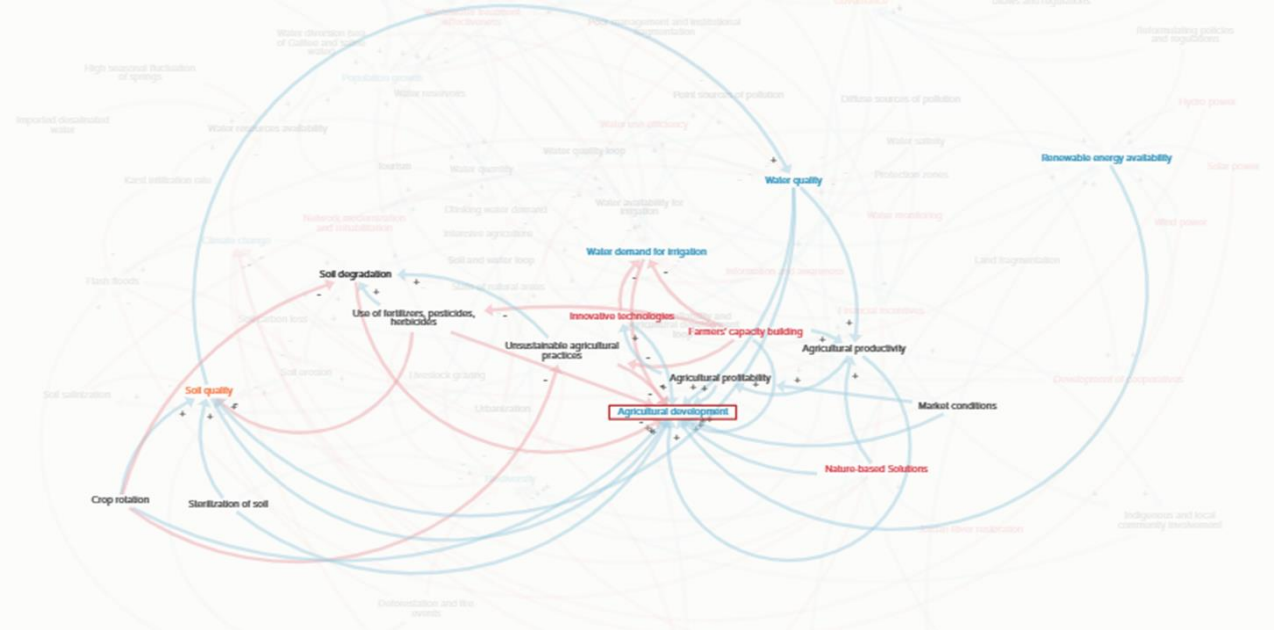

Figure 9. Variables affecting agricultural development

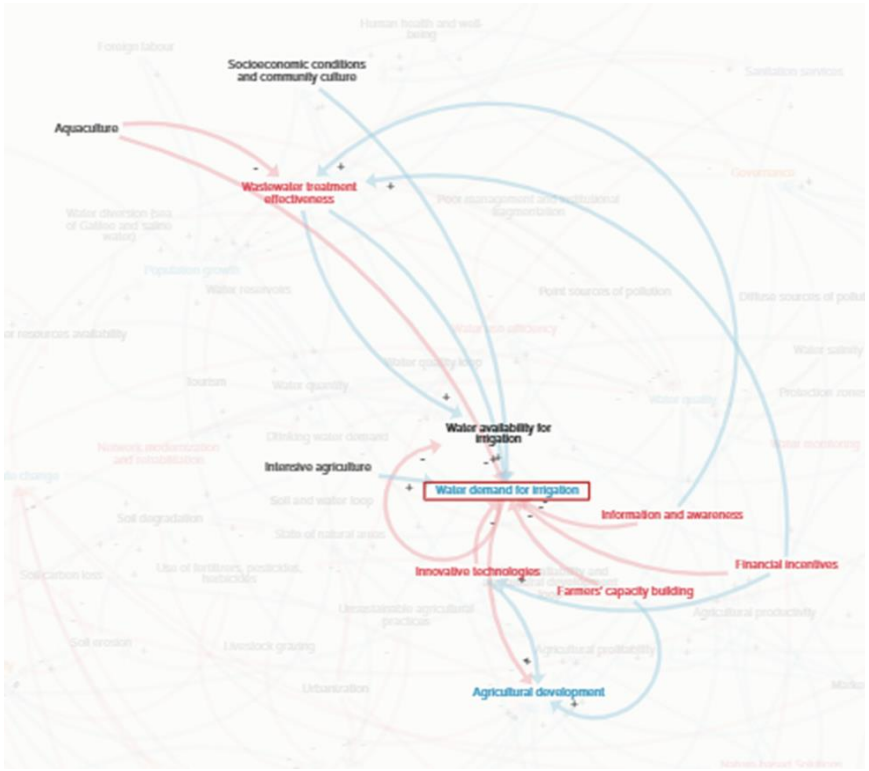

Figure 10. Variables affecting water demand for irrigation

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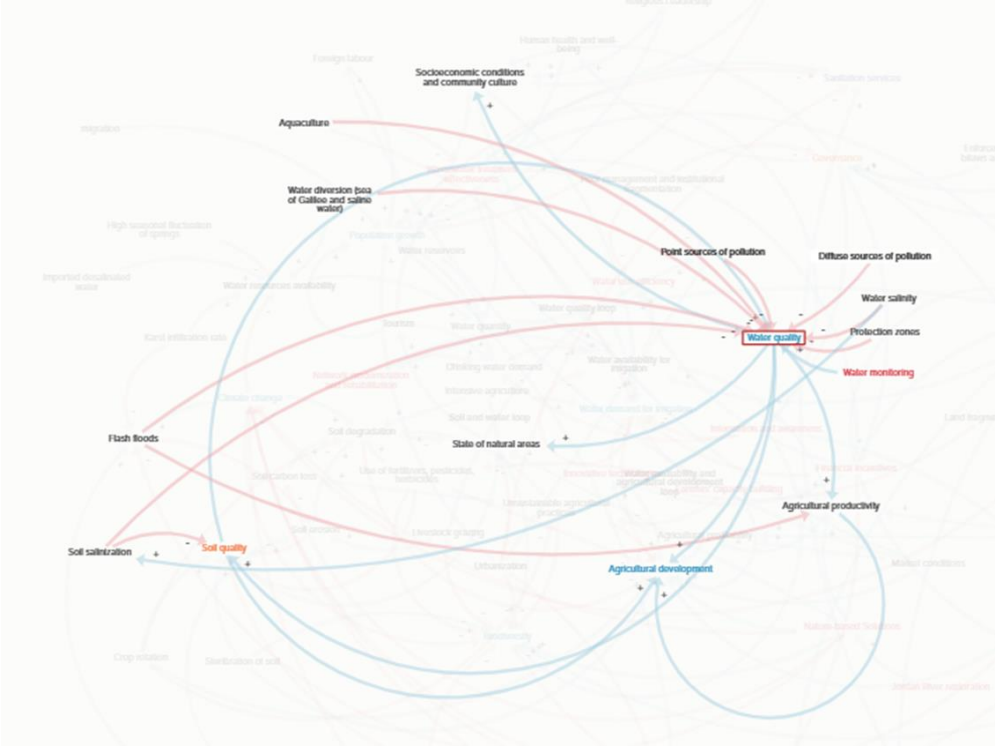

Figure 11. Variables affecting water quality

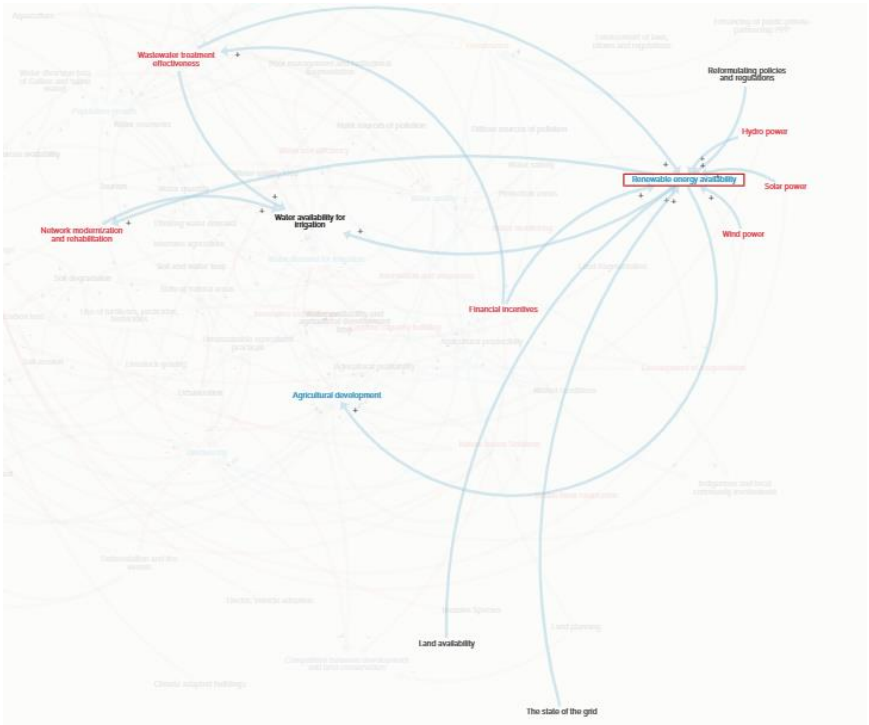

Figure 12. Variables affecting renewable energy availability

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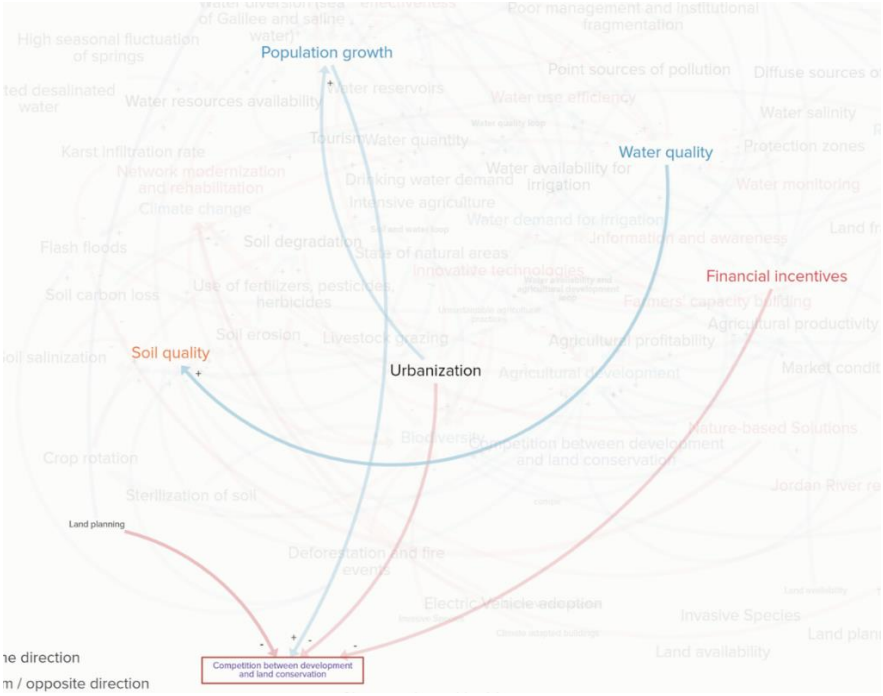

Figure 13. Variables affecting competition between development and land conservation

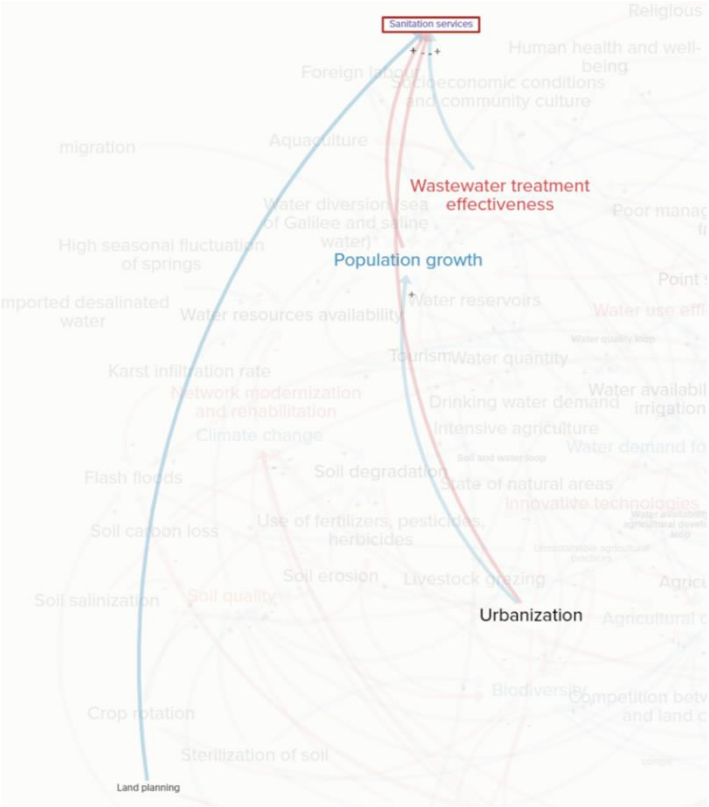

Figure 14. Variables affecting sanitation services

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3.5 Jordanian stakeholders' prioritization of challenges and discussion on CLD

The Jordanian Living Lab was established to bring together a diverse range of stakeholders in the pursuit of comprehensive and actionable strategies. In the second living lab that took place on the 13th of December 2023, the development of the CLD for Jordan was discussed and priorities on the challenges faced by the stakeholders were established. The following stakeholders participated in the living lab representing the following organizations:

- **Government/ MWI**: Director of Water and Environment/Water Authority, Laboratories Director/Jordan Valley Authority and Irrigation Water Distribution & Control /Jordan Valley Authority
- **Academia**: Jordan University of Science and Technology (JUST) and Representative: University of Jordan (UJ)
- **Farmers / civil society**: Deir Alla, Karameh and South Shuneh, Water User Associations, MIRA Farming Association
- **Project Team**: NARC: Dr. Abeer Albalawneh (NARC's Project Coordinator), project team members and one NARC guest.

The workshop (Figure 15) was divided into two sessions. First Dr. Abeer Albalawneh gave an insightful presentation detailing every aspect of the project, describing the role of the living lab in the project, the preliminary CLD for Jordan and the identified challenges, paving the road for the subsequent discussions. The ranking of the challenges by the partners was not presented to the stakeholders allowing them to develop their own opinion on the issue. In the second session, the stakeholders discuss the importance of the challenges presented, identified new challenges and finally ranked the challenges in terms of importance. The 10 participants who attended the meeting ranked the challenges. The number of challenges was originally 9, however participants added 2 more challenges that include seed quality and food processing. Participants were urged to share and suggest the ranking of the main challenges in the Jordan Valley related to water, energy, food, and environment, drawing from the rich and varied perspectives of all the attendees. Eleven main challenges were mentioned and discussed.

Figure 15. Presentation of Dr. Abeer Albalawneh during the 2nd Living Lab meeting

A very vivid discussion tool place among the stakeholders regarding the importance of the identified challenges for the JV before the voting took place. Voting results are as following:

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- Water Quality: 7 out of 10 voted as the most important challenge, 2 out of 10 voted as second in importance, and 1 voted as third in importance.
- Water Demand for Irrigation: 7 out of 10 voted as the second important challenge, 2 out of 10 voted as first in importance, and 1 voted as number 8 in importance.
- Soil Quality: 8 out of 10 voted as the third in importance, 1 voted as number 6 in importance, and 1 voted as number 8 in importance.
- Biodiversity: 5 out of 10 ranked it as number 5, 3 out of 10 ranked it as number 4, 1 out of 10 ranked it as number 7, and 1 out of 10 ranked it as number 8.
- Agricultural Development: 4 out of 10 ranked it as number 4, 3 out of 10 ranked it as number 6, 1 out of 10 ranked it as number 5, 1 out of 10 ranked it as number 9, and 1 out of 10 ranked it as number 11.
- Climate Change: 4 out of 10 ranked it as number 6, 3 out of 10 ranked it as number 5, 1 out of 10 ranked it as number 4, 1 out of 10 ranked it as number 3, and 1 out of 10 ranked it as number 9.
- Renewable Energy: 4 out of 10 ranked it as number 7, 3 out of 10 ranked it as number 8, 1 out of 10 ranked it as number 2, 1 out of 10 ranked it as number 6, and 1 out of 10 ranked it as number 4.
- Governance: 4 out of 10 ranked it as number 8, 4 out of 10 ranked it as number 7, 1 out of 10 ranked it as number 9, and 1 out of 10 ranked it as number 1.
- Population Increases: 7 out of 10 ranked it as number 9, 1 out of 10 ranked it as number 11, 1 out of 10 ranked it as number 4, and 1 out of 10 ranked it as number 6.
- Seed Quality: 1 out of 10 ranked it as number 3, and 1 out of 10 ranked it as number 4.
- Food Processing: 2 out of 10 ranked it as number 10.

The final results of the voting on ranking the challenges are as follows considering 2 new added challenges:

1. Water quality.
2. Water demand for irrigation.
3. Soil quality.
4. Agricultural development.
5. Biodiversity.
6. Climate change.
7. Renewable energy.
8. Governance.
9. Population increases.
10. Food processing.

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11. Seed quality.

The results of the consultation presented above lead to the following conclusions:

- **Added challenges:** The stakeholders suggested two more challenges faced by the JV, food processing and seed quality. Even though both of these issues can be categorized as actions/leverage points affecting the existing challenge of agricultural development, we entered them in the voting as challenges in order to ascertain their importance in the agricultural development dimension.
- **Ranking of the challenges:** The raking of the challenges of the stakeholders is the same as identified by the EcoFuture Jordanian partners indicating the importance of close collaboration between the National Agricultural Research Center and the JV stakeholders in understanding stakeholder needs and priorities.
- **Highest priorities:** The top four identified challenges by the Jordanian stakeholders are water quality, water demand for irrigation, soil quality and agricultural development. It is clear that Jordanian stakeholders are mostly concerned with the availability of good quality water, the fertility of the soil and in general all aspects of agricultural development.
- **Lesser priorities:** The next four challenges are biodiversity, climate change, renewable energy and governance. It is interesting to notice that a few of the stakeholders (mostly from academia) ranked these challenges in the top four priorities indicating the difference of opinion between different sectors. Finally, population increases was last in the ranking of challenges.
- **Priority for the pilot demonstration:** The results of this study identified the urgency to provide sustainable solutions to the stakeholders dealing with their top 4 challenges. The pilot demonstration should provide solutions that improve the water quality, supply sufficient amount of water for irrigation and improve the soil quality and soil fertility.

3.6 Israeli stakeholders' prioritization of challenges

The priortitization of challenges from Israeli stakeholders was conducted through interviews. Firstly, the stakehoders were asked through a questionnaire if they agree with the 9 challenges (Water demand for irrigation, Water quality, Agricultural development, Renewable energy availability, Biodiversity, Climate change, Population growth, Competition between development and land conservation, Sanitation services (wastewater and solid waste), identified by Israeli partners and experts. Secondly, they asked if they would like to add any new challenge if missing from the list and thirdly, they were asked to rank-prioritize the final list of challenges from their perspective. 8 stakeholders participated in the survey representing the following sectors:

- **Government** (1 participant)
- **Academia/experts** (2 participants)
- **Civil society** (3 participants)

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- **Farmers** (1 participant)
- **Private Sector** – Consultant (1 participant)

Voting results are as following:

- Water Quality: 1 out of 8 voted as the most important challenge, 1 voted as 3rd in importance, 1 voted as 9th, 1 voted as 8th in importance and 1 voted as 6th, and 3 voted as 8th in importance.
- Water Demand for Irrigation: 1 out of 8 voted as the 6th important challenge, 1 voted as 7th, 2 out of 8 voted as fifth in importance, 2 voted as 9th and 2 voted as 10th.
- Biodiversity: 1 out of 8 ranked it as number 1, 1 out of 8 ranked it as number 8, 2 ranked it as number 7, 2 ranked it as number 3 and 2 voted as number 2.
- Agricultural Development: 3 out of 8 ranked it as number 7, 1 out of 8 ranked it as number 6, 1 ranked it as number 4, 2 out of 8 ranked it as number 5 and 1 ranked it as number 8.
- Climate Change: 3 out of 8 ranked it as number 1, 3 ranked it as number 2, 1 out of 8 ranked it as number 3 and 1 out of 8 ranked it as number 8.
- Renewable Energy: 1 out of 8 ranked it as number 9, 1 ranked it as number 2, 1 ranked it as number 6, 1 ranked it as number 7, 2 ranked it as 5th and 2 ranked it as 4th.
- Population Increases: 3 out of 8 ranked it as number 9, 2 out of 8 ranked it as number 4, 1 ranked it as number 8, 1 ranked it as 3 and 1 ranked it as the most important challenge.
- Competition between development and land conservation: 2 out of 8 voted as the most important challenge, 2 voted as 2nd, 2 voted as 3rd and 2 voted as 4th.
- Sanitation services (wastewater and solid waste): 4 out of 8 voted as the 6th in importance, 1 voted as 7th, 1 as 9th, 1 as 4th and 1 as 3rd.

The final results of the ranking of challenges are as follows:

1. Climate change and Competition between development and land conservation
2. Biodiversity
3. Renewable energy availability
4. Population growth and Sanitation services
5. Agricultural development
6. Water quality
7. Water demand for irrigation

The results of the consultation process presented above lead to the following conclusions:

- **Added challenges:** The stakeholders suggested also other challenges, such as education and awareness, socioeconomic conditions, tourism, geopolitical tension, governance and institutional

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capacity building, infrastructure development and transportation networks. All these issues had already been taken into consideration and had been included as leverage points in the unified CLD.

- **Ranking of the challenges:** The ranking of the challenges from the stakeholders had similarities but it was not the same as this of the partners. Climate change ranked as the most important challenge by stakeholders and as second one by Israeli partners. Stakeholders ranked also competition between development and land conservation as the first voted challenge together with climate change.
- **Highest priorities:** The top four identified challenges by the Israeli stakeholders are climate change, Competition between development and land conservation, biodiversity and renewable energy availability, while Israeli partners ranked as most important the population growth, and then climate change, agricultural development, water demand for irrigation and competition between development and land conservation.
- **Lesser priorities:** The next challenges in order, by Israeli stakeholders, are population growth, sanitation services, agricultural development and water quality, and the last priority is water demand for irrigation. Biodiversity, water quality and renewable energy availability were next challenges by Israeli partners and the last priority is sanitation services.

3.7 Palestinian stakeholders' prioritization of challenges

The priortitization of challenges from Palestinian stakeholders was conducted through interviews. Firstly, the stakehoders were asked through a questionnaire if they agree with the 7 challenges (Water demand for irrigation, Water quality, Agricultural development, Renewable energy availability, Biodiversity, Climate change, Population growth), identified by Palestinian partners and experts. Secondly, they asked if they would like to add any new challenge if missing from the list and thirdly, they were asked to rank-prioritize the final list of challenges from their perspective. 11 stakeholders participated in the survey representing the following sectors:

- **Government**: Plant production and plant protection/Jericho Agriculture Directorate (4 participants), Al-Jiftlik Unit (1 participant), Tubas Agriculture Directorate (1 participant)
- **Academia/experts** (3 participants)
- **Farmers / civil society**: Odeh/plant production (1 participant), Vegetable Production / Al Sharabati Company (1 participant)

The number of challenges was originally 7, however participants added 1 more challenge that includes land use change.

Voting results are as following:

- Water Quality: 8 out of 11 voted as the second important challenge, 1 voted as forth in importance, 1 voted as 7th and 1 voted as 8th in importance.

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- Water Demand for Irrigation: 9 out of 11 voted as the first important challenge, 2 out of 11 voted as third in importance.
- Biodiversity: 3 out of 11 ranked it as number 7, 3 out of 11 ranked it as number 6, 3 out of 11 ranked it as number5, 1 out of 11 ranked it as number 8 and 1 voted as number 3.
- Agricultural Development: 5 out of 11 ranked it as number 3, 3 out of 11 ranked it as number 4, 1 out of 11 ranked it as number 1, 2 out of 11 ranked it as number 5.
- Climate Change: 1 out of 11 ranked it as number 1, 1 ranked it as number 2, 1 out of 11 ranked it as number 3, 3 out of 11 ranked it as number 5, and 1 out of 11 ranked it as number 7 and 4 out of 11 ranked it as number 6.
- Renewable Energy: 3 out of 11 ranked it as number 3, 5 out of 11 ranked it as number 4, 2 out of 11 ranked it as number 5, 1 out of 11 ranked it as number 6.
- Population Increases: 6 out of 11 ranked it as number 7, 3 out of 11 ranked it as number 6 and 2 out of 11 ranked it as number 4.

The final results of the voting on ranking the challenges are as follows:

1) Water demand for irrigation
2) Water quality
3) Agricultural development
4) Renewable energy availability
5) Climate change
6) Biodiversity
7) Population growth

The results of the consultation process presented above lead to the following conclusions:

- **Added challenges:** The stakeholders suggested 1 more challenge facing the JV: land use. They noticed that there are tourism, entertainment, and industrial projects that have become a priority in the JV region at the expense of the agricultural sector. Moreover, the issue of government support for agriculture and compensation was considered as important, in addition to the availability of agricultural water and salt water treatment. They also think, that the biggest challenge is political due to the occupation and its control over approximately 90% of the Palestinian JV and its control over crossings and trade, as well as giving preference to agricultural products belonging to the settlements, as well as restrictions on the export of agricultural products and also on the uses of fertilizers and preventing some of them under the pretext of dual use. All these issues can be categorized as leverage points affecting the existing challenge of agricultural development, and it had already incorporated in the CLD.

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- **Ranking of the challenges:** The raking of the challenges of the stakeholders has similarities but it is not the same as this of the partners. Both stakeholders and Palestinian partners think that water demand for irrigation is the most important challenge. Agricultural development is also important, while stakeholders ranked with number 3 and partners with number 4.
- **Highest priorities:** The top four identified challenges by the Palestinian stakeholders are water demand for irrigation, water quality, agricultural development and renewable energy availability, while Palestinian partners ranked also climate change and population growth among the top four challenges. It is clear that Palestinian stakeholders are mostly concerned with the availability and good quality of water, and in general all aspects of agricultural development.
- **Lesser priorities:** The next challenges in order, by Palestinian stakeholders, are climate change, biodiversity, and finally, population growth. Partners also ranked biodiversity as the last priority.

3.8 Comparison of stakeholders' prioritization of challenges

Table 6 presents the results of the CLD analysis regarding the Nexus challenges as they were revised and ranked by the Israeli, Jordanian and Palestinian stakeholders. There are similarities and differences in priorities for the three territories. The top four challenges according to the Jordanian and Palestinian stakeholders are mainly related to agriculture: water quality, water demand for irrigation, and agricultural development. Soil quality is included in the list of the top challenges from Jordanian perspective, while renewable energy availability is included in the list from Palestinian perspective. On the other hand, for Israeli stakeholders, climate change, competition between development and land conservation, biodiversity and renewable energy availability are of high priority.

The next (lesser) priorities for Jordanian and Palestinian stakeholders are biodiversity and climate change. Jordanian stakeholders included among the list of challenges of lesser priorities the renewable energy availability and governance. For Israeli stakeholders, population growth, sanitation services, agricultural development and water quality constitute the next (lesser) priorities.

The last priority for Jordanian and Palestinian stakeholders is population growth while for Israeli stakeholders is water demand for irrigation. From the results of the prioritization of challenges, it is concluded that the priorities for Palestinian and Jordanian stakeholders are similar while Israeli stakeholders have other priorities.

Table 6. Priorities regarding the Nexus challenges of the 3 territories according to stakeholders' opinion

	Jordan	Israel	Palestine
Highest priorities	1) Water quality 2) Water demand for irrigation 3) Soil quality	1) Climate change 2) Competition between development and land conservation	1) Water demand for irrigation 2) Water quality

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	4) Agricultural development	3) Biodiversity 4) Renewable energy availability	3) Agricultural development 4) Renewable energy availability
Lesser priorities	5) Biodiversity 6) Climate change 7) Renewable energy availability 8) Governance	5) Population growth and Sanitation services 6) Agricultural development 7) Water quality	5) Climate change 6) Biodiversity
Last priority	9) Population growth	8) Water demand for irrigation	7) Population growth

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4. Conclusions

The lack of interdisciplinary methods for analysing the Nexus connections has been discussed as being a key barrier to overcome. Most of the existing frameworks focus exclusively on technical aspects related to Nexus management, neglecting the importance of the socio-economic elements of the system.

The CLD created by the experts and the Israeli, Jordanian and Palestinian partners, was used as a first level of engagement of stakeholders in JV and the results validated its effectiveness as a tool for engagement. The usability of this analysis for leading decision-makers and stakeholders in the co-design of WEFE Nexus policies will be evaluated at the second Work Package of the EcoFuture project.

Through this analysis, the challenges that face JV were identified and prioritized. Water demand for irrigation, Water quality, Agricultural development, Soil quality, Renewable energy availability, Biodiversity, Climate change, Population growth, Competition between development and land conservation, Sanitation services (wastewater and solid waste) and Governance is the whole list of identified challenges in the area according to Israeli, Jordanian, Palestinian partners and stakeholders and scientific experts. Table 7 presents all challenges and the related problems and solutions identified through CLD analysis.

There are similarities and differences in priorities for the three territories. From the results of the prioritization of challenges, it is concluded that:

- The ranking of the challenges of the stakeholders is the same as identified by the EcoFuture Jordanian partners indicating the importance of close collaboration between the National Agricultural Research Center and the JV stakeholders in understanding stakeholder needs and priorities.
- The priorities for Palestinian and Jordanian stakeholders are similar while Israeli stakeholders have other priorities.

The CLD analysis will be used as the first step of stakeholder engagement within the project and as a first attempt of co-design process for the identification of priorities in JV. The results of this analysis will be presented in the WEFE prioritization workshop.

Table 7. All challenges and the related problems and solutions, identified through CLD analysis

Challenges	Problems	Solutions
Water quality	Aquaculture, Water diversion (sea of Galilee and saline water, Flash floods, Soil sanitization, Point sources of pollution, Diffuse sources of pollution, Water salinity, Protection zones	Water monitoring, Agricultural productivity, Agricultural development, State of natural areas, Socioeconomic conditions and community culture, Soil quality

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Water demand for irrigation	Socioeconomic conditions and community culture, Wastewater treatment effectiveness, Intensive agriculture	Aquaculture, Innovative technologies, Agricultural development, Farmers capacity training, Financial incentives, Information and awareness, Water availability for irrigation
Soil quality	Soil salinization, Soil erosion, Deforestation and fire events, Use of fertilizer, pesticides and herbicides, Water quality	Agricultural development, Intensive agriculture, Sterilization of soil, Crop rotation
Agricultural development	Soil degradation, Use of fertilizer, pesticides and herbicides, Unstable agricultural practices, Water demand for irrigation	Crop rotation, Sterilization of soil, Soil quality, Innovative technologies, Farmers capacity building, Agricultural profitability, Water quality, Agricultural productivity, Market conditions, Nature-based solutions, Renewable energy
Biodiversity	Climate change, Deforestation and fire events, Use of fertilizers, pesticides, herbicides, Livestock grazing, Urbanization, Unstable agricultural practices, Invasive species	Sterilization of soil, State of natural areas, Nature-based solutions, Information and awareness, Indigenous and local community involvement
Climate change	Flash floods, soil degradation	Water resources availability, Biodiversity, Electric vehicle adoption, Climate adapted buildings, Nature-based solutions, Wind, solar and hydro power

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Renewable energy		Wastewater treatment effectiveness, Network modernization and rehabilitation, Water availability for irrigation, Financial incentives, Agricultural development, Land availability, The state of the grid, Reformulating policies and regulations, hydro, wind and solar power
Governance	Poor management and institutional fragmentation	Socioeconomic conditions and community culture, Human health and well-being, Enforcement of laws, bilaws and regulations, Enhancing of public-private partnership PPP, Reformulating policies and regulations, Development of cooperatives, Financial incentives, Information and awareness
Population growth	Urbanization, Drinking water demand, Tourism, Migration, Foreign labour, Religious leadership, Socioeconomic conditions and community culture, Human health and well-being	Competition between development and land conservation, Sanitation services, Women's education
Competition between development and land conservation	Urbanization, Population growth	Land planning, Financial incentives
Sanitation Services	Urbanization, Population growth	Wastewater treatment effectiveness, Land planning

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Appendix A. Initial version of the CLD produced for the JV

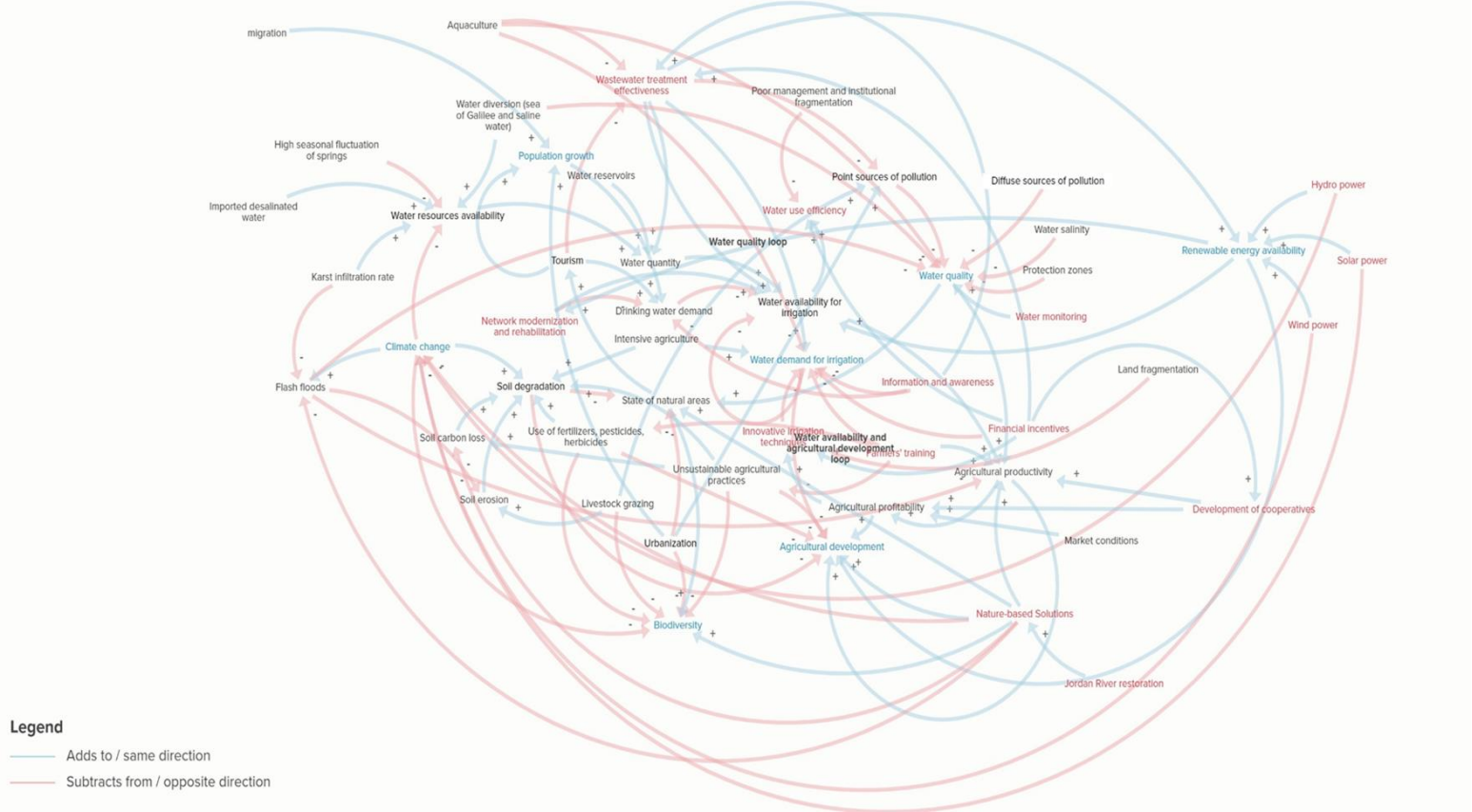

Figure A.1. Initial version of the CLD produced for the JV.

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Appendix B. Behavioral Analysis of the Jordanian CLD

Table B.1. Degree Centrality Ranking.

Nexus challenges ranked by Jordanian partners	
Water quality	1st
Water demand for irrigation	2nd
Soil quality	3rd
Agricultural development	4th
Biodiversity	5th
Climate change	6th
Renewable energy availability	7th
Governance	8th
Population growth	9th

Degree Centrality

Rank	Label	Value
#1	Water quality	15
#2	Water demand for irrigation	8.6
#3	Soil quality	8.3
#4	Agricultural development	8.2
#5	Biodiversity	6.6
#6	Climate change	4.8
#7	Renewable energy availability	4.5
#8	Governance	4.5
#9	Population growth	3.5

Table B.2. Betweenness centrality ranking

Nexus challenges ranked by Jordanian partners	
Water quality	1st
Water demand for irrigation	2nd
Soil quality	3rd
Agricultural development	4th
Biodiversity	5th
Climate change	6th
Renewable energy availability	7th
Governance	8th
Population growth	9th

Rank	Label	Value
#1	State of natural areas	0.082
#2	Tourism	0.072
#3	Wastewater treatment effectiveness	0.072
#4	Soil degradation	0.067
#5	Water availability for irrigation	0.060
#6	Agricultural productivity	0.059
#7	Water quality V	0.047
#8	Agricultural profitability	0.026
#9	Point sources of pollution	0.020
#10	Governance V	0.017
#11	Soil erosion	0.017
#12	Drinking water demand	0.016
#13	Water quantity	0.016
#14	Innovative technologies	0.014
#15	Climate change V	0.014
#16	Renewable energy availability V	0.010

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Table B.3. Eigenvector Centrality Ranking.

Nexus challenges ranked by Jordanian partners	
Water quality	1st
Water demand for irrigation	2nd
Soil quality	3rd
Agricultural development	4th
Biodiversity	5th
Climate change	6th
Renewable energy availability	7th
Governance	8th
Population growth	9th

Eigenvector Centrality

Rank	Label	Value
#1	Agricultural development V	0.298
#2	Water availability for irrigation	0.110
#3	Agricultural productivity	0.103
#4	Water use efficiency	0.089
#5	Agricultural profitability	0.084
#6	Water demand for irrigation V	0.074
#7	Innovative technologies	0.068
#8	Drinking water demand	0.031
#9	Population growth V	0.021
#10	Water quality V	0.018
#11	State of natural areas	0.014
#12	Soil quality V	0.014
#13	Socioeconomic conditions and community culture	0.014
#14	Biodiversity V	0.012
#15	Tourism	0.012
#16	Wastewater treatment effectiveness	0.009
#17	Water quantity	
#18	Renewable energy availability V	

Table B.4. Closeness Centrality Ranking.

Closeness Centrality

Rank	Label	Value
#1	Water quality	0.228
#2	Climate change	0.173
#3	Governance	0.146
#4	Water salinity	0.139
#5	Soil salinization	0.139
#6	Water monitoring	0.134
#7	Diffuse sources of pollution	0.134
#8	Protection zones	0.134
#9	Soil quality	0.130
#10	Point sources of pollution	0.127
#11	Wind power	0.108
#12	Hydro power	0.108
#13	Solar power	0.108
#14	Water diversion (sea of Galilee and saline water)	0.099
#15	Sterilization of soil	0.098
#16	Financial incentives	0.094
#18	Jordan River restoration	0.093
#19	Nature-based Solutions	0.093
#20	Aquaculture	0.089

Nexus challenges	Leverage points
Water quality	Reduction of Water salinity, Wastewater treatment effectiveness, Water monitoring, Reduction of Point sources of pollution, Socioeconomic conditions and community culture, Reduction of Diffused sources of pollution, Water diversion, Protection zones
Water demand for irrigation	Wastewater treatment effectiveness, Financial incentives, Innovative technologies, Farmers capacity building, Intensive agriculture, Socioeconomic conditions and community culture
Soil quality	Intensive agriculture, Use of fertilizers, pesticides, herbicides, Soil salinization, Strerilization of soil, Crop rotation, Water quality, Soil erosion
Agricultural development	Innovative technologies, Market conditions,Water demand and quality, Financial incentives, Imroving soil quality, Reduction of unsustainable agricultural practices, Farmers capacity building, NBS
Biodiversity	State of natural areas, Use of fertilizers, pesticides, herbicides, NBS, Climate change, Urbanization, Indigenous and Local Community Involvement, Livestock grazing, Deforestation and fire events
Climate change	Livestock grazing, Unsustainable agricultural practices, Financial invcentives, Solar power, NBS, Farmers capacity building, Information and awareness, Socioeconomic conditions and community culture, Hydropower
Renewable energy availability	Refomulating polices and regulations, Solar power, Innovative technologies, Finantial incentives, Wind power, Hydro power
Governance	Enforcement of laws, bilaws, and regulations, Refomulating polices and regulations, Enhancing of the Public-Private Partnership
Polulation growth	Socioeconomic conditions and community culture, Foreign Labour, Human Health & Well-Being, Migration, Tourism, Urbanization

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Appendix C. Behavioral Analysis of the Israeli CLD

Table C.1. Degree Centrality Ranking.

Nexus challenges ranked by Israeli partners	
Population growth	1st
Climate change	2nd
Agricultural development	3rd
Water demand for irrigation	4th
Competition between development and land conservation	5th
Biodiversity	6th
Water quality	7th
Renewable energy availability	8th
Sanitation services (wastewater and solid waste)	9th

Degree Centrality

Rank	Label	Value
#1	Agricultural development	12.0
#2	Population growth	11
#3	Climate change	9.0
#4	Water quality	7.8
#5	Biodiversity	7.5
#6	Water demand for irrigation	7.1
#7	Renewable energy availability	5.8
#8	Competition between development and land conservation	3.1
#9	Urbanization	2.8
#10	Sanitation services	2.5

Table C.2. Betweenness centrality ranking

Nexus challenges ranked by Israeli partners	
Population growth	1st
Climate change	2nd
Agricultural development	3rd
Water demand for irrigation	4th
Competition between development and land conservation	5th
Biodiversity	6th
Water quality	7th
Renewable energy availability	8th
Sanitation services (wastewater and solid waste)	9th

Betweenness Centrality

Rank	Label	Value
#1	State of natural areas	0.072
#2	Tourism	0.065
#3	Soil degradation	0.064
#4	Wastewater treatment effectiveness	0.058
#5	Water availability for irrigation	0.056
#6	Agricultural productivity	0.049
#7	Water quality V	0.038
#8	Agricultural profitability	0.022
#9	Population growth V	0.019
#10	Climate change V	0.019
#11	Soil erosion	0.016
#12	Drinking water demand	0.016
#13	Governance	0.015
#14	Water quantity	0.014
#15	Point sources of pollution	0.014
#16	Innovative technologies	0.011
#17	Renewable energy availability V	0.010
#18	Flash floods	0.009
#19	Financial incentives	0.008
#20	Soil quality	0.008

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Table C.3. Eigenvector Centrality Ranking.

Nexus challenges ranked by Israeli partners	
Population growth	1st
Climate change	2nd
Agricultural development	3rd
Water demand for irrigation	4th
Competition between development and land conservation	5th
Biodiversity	6th
Water quality	7th
Renewable energy availability	8th
Sanitation services (wastewater and solid waste)	9th

Eigenvector Centrality

Rank	Label	Value
#1	Agricultural development V	0.286
#2	Water availability for irrigation	0.106
#3	Agricultural productivity	0.099
#4	Water use efficiency	0.085
#5	Agricultural profitability	0.080
#6	Water demand for irrigation V	0.071
#7	Innovative technologies	0.065
#8	Drinking water demand	0.030
#9	Sanitation services V	0.024
#10	Population growth V	0.020
#11	Water quality V	0.017
#12	Competition between development and land conservation V	0.016
#13	State of natural areas	0.014
#14	Soil quality	0.014
#15	Socioeconomic conditions and community culture	0.014
#16	Biodiversity V	0.011
#17	Tourism	0.011
#18	Wastewater treatment effectiveness	0.009
#19	Water quantity	0.007
#20	Renewable energy availability V	0.007

Table C.4. Closeness Centrality Ranking.

Closeness Centrality

Rank	Label	Value
#1	Climate change	0.231
#2	Wind power	0.140
#3	Hydro power	0.140
#4	Solar power	0.140
#5	Electric Vehicle adoption	0.135
#6	Climate adapted buildings	0.135
#7	Water quality	0.115
#8	Population growth	0.112
#9	Jordan River restoration	0.088
#10	Nature-based Solutions	0.088
#11	Enforcement of laws, bilaws and regulations	0.080
#12	Enhancing of public-private partnership PPP	0.080
#13	Governance	0.080
#14	Poor management and institutional fragmentation	0.080
#15	Reformulating policies and regulations	0.080
#16	Socioeconomic conditions and community culture	0.077
#17	Women's education	0.077
#18	Religious Leadership	0.077
#19	Urbanization	0.077
#20	Financial incentives	0.076

Nexus challenges	Leverage points
Water quality	Reduction of Water salinity, Wastewater treatment effectiveness, Water monitoring, Reduction of Point sources of pollution, Socioeconomic conditions and community culture, Reduction of Diffused sources of pollution, Water diversion, Protection zones
Water demand for irrigation	Wastewater treatment effectiveness, Financial incentives, Innovative technologies, Farmers capacity building, Intensive agriculture, Information and awareness, Aquaculture
Sanitation services	Land planning, population growth, urbanization, wastewater treatment effectiveness
Agricultural development	Financial incentives, Reduction of unsustainable agricultural practices, Farmers capacity building, NBS, Reduction of soil erosion, Reduction of the use of fertilizers, pesticides, herbicides
Biodiversity	State of natural areas, Use of fertilizers, pesticides, herbicides, NBS, Climate change, Urbanization, Livestock grazing
Climate change	Solar power, NBS, Wind power, Climate adapted building, EV adoption
Renewable energy availability	Wastewater treatment effectiveness, Solar power, Wind power, Hydro power, state of grid, Land availability
Competition between development and land conservation	Land planning, population growth, Financial incentives, urbanization
Polulation growth	Migration, Financial incentives, women's education, religious leadership

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Appendix D. Behavioral Analysis of the Palestinian CLD

Table D.1. Degree Centrality Ranking.

Nexus challenges ranked by Palestinian partners	
Water demand for irrigation (scarce water resources)	1st
Climate change	2nd
Population growth	3rd
Agricultural development	4th
Renewable energy availability	5th
Water quality	6th
Biodiversity	7th

Degree Centrality

Rank	Label	Value
#1	Water demand for irrigation	10
#2	Climate change	10
#3	Population growth	9.90
#4	Agricultural development	8
#5	Renewable energy availability	6.50
#6	Water quality	6.30
#7	Biodiversity	5.50

Table D.2. Betweenness centrality ranking

Nexus challenges ranked by Palestinian partners	
Water demand for irrigation (scarce water resources)	1st
Climate change	2nd
Population growth	3rd
Agricultural development	4th
Renewable energy availability	5th
Water quality	6th
Biodiversity	7th

Betweenness Centrality

Rank	Label	Value
#1	State of natural areas	0.070
#2	Soil degradation	0.064
#3	Tourism	0.063
#4	Wastewater treatment effectiveness	0.062
#5	Water availability for irrigation	0.052
#6	Agricultural productivity	0.048
#7	Water quality	0.038
#8	Agricultural profitability	0.022
#9	Climate change	0.019
#10	Soil erosion	0.016
#11	Governance	0.015
#12	Water quantity	0.014
#13	Point sources of pollution	0.014
#14	Drinking water demand	0.013
#15	Population growth	0.012
#16	Innovative technologies	0.012
#17	Renewable energy availability	0.011

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Table D.3. Eigenvector Centrality Ranking.

Nexus challenges ranked by Palestinian partners	
Water demand for irrigation (scarce water resources)	1st
Climate change	2nd
Population growth	3rd
Agricultural development	4th
Renewable energy availability	5th
Water quality	6th
Biodiversity	7th

Eigenvector Centrality

Rank	Label	Value
#1	Agricultural development	0.286
#2	Water availability for irrigation	0.106
#3	Agricultural productivity	0.099
#4	Water use efficiency	0.085
#5	Agricultural profitability	0.080
#6	Water demand for irrigation	0.071
#7	Innovative technologies	0.065
#8	Drinking water demand	0.030
#9	Sanitation services	0.024
#10	Population growth	0.020
#11	Water quality	0.017
#12	Competition between development and land conservation	0.016
#13	State of natural areas	0.014
#14	Soil quality	0.014
#15	Socioeconomic conditions and community culture	0.014
#16	Biodiversity	0.011
#17	Tourism	0.011
#18	Wastewater treatment effectiveness	0.009
#19	Water quantity	0.007
#20	Renewable energy availability	0.007

Table D.4. Closeness Centrality Ranking.

Closeness Centrality

Rank	Label	Value
#1	Climate change	0.262
#2	Wind power	0.158
#3	Hydro power	0.158
#4	Solar power	0.158
#5	Electric Vehicle adoption	0.152
#6	Climate adapted buildings	0.152
#7	Population growth	0.101
#8	Water quality	0.100
#9	Jordan River restoration	0.081
#10	Nature-based Solutions	0.081
#11	Socioeconomic conditions and community culture	0.079
#12	Women's education	0.079
#13	Religious Leadership	0.079
#14	Water demand for irrigation	0.076
#15	Market conditions	0.066
#16	Renewable energy availability	0.064
#17	Foreign labour	0.064
#18	Human health and well-being	0.064
#19	migration	0.064

Nexus challenges	Leverage points
Water quality	Reduction of Water salinity, Wastewater treatment effectiveness, Water monitoring, Reduction of Point sources of pollution, Reduction of Diffused sources of pollution, Water diversion, Protection zones
Water demand for irrigation	Wastewater treatment effectiveness, Financial incentives, Innovative technologies, Farmers capacity building, Intensive agriculture, Information and awareness, Aquaculture
Agricultural development	Financial incentives, Reduction of unsustainable agricultural practices, Farmers capacity building, NBS, Reduction of soil erosion, Reduction of the use of fertilizers, pesticides, herbicides
Biodiversity	State of natural areas, Use of fertilizers, pesticides, herbicides, NBS, Climate change, Urbanization, Livestock grazing
Climate change	Solar power, NBS, Wind power
Renewable energy availability	Wastewater treatment effectiveness, Solar power, Wind power, Hydro power
Population growth	Migration

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Project Coordinator

Project Partners

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