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# Environmental efficiency of olive oil production by small and micro-scale farmers in northern Jordan: Life cycle assessment

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ABSTRACT

Olive groves cover nearly 73% of the total tree-planted agricultural land in Jordan, making olive oil production one of the most important agri-business sectors in the country. Nearly half of the olive trees are planted in the northern region of Jordan where the sector is dominated by small and micro-scale farming practices. Olive farmers rely on traditional production methods with little mechanization or chemicals use. To better understand the environmental impact of the industry on the environment and to compare it to other olive oil production practices in the Mediterranean region; life cycle assessment study was carried out. Five environmental impact categories relevant in the context of Jordan were assessed: acidification (AP); particulate matter formation ($PM_{10}$); human toxicity (HTP); climate change ($GWP_{100}$) and agricultural land occupation (AGLO). The study revealed that olive oil production in the northern region of Jordan is environmentally efficient when compared to large scale production practices common in other Mediterranean olive oil producing countries. On average, the production of 1 kg of olive oil in northern Jordan contributed: 0.57 kg $CO_{2eq}$ to $GWP_{100}$; $11.8 \times 10^{-3}$ kg $SO_{2eq}$ to AP; $5.99 \times 10^{-3}$ kg $PM_{10eq}$; 0.77 kg 1,4-$DB_{eq}$ to HTP and 22.54 $m^2$*a to AGLO. Uncertainty due to variation at farm level practices affected all impact categories. Monte Carlo analysis showed that $GWP_{100}$ was the most sensitive to variation at farm level practices while HTP was the least sensitive. Nevertheless, despite the high level of uncertainty, Monte Carlo analysis suggested that the $GWP_{100}$ was <1.55 kg $CO_{2eq}$, 95% of the time. The efficiency of the Jordanian small and micro-olive oil production sector is due to its low level of water, energy and chemical usage in the agriculture phase and the efficient use of waste material for energy production to displace fossil fuel. Soil management practices are the major contributor of the environmental impacts. The system may be further improved if farmers adopt low tillage or no-tillage practices.



## 1. Introduction

The olive industry is an important sector of Jordan's agri-business. Jordan is the world's second exporter of table olives and the eighth exporter of olive oil (ILO, 2014). Olive groves are estimated to cover 130 thousand hectares of Jordanian agricultural land which is nearly 73% of the total area planted with fruit trees in Jordan. The industry has been expanding at a rapid rate over the past two decades, due to higher local and export demand. The area cultivated with olive trees has doubled between 1991 and 2014 (National Center for Agricultural Research (NCARE), 2015). The Department of Statistics estimated that in 2014, the olive oil production in Jordan reached 22,835 Mg which is 20% more than that of the 2013 season. More than half of the olive oil came from the northern governorates. Despite of the economic benefits, the increase in production also brings with it significant environmental challenges; for example, olive mill wastewater and solid waste have recently been associated with the contamination of drinking water sources (springs) in Ajloun (Namrouqa, 2012).

The north west region of Jordan which is comprised of Irbid, Ajloun and Jerash governorates (Fig. 1) accounts for nearly 32% of total olive oil production in Jordan (ILO, 2014). Olive trees are mainly rain fed. Despite the economic and nutritional value of olive oil, the industry consumes significant amounts of resources and generates large quantities of solid and liquid waste (Tsarouhas et al., 2015; El Hanandeh, 2015a). Olive farming in Irbid is dominated by small and micro-scale family based independent farmers. This poses a challenge to the economic and environmental sustainability of the industry because farmers are unable to take advantage of economies of scale. On the other hand, being small scale farmers necessitates shared use of resources such as farming equipment which increases their utilization rate; thus efficient use of machinery. Therefore, it is important to assess the environmental impacts of the industry using comprehensive methodology.

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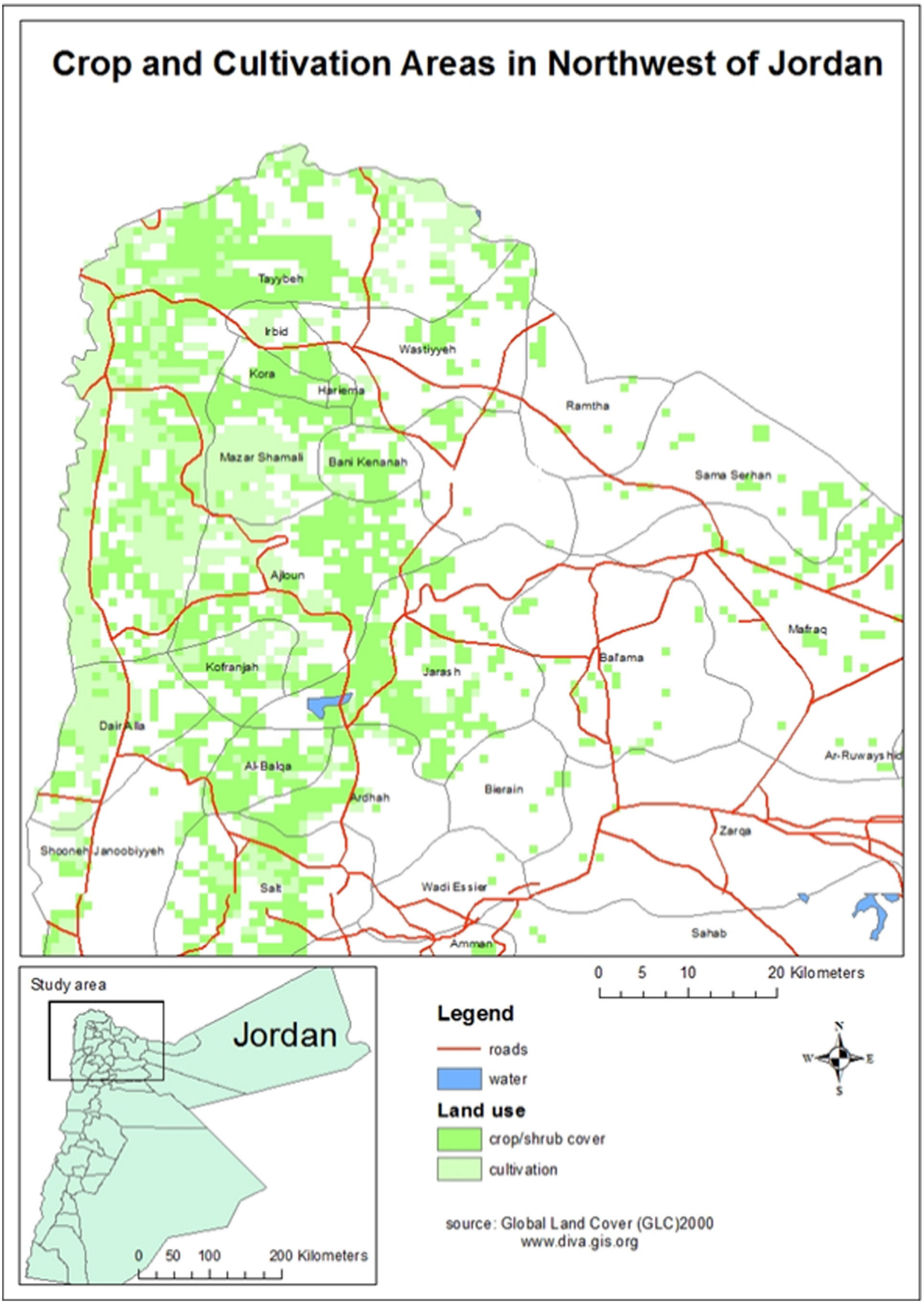


**Fig. 1.** Location and detail of the study area in northwest Jordan.