7 DS ANALYSIS AND AI SCENARIOS FOR DS4 IN ISRAEL

7.1 Context and challenges

The Israeli Demo Site (DS4) is located in the Negev region, a semi-arid area where agriculture faces severe water scarcity and high energy demand for irrigation. Groundwater overexploitation, increasing salinity, and climate variability exacerbate the challenges of ensuring sustainable food production. The Demo Site therefore explores technologies that combine efficient water use, non-conventional water resources, and renewable energy.

The main Nexus challenges in this context include:

- Water: limited freshwater availability and high reliance on irrigation.
- Energy: energy-intensive pumping and desalination.
- Food: maintaining agricultural productivity under water and climate stress.
- Ecosystems: risks of soil degradation and salinisation due to irrigation practices.

The Israeli Living Lab, coordinated and managed by KKL-JNF in collaboration with Kibbutz Ma'ale-Gilboa and supported by MIGAL research institute, focused on the integration of photovoltaic panels with agricultural production in the Jordan Valley. Milestone 6.2 noted that “the Emek HaMaayanot demo site will test agrovoltaic fields, combining solar panels with crops, thereby producing renewable energy, maintaining agricultural productivity and enhancing community resilience.”

Implementation faced significant delays, as noted in the Grant Agreement Amendment, due to the current situation in Israel. Nevertheless, the concept was recognized as highly innovative, with the potential to simultaneously provide energy autonomy, diversify income sources and mitigate rural exodus. According to the first results from LCA, the approach was highly promising for future scaling.

7.2 Top 3 prioritised solutions

During the stakeholder workshop, 20 NBS and BES were evaluated using the SureNexus MCA tool. The three solutions that surpassed the threshold of 50 (Figure 22) were:

- **Subsurface rainwater harvesting**, which ranked highest. This solution reduces evaporation losses, provides reliable water storage, and increases resilience against rainfall variability.
- **Irrigation systems** (including precision and smart irrigation technologies) ranked second. They enhance water use efficiency, reduce waste, and support stable crop yields under scarce water conditions.

- **Solar-driven vapour condensation units**, in third position, were recognised for their innovation in producing freshwater from air humidity or vapour using renewable energy, thereby reducing dependence on conventional water sources.

Subsurface rainwater harvesting directly addresses water security, irrigation systems improve agricultural productivity and reduce pressure on groundwater, while solar vapour condensation units offer an innovative renewable energy-based source of freshwater.

In this report, the most relevant outputs from the AI WEFE Nexus Tool are those related to **water productivity under different solar panel configurations**. The analysis focuses on how the installation of solar panels alters local microclimatic conditions—particularly air and soil temperature, incident solar radiation, and soil evaporation—and how these changes, in turn, influence crop evapotranspiration, irrigation requirements, and final production. By comparing scenarios with and without solar panels, the tool allows us to quantify the trade-offs between water savings, energy generation, and yield, providing a robust basis for **evaluating agrovoltaic systems from an integrated WEFE Nexus perspective.**

7.3 AI scenario results and discussion

Figure 45 shows the seasonal pattern of irrigation requirements for the vineyard under the **two scenarios: S1 Solar agrovoltaic system and S2 conventional grid-based system.** Both Net Irrigation Requirements (NIR) and Gross Irrigation Requirements (GIR) are concentrated between May and October, which corresponds to the dry, high-evapotranspiration period of the Mediterranean-semiarid climate. From May to September, the **grid scenario (S2) consistently demands more water than the solar agrovoltaic scenario (S1)**. For example, in June and July NIR in S2 reaches its maximum values (around 120–135 mm/month), while S1 remains significantly lower (around 50-95 mm/month). The same pattern is observed for GIR, where the irrigation applied in S2 is around one third higher than in S1 for the peak summer months.

The comparison highlights that the **agrovoltaic configuration substantially reduces irrigation water demand** without changing the seasonal timing of irrigation. This reduction is a **direct consequence of the partial shading produced by the solar panels, which lowers crop evapotranspiration and therefore the water demand of the vineyard.** The figure also shows that in early spring (May) and late season (October) NIR and GIR are relatively low in both scenarios, indicating that most of the irrigation pressure on the local water resources is concentrated in just three to four critical summer months.

From a WEFE perspective, this figure evidences the **water-saving potential of agrovoltaic systems,** particularly under hot, dry conditions.

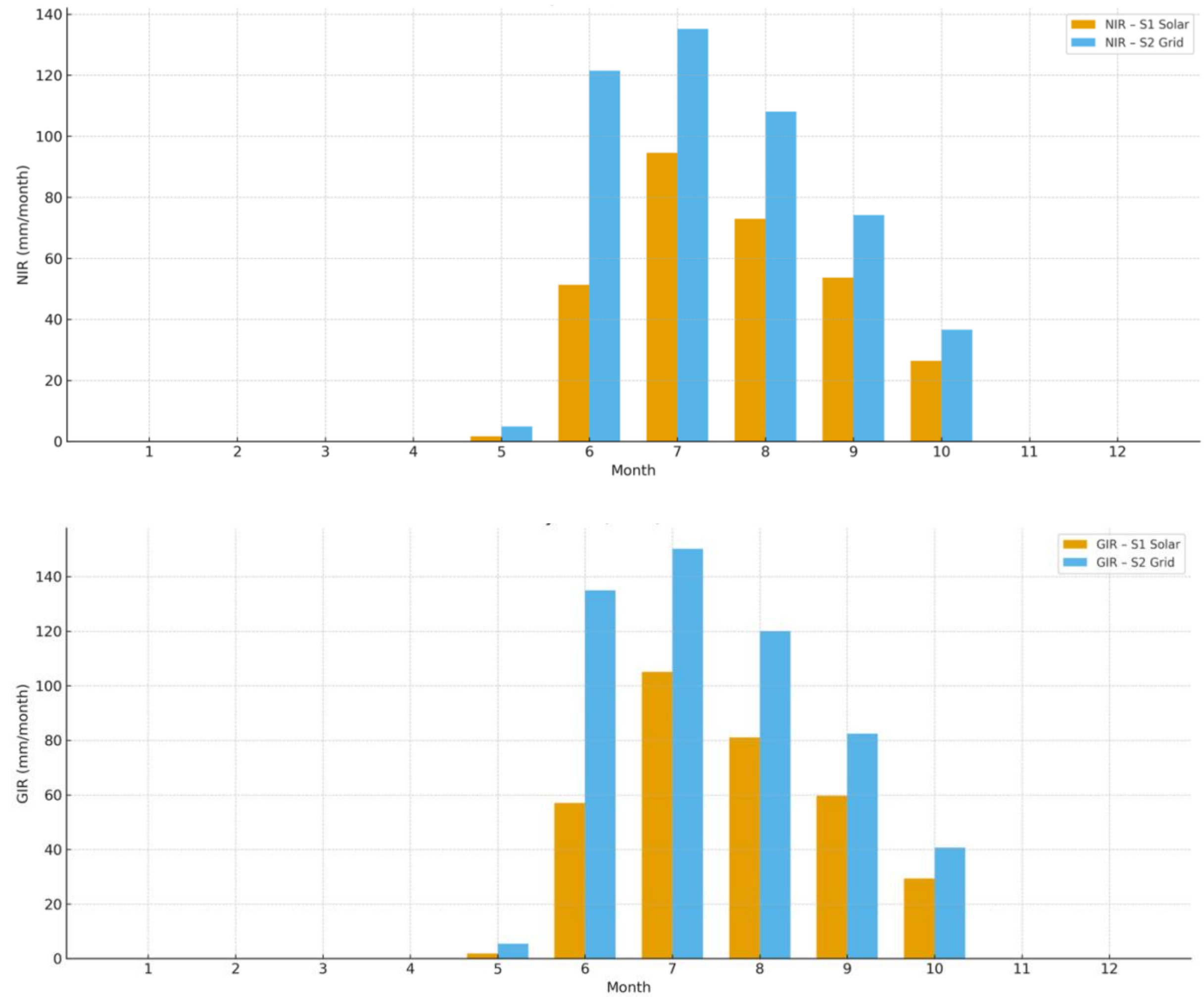

FIGURE 45. MONTHLY NIR AND GIR FOR VINEYARDS IN ISRAEL.

Figure 46 illustrates the **energy-climate dimension of the agrovoltaic system**. The yellow bars represent the solar energy generated each month, while the green bars show the **greenhouse gas (GHG) emissions avoided by substituting grid electricity with on-site solar production**. Solar energy generation is high and almost constant throughout the year, with values close to 140,000 kWh/month, reflecting both the large installed capacity of the system and the high solar resource at the KKL site.

The **avoided GHG emissions (expressed in tons of CO_2-equivalent per month)** follow the same pattern as the energy bars, demonstrating a nearly linear relationship between renewable energy production and emissions reduction. This means that every month the agrovoltaic system offsets a substantial amount of CO_2e that would otherwise be emitted by using conventional grid electricity.

In WEFE terms, this figure shows that the **agrovoltaic solution not only reduces water consumption (**Figure 45) **but also delivers strong climate-mitigation benefits and greater energy independence,** turning the vineyard into an active producer of clean energy.

Figure 47 compares the **water productivity (WP)** of the two scenarios, expressed as kg of grapes produced per cubic meter of water consumed (kg/m³). Both bars are almost identical (≈3.0 kg/m³), with S1 Solar showing a value of 2.994 kg/m³ and S2 Grid 2.997 kg/m³. This indicates that, **despite the differences in irrigation volume, both systems achieve very similar water-use efficiency in terms of yield per unit of water.**

The key interpretation is that the **agrovoltaic system maintains crop productivity while requiring substantially less irrigation water** (as seen in Figure 45). In other words, S1 does not improve water productivity per se (kg/m³ are similar), but it reaches comparable productivity with lower total water input, which is crucial in a water-scarce context. This confirms that the **reduction in evapotranspiration due to shading does not penalize yield at vineyard scale**, and reinforces the idea that agrovoltaic systems can be deployed without compromising the food-production function of the land.

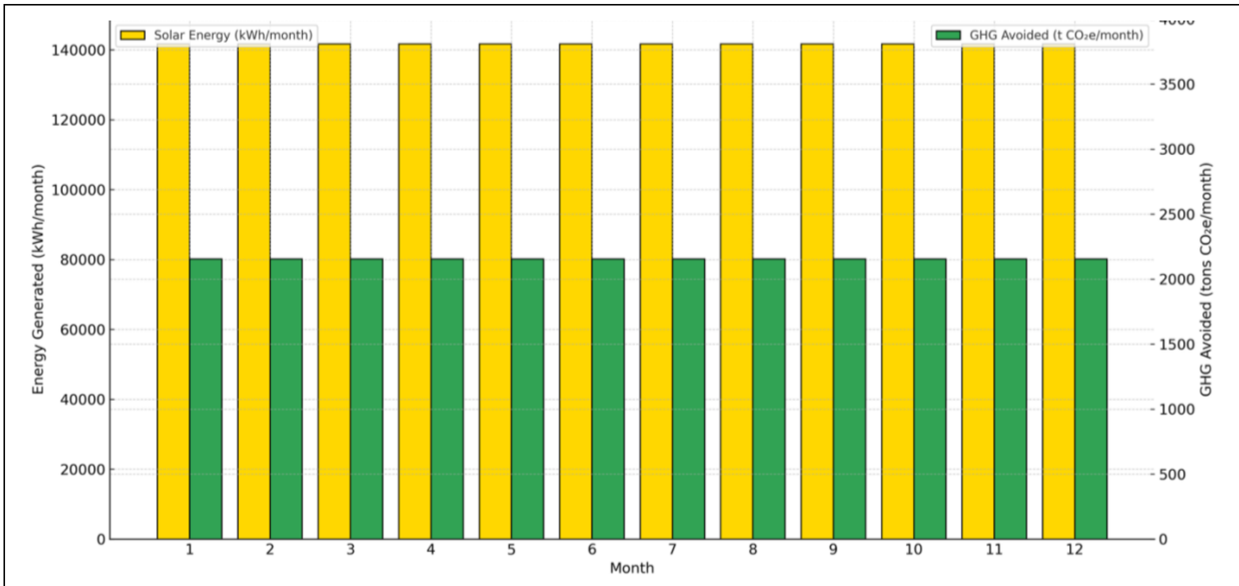

FIGURE 46. MONTHLY SOLAR ENERGY AND GHG AVOIDED FROM ENERGY GENERATED FROM SOLAR PANNELS.

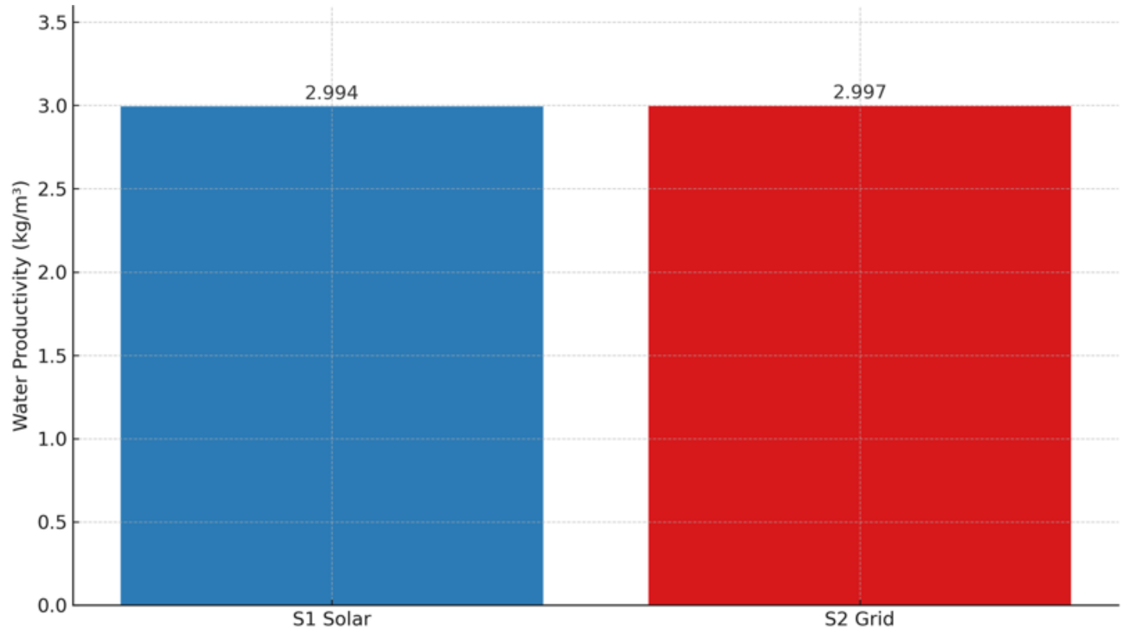

FIGURE 47. WATER PRODUCTIVITY FROM BOTH SCENARIOS, S1 SOLAR AGROVOLTAIC SYSTEM AND S2, CONVENTIONAL CONTROL SYSTEM WITHOUT SOLAR PANNELS.

7.4 AI WEFE Nexus Trade-off Analysis for KKL Demosite

Figure 48 presents a **WEFE Composite Index heatmap** that integrates the performance of both scenarios across **three normalized indicators—WaterEff_GIR, WaterEff_NIR and FoodEff—and a global WEFE_ComIndex**. Each indicator is scaled between 0 and 1, where 1 represents the best performing scenario. For the water-efficiency indicators (WaterEff_GIR and WaterEff_NIR), the agrovoltaic scenario S1 attains medium values of 0.37, while the conventional scenario S2 scores 0, indicating that S1 clearly outperforms S2 in terms of reducing irrigation water use on both net and gross bases.

For food efficiency (FoodEff), S2 achieves the maximum normalized value (1.0), while S1 obtains 0.62. This reflects the fact that the control scenario provides slightly higher yield, or higher productivity under the selected normalization, even though the difference in water productivity is small (Figure 47).

When all three dimensions are combined into the **WEFE_ComIndex, S1 reaches a value of 0.46, higher than the 0.33 obtained for S2.** This means that, when water efficiency and food production are considered simultaneously, the solar agrovoltaic scenario offers a more balanced and sustainable WEFE performance than the grid-based control. The heatmap visually captures this trade-off: S2 maximizes food efficiency at the expense of water performance, while S1 delivers a more integrated solution, improving water and energy-climate outcomes with only a moderate sacrifice in food efficiency.

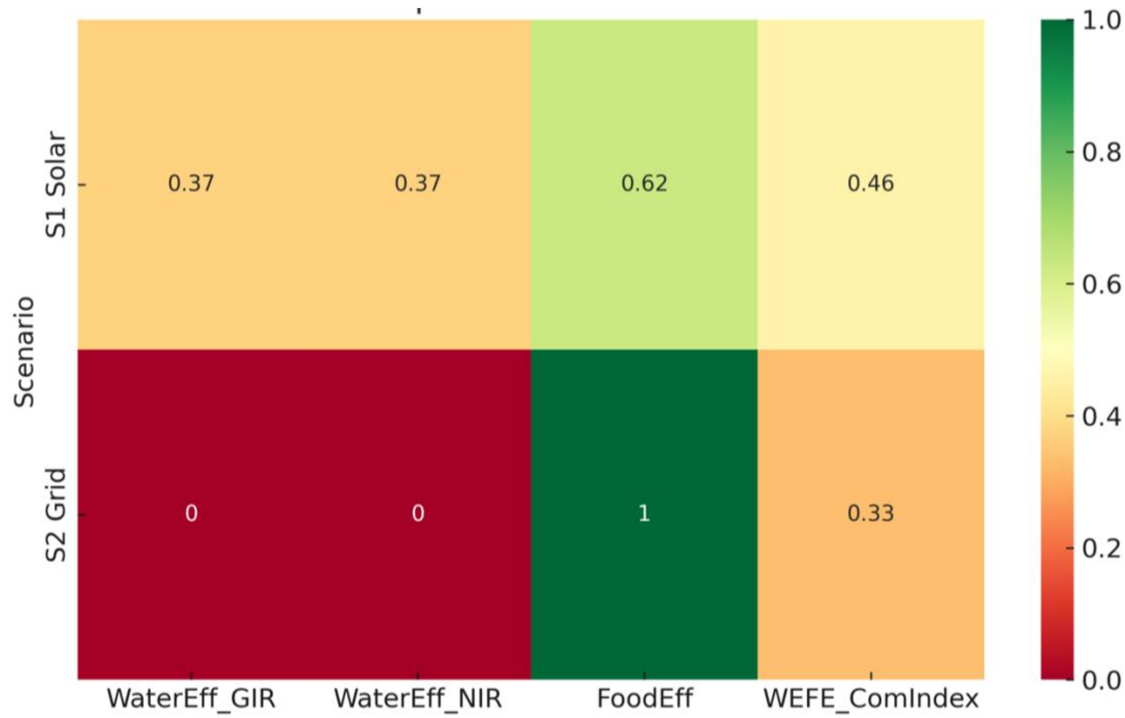

Figure 48. Heatmap from a WEFE Composite index considering scenario s1 (solar agrovoltaic) and S2, control without solar pannels.