BENAKI PHYTOPATHOLOGICAL INSTITUTE

The carbon footprint of three olive orchards under different agricultural practices in the Mediterranean Region

LABORATORY OF NON PARASITIC DISEASES

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Introduction

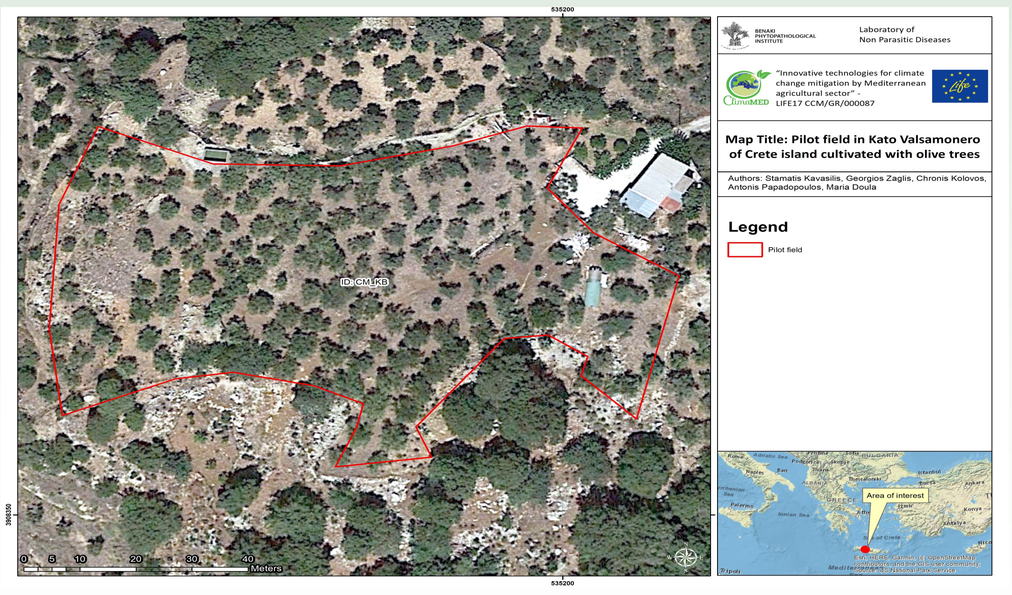
The Mediterranean countries are considered vulnerable to climate change and are expected to be more severely affected by climate change than the other Central and Northern European countries, whose agricultural sector could, in some extent, be benefitted from temperature increase and rainfall decrease. The Mediterranean agricultural sector has to be prepared to address severe decrease in water resources availability, unfavorable temperatures for plant cultivation, decrease in yields and in farmers' incomes. Therefore, it is necessary to develop strategies for climate impacts mitigation as well as practices for adapting to the new climatic conditions.

The first step for this is the recording and assessment of the current agricultural practices that are considered unsustainable and sources of Greenhouse Gas (GHG) emissions. Although these practices are known to policy makers and also to many farmers, their translation into CO_2 units may be a more valuable tool for identifying the major GHG emission sources and therefore, to prioritize the targets for emissions decrease; and also, a convincing method to make farmers understand what they do wrong.

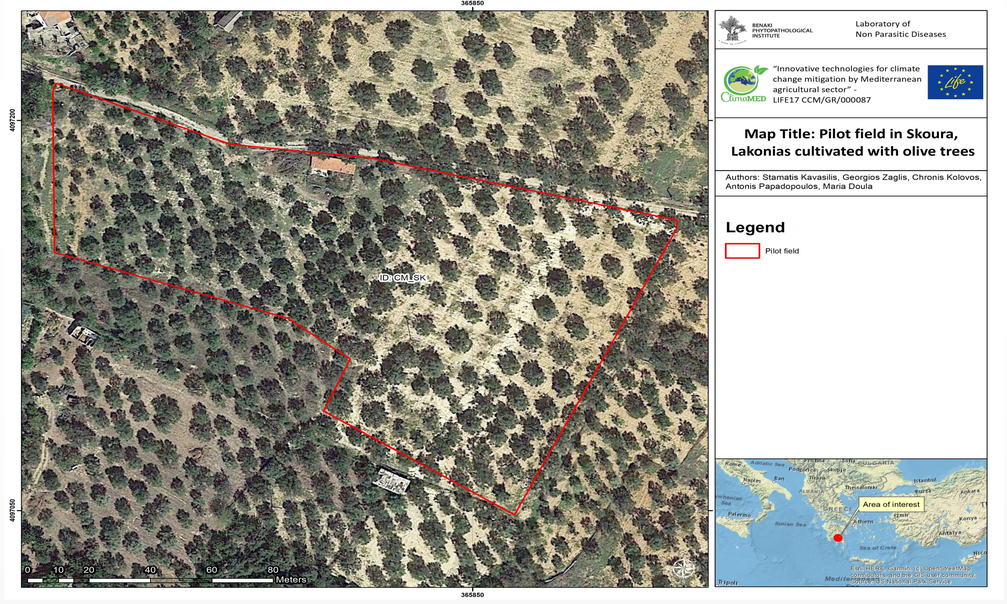
Study Area and Methodology

- **Study area**

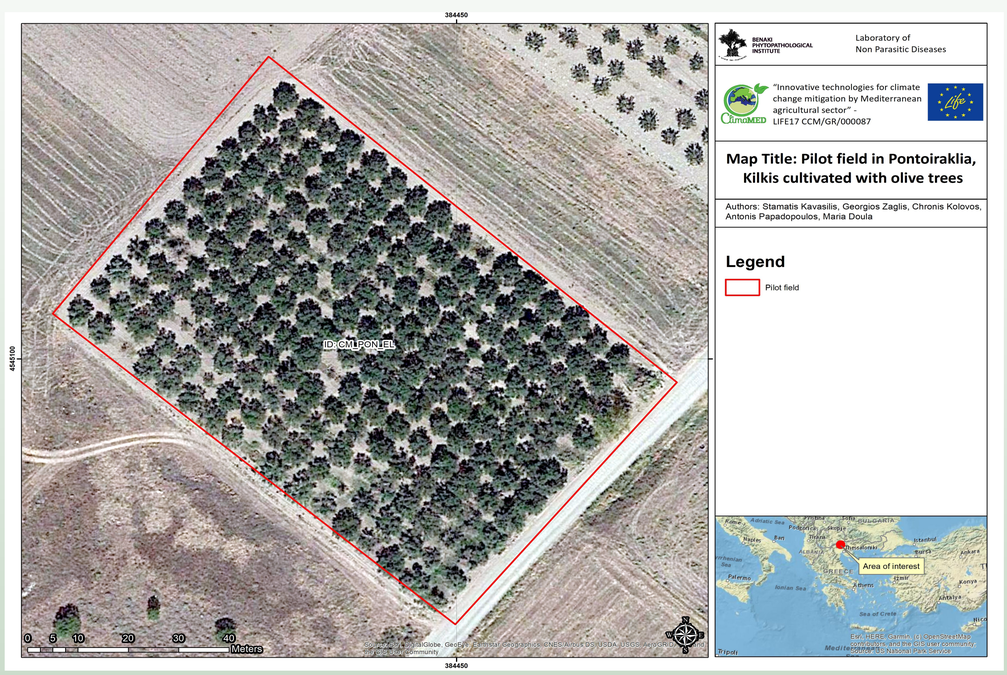
Three pilot fields of olive cultivation located in south, central and northern Greece were studied in terms of unsustainable practices, implemented by the farmers, and are considered GHG sources. The olive orchard in Crete in southern Greece is under organic cultivation, combined with livestock farming, while the two other orchards, in Skoura Lakonias, Peloponnese and in Kilkis Northern Greece, are under conventional agriculture (mineral fertilization, pesticides, etc.).



Map 1 Pilot field in Kato Valsamonero, Crete Island, Southern Greece



Map 2 Pilot field in Lakonia, Peloponnese, Central Greece



Map 3 Pilot field in Kilkis, Northern Greece

- **Methodology**

The IPCC guidelines (2006, 2019) were applied for the estimation of the carbon footprint of the orchards for three consecutive years 2018, 2019, and 2020 by collecting field data and estimating CO_2, CH_4 and N_2O emissions.

Carbon footprint was calculated by using IPCC (2006, 2019) guidelines as regard:

- fertilization (use of chemical fertilizers and organic materials);
- fuels use (diesel and gasoline) for the field machinery and irrigation;
- livestock farming;
- electricity consumption and
- burning agricultural residues.

e.g. for fertilization the N_2O emissions considered for the development of the methodology include, direct and indirect N_2O emissions. The equation for the total direct N2O emission is:

$$N_2O_{Direct}\text{–}N = N_2O\text{–}N_{inputs} + N_2O\text{–}N_{OS} + N_2O\text{–}N_{PRP\text{-}m}$$

For the calculation, Tier 2 emission factors were used for the main emission categories, as these were defined by the Greek State (Annual Inventory of Greece, 2019), while emission factors of Tier 1 of IPCC (2016, 2019) guidelines were used for the other categories. Emission of Scope 3 category, i.e., fuels from rented machinery, are not considered in this study. All pilot fields belong to the Cropland remaining Cropland category.

Results—Discussion

From the information gathered, it was found that there is a significant heterogeneity in the practices that the farmers apply for the same type of cultivation. This is largely due to the lack of strategic planning in agriculture, both by climate area and type of cultivation. The result is the overuse of natural resources and energy and also soil and environment degradation, as producers apply practices based on their experience and knowledge, which, however, lack scientific basis.

Results show that organic agriculture combined with livestock farming, which is located in the pilot field in Crete (Southern Greece), apart from other benefits, as for example increased soil organic matter, i.e. ca 6,0%, caused less GHG emissions in comparison to the fields under conventional practices for the three years straight.

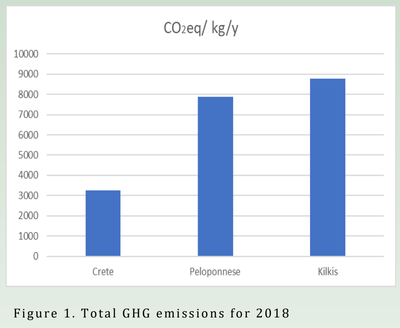


Figure 1. Total GHG emissions for 2018

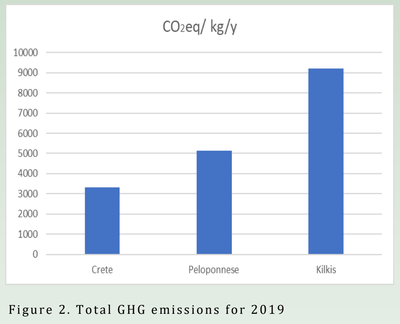


Figure 2. Total GHG emissions for 2019

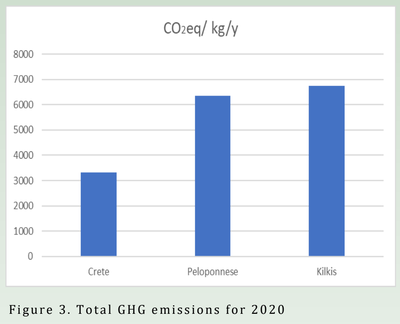


Figure 3. Total GHG emissions for 2020

On the other hand, the normalization of the numbers as per annual yield (Figs. 4-6) reveals that conventional farming emits the smallest amount of GHGs. This is particular important when comparing conventional with organic farming and is mainly due to the decreased yields in the latter case and also the presence of animals and emissions of CH_4 due to enteric fermentation and manure management. In the case of Crete, no particular manure management plan is implemented, which leads to higher CH_4 emissions. Nevertheless, the benefit of the very high soil organic matter in the organic farm, makes this system more environmentally sustainable. In Northern Greece, in all the cases, the GHGs emissions are the most and this is explained by the overuse of the fuels to irrigate the olive cultivation.

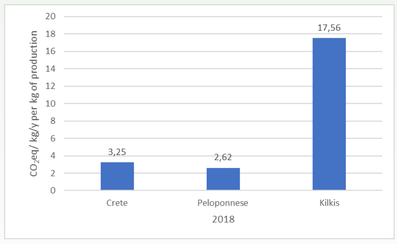


Figure 4. Emissions per kg of production in 2018

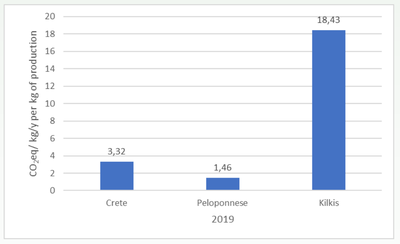


Figure 5. Emissions per kg of production in 2019

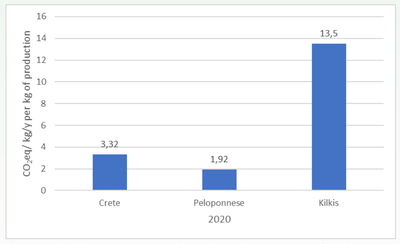


Figure 6. Emissions per kg of production in 2020

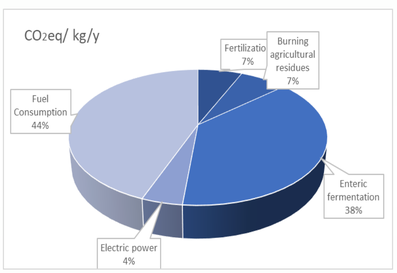


Figure 7. GHGs emissions contribution for 2018

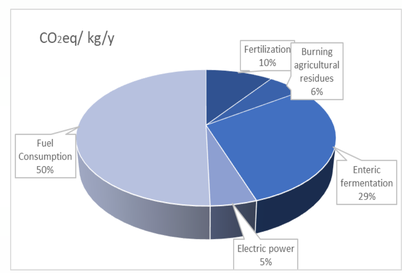


Figure 8. GHGs emissions contribution for 2019

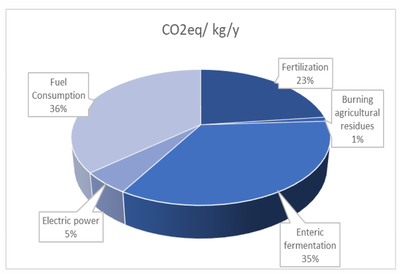


Figure 9. GHGs emissions contribution for 2020

Finally, for the total emissions per year of all pilot fields (Figure 10), it can be easily observed that over time farmers have a tendency to reduce greenhouse gas emissions by changing environmentally harmful agricultural practices to more rational and sustainable ones, after following the suggestions of our lab, e.g. overuse in mineral fertilization and energy etc.

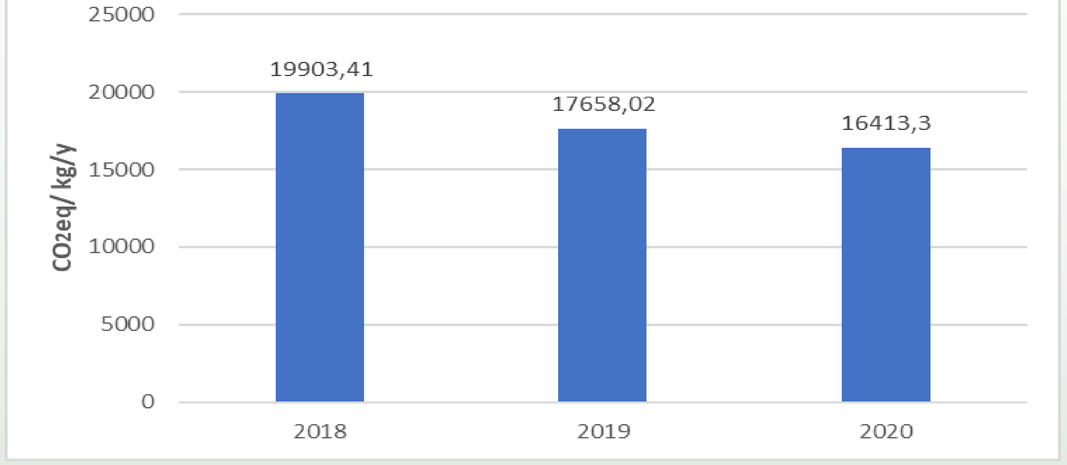


Figure 10. Total emissions per year for all pilot fields

Conclusions

- Practices that were found as major contributors to the emissions are machinery use (i.e., fuels), nitrogen fertilizers, and burning of agricultural residues. Motivating farmers to implement sustainable practices will lead to reduction of GHGs emissions from agriculture but also to the conservation of natural resources, avoiding energy overuse, and protecting the agricultural environment.
- Compared to conventional agriculture, organic farming has shown the way to a lower carbon footprint in agricultural sector, and under the threat of climate change, there is an urgent need for the farmers to adopt the less harmful agricultural practices.

Acknowledgment

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