



Quantification of ecosystem services flows to Israel

Key findings

- This study compares three watersheds in Iowa, Kansas, and the Ukraine with respect to three ecosystem services (ES) using indices to quantify the trade-offs in ES flows to Israel.
- All three watersheds have a relatively high freshwater provisioning service. The Iowa watershed has a slightly lower erosion regulation service, and the USA watersheds are clearly superior in food provisioning compared to the Ukraine watershed.
- We use normalized ES indices which are unitless values between 0 and 1, enabling us to compare watersheds of different sizes and streamflow quantities.

Motivation

Global trade in crop commodities enables countries with limited water and land resources to maintain food security, but it also makes them reliant on ecosystems abroad. The term ecosystem services (ES) represents the benefits people obtain from ecosystems. ES include food provisioning, freshwater

provisioning, and erosion regulation, among others. This study focuses on these three services that are considered key to maintaining food and water security. It looks at Israel as a case study, focusing on the staple crops wheat, maize, and soybean that are imported to Israel from the USA and Ukraine. Similar to the concept of virtual water or the water footprint, we view ES as virtually imported or the importing country having an ES footprint in the exporting country. The provision of ES varies in different countries and within countries, and some regions can be considered more suitable for the production of certain crops than others. This study looks at crop production within specific watersheds and compares them using a set of ES indices.

Methodology

Over the last few decades, Israel has imported significant quantities of wheat, corn, and soybean from the USA and Ukraine. We compare three watersheds in terms of the ES provided and the global flows of virtual ES to Israel (Koellner et al., 2019). We modeled two watersheds in Iowa and Kansas (USA) and one in Ukraine using the Soil and Water Assessment Tool (SWAT). These watersheds represent a range of production systems, from a relatively low precipitation

climate with wheat and irrigated corn production in western Kansas, to rainfed corn and soybean production in Iowa, and rainfed corn, soybean, and wheat production in Ukraine. The monthly streamflow is used to calculate a freshwater provisioning index based on an environmental flow requirement of 30% of long-term flow. The biomass and yield of the relevant crops are used to calculate the food provisioning index based on the maximum yield across all watersheds. The sediment yield is used to calculate the erosion regulation index based on a maximum tolerable soil loss rate of 5 t/ha per year.

Quantification approach

The Soil and Water Assessment Tool (SWAT; Arnold et al., 1998) is a watershed-scale hydrological model capable of producing outputs that can be used to quantify a large variety of ecosystem services. For this analysis, we used the outputs on streamflow (freshwater provisioning), crop and biomass yield (food provisioning), and sediment yield (erosion regulation) to compare the different watersheds. Each index is normalized to a value of 0 to 1 to enable a direct comparison of the watersheds.

Results

When comparing the three watersheds in terms of freshwater provisioning (Figure 1a), the index is relatively high for all three cases, meaning that in each individual month the streamflow is rarely below the 30% threshold. Figure 1b shows the erosion regulation index, indicating a slight differentiation between the watersheds with Iowa having a slightly lower index. This is likely due to higher precipitation and having only corn-soybean rotation. When we look at the food provisioning index (Figure 1c), Iowa and Kansas stand out significantly over the Ukrainian watershed. This is primarily driven by the lower yields in Ukraine, which means that the USA watersheds are more efficient food producers. Based on

the results for these three services it appears that crop production in the USA is more efficient when all ES are taken into account than in Ukraine. An additional watershed from Brazil will further be included in the analysis, as well as indices for additional ES. A more comprehensive analysis of the trade-offs can also be made by including calculations of energy demand and emissions associated with Israel's crop imports.

Application

An analysis of ES flows will enable policy-makers to identify countries and watersheds that have high ES indices and from which they could import crops while reducing environmental impacts. The concept of virtual ES provides an ad-

ditional lens through which to investigate the reliance of importing countries on ecosystems abroad and identify non-linear trade-offs. Rather than using a simple indicator such as tons per hectare or cubic meters per second, we opted to use an index which is a normalized unitless value between 0 and 1. This enables us to compare watersheds of different sizes and streamflow quantities. On the other hand, indices introduce an extra layer of complexity and therefore uncertainty.

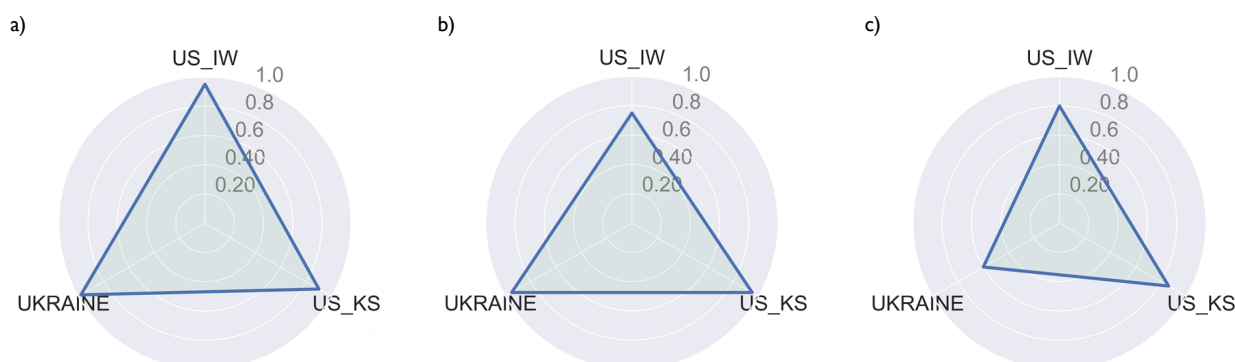


Figure 1: Comparison of a) Freshwater provisioning service, b) Erosion regulation service, c) Food provisioning service for the watersheds in Iowa and Kansas (USA) and Ukraine

References

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