# Applying a resource Nexus analysis to quantify synergies and trade-offs in the agricultural sector and reveal implications of a legume production shift

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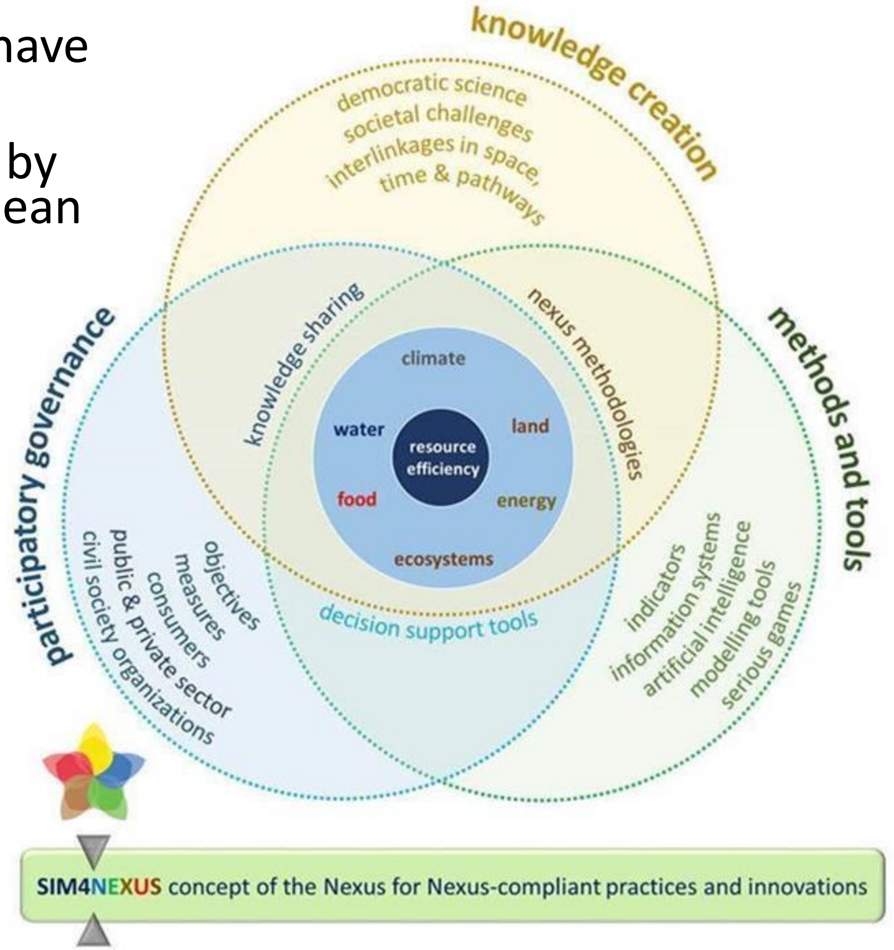
# introduction- What is the Nexus?

## Resources Nexus

- Resources systems are interdependent
- Multiple and complex mechanisms describe their interrelations
- These interrelations are distinguished in synergies and trade-offs
- The Nexus is a dynamic system: A change in one of the components causes domino effects in all
- The Nexus approach facilitates a holistic approach and integrated management of resources

# Nexus approaches

- Many alternative nexus approaches have been introduced
- The well-established Water-Energy-Food nexus
- Soil, Land, Biodiversity, Ecosystems, Health, Climate, etc. have also been interlinked through different approaches
- WEFCL is the five-component nexus approach introduced by the SIM4NEXUS EU Project, in RBD, Local, National, European and Global scale




SIM4NEXUS

for more information visit
[www.sim4nexus.eu](http://www.sim4nexus.eu)

# our methodology

## case study

- application of a simplified SIM4NEXUS scheme in farm level
- October 2019- September 2020
- case study: an agricultural cooperative in Thessaly plain, Greece
- over 20,000 stremmas of cereals, cotton, legume and energy crops
- drip irrigation systems

## steps

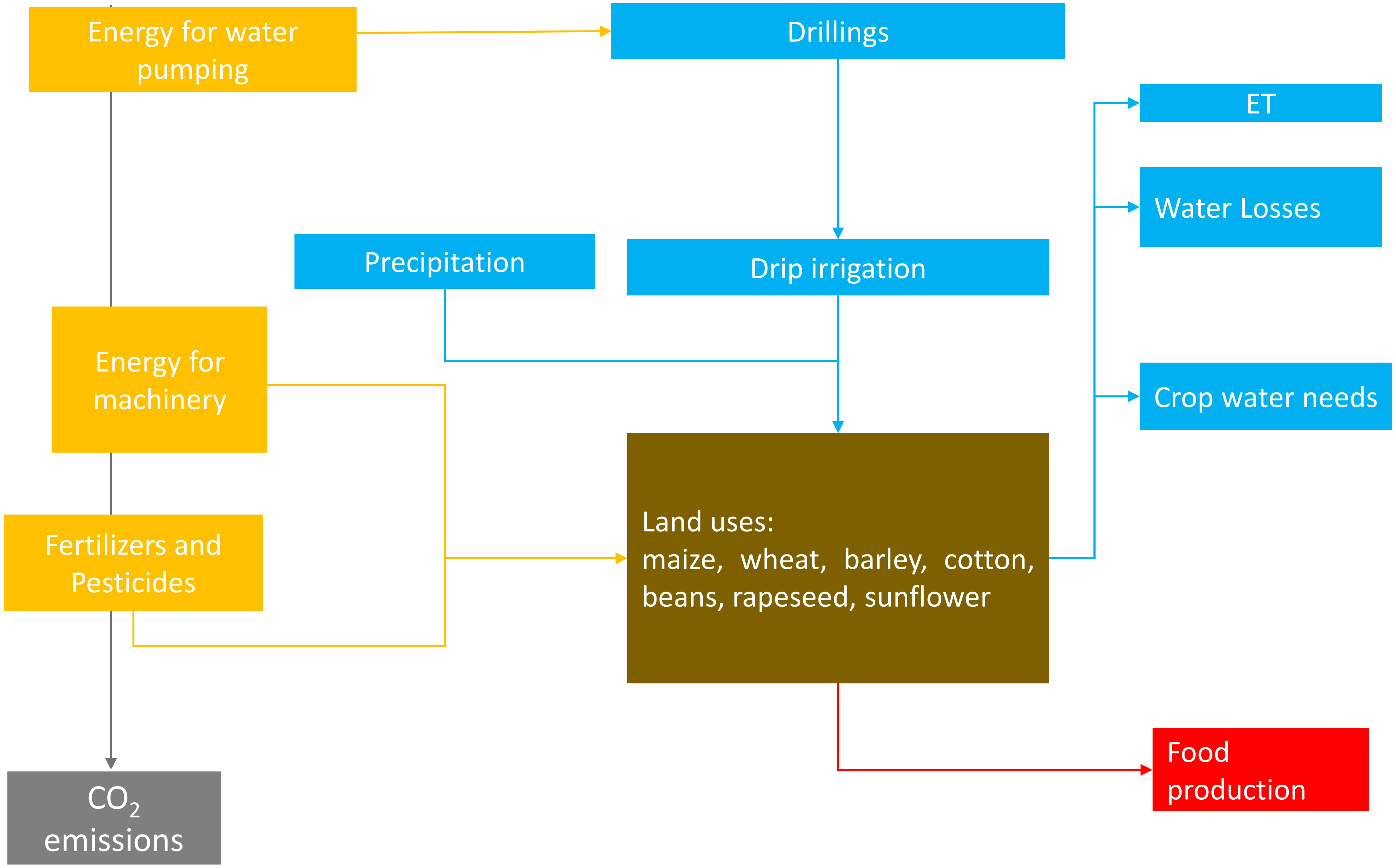
- conceptual model
- identification of interlinkages
- definition of equations
- data collection
- assessment of scenarios
- conclusions

ΘΕΣ γη

συνεταιρισμός αγροτών Θεσσαλίας

# Conceptual model

Co-designed with the cooperative



# data sources

agricultural cooperative

- fertilizers and pesticides use
- timeline for all agricultural activities
- type of machinery
- irrigation and drilling specifications
- land uses
- pumping energy
- aquifer level

The Nexus_SDM data base for water district of Thessaly (GR08)

- water demand needs
- evapotranspiration
- losses

EPA and literature for functions and parameters relevant to energy, carbon and water footprints and drip irrigation system specifications

Hellenic National Meteorological Service

- precipitation

Hellenic Statistical Authority

- food production

# water crop demand – land use

crop demands / stremma

Sim4Nexus database

Nexus_SDM

Laspidou et al, 2020

| | Maize | Wheat | Barley | Rapeseed | Beans | Cotton | Sunflower |
|---|---|---|---|---|---|---|---|
| JAN | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| FEB | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MAR | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| APR | 14 | 0 | 0 | 19 | 0 | 74 | 37 |
| MAY | 39 | 0 | 0 | 69 | 0 | 99 | 136 |
| JUN | 188 | 0 | 0 | 114 | 0 | 112 | 223 |
| JUL | 235 | 0 | 0 | 48 | 69 | 121 | 93 |
| AUG | 71 | 0 | 0 | 0 | 95 | 115 | 0 |
| SEP | 0 | 0 | 0 | 0 | 128 | 93 | 0 |
| OCT | 0 | 0 | 0 | 0 | 120 | 0 | 0 |
| NOV | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| DEC | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

crop demands

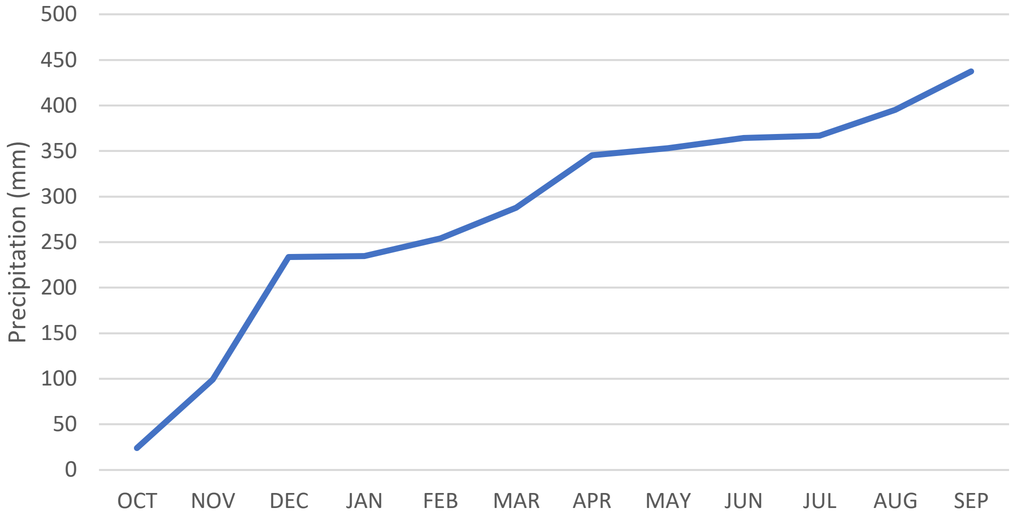
| | Maize | Wheat | Barley | Rapeseed | Beans | Cotton | Sunflower |
|---|---|---|---|---|---|---|---|
| JAN | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| FEB | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MAR | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| APR | 13.750 | 0 | 0 | 9.397 | 0 | 185.578 | 29.328 |
| MAY | 38.718 | 0 | 0 | 34.738 | 0 | 246.734 | 108.411 |
| JUN | 188.066 | 0 | 0 | 57.088 | 0 | 280.476 | 178.161 |
| JUL | 235.119 | 0 | 0 | 23.857 | 34.290 | 301.564 | 74.454 |
| AUG | 71.388 | 0 | 0 | 0 | 47.596 | 286.802 | 0 |
| SEP | 0 | 0 | 0 | 0 | 64.092 | 231.972 | 0 |
| OCT | 0 | 0 | 0 | 0 | 59.878 | 0 | 0 |
| NOV | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| DEC | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

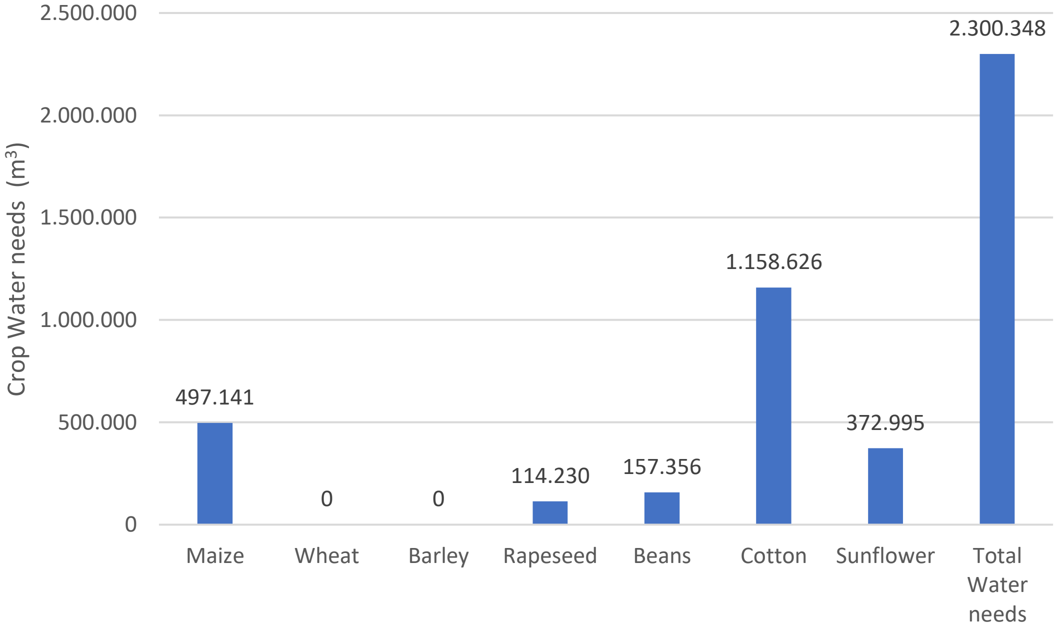
# water irrigation demand-land use

- precipitation

Hellenic National Meteorological Service

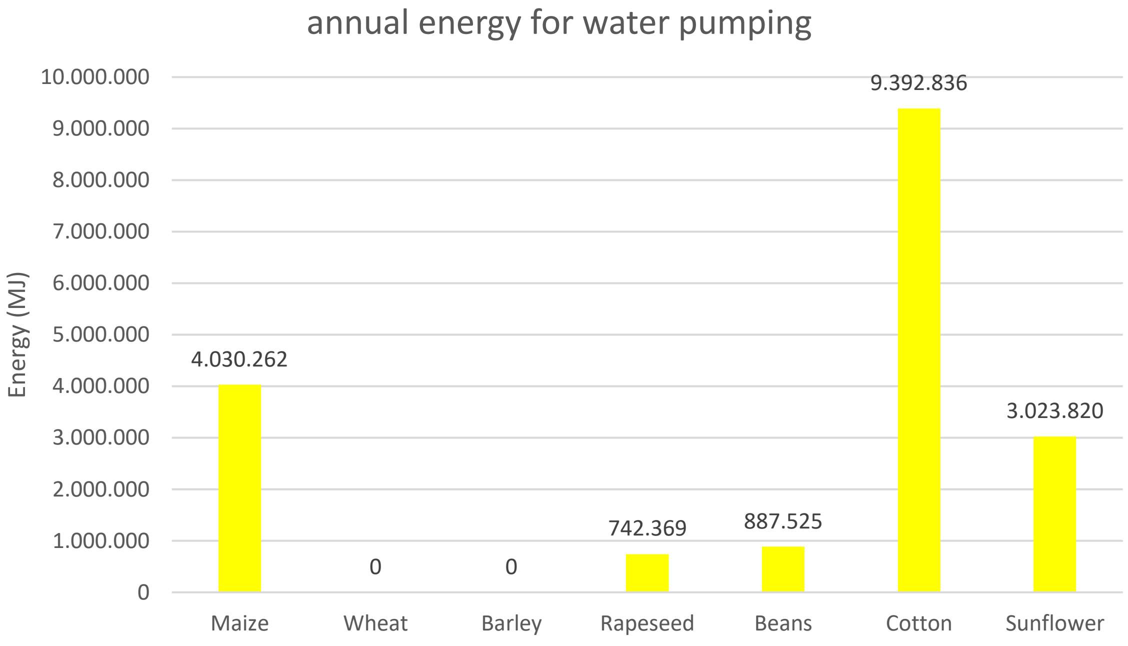
- estimation of water needs by extracting precipitation



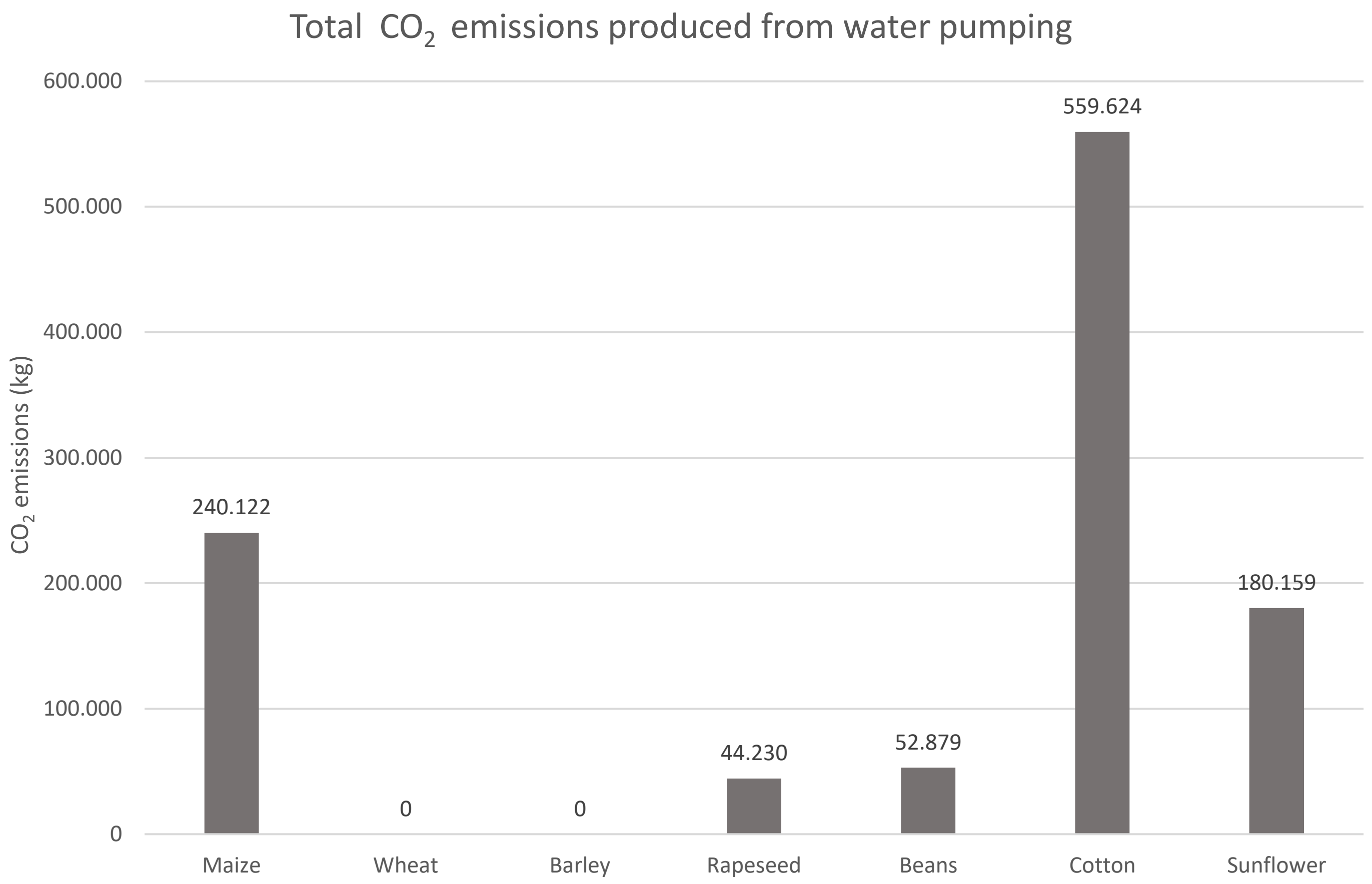



# energy demand for water pumping

- no tanks in the irrigation system
- drip irrigation system specifications
- flowrate to cover crop needs
- pumping duration to meet the needed water volumes per day
- energy demand to pump from aquifer level at -150m for the estimated flowrates and duration



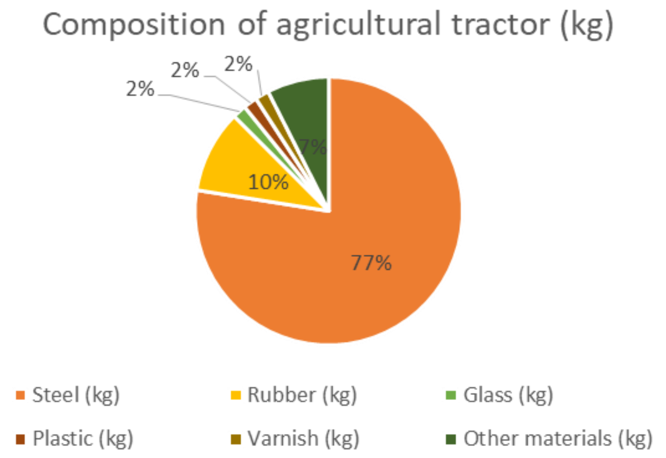
# $CO_2$ emissions for water pumping




Environmental Protection Agency:

1 MJ produces 0,0595 kg $CO_2$

# energy for machinery-land use



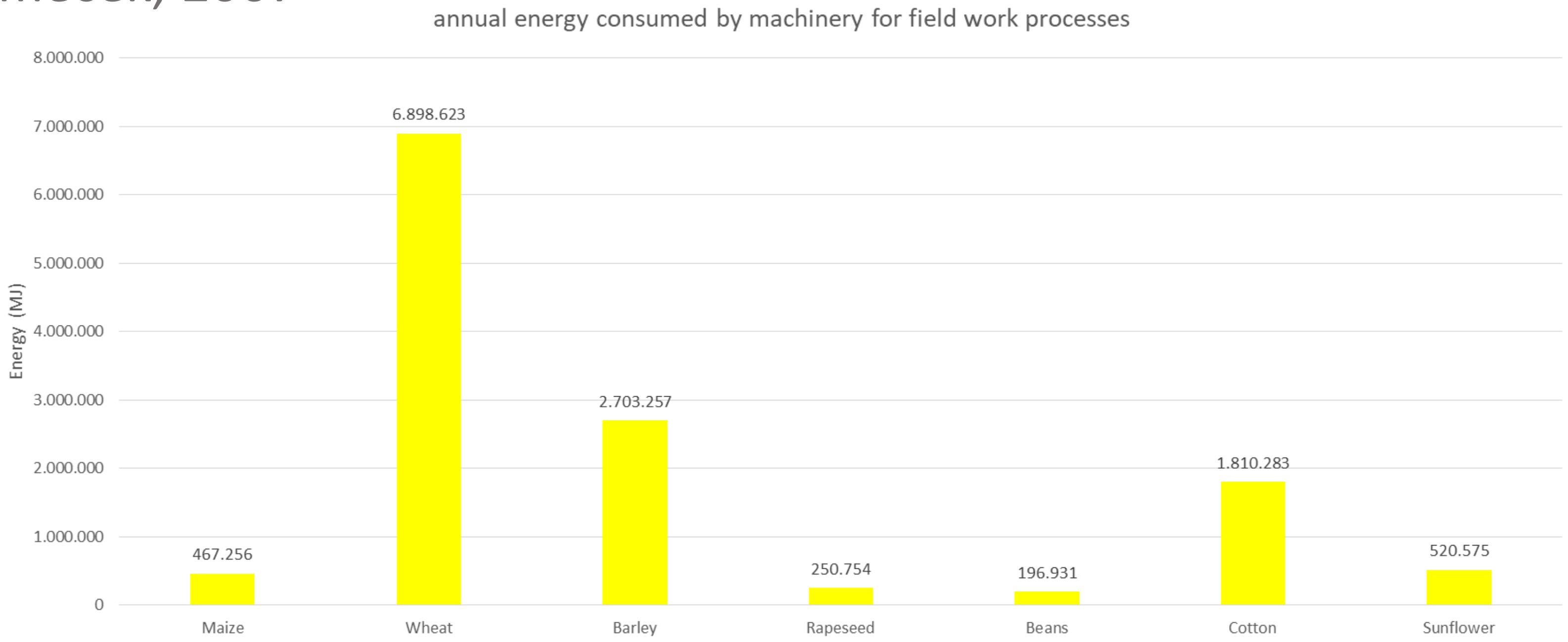

- Energy for the life cycle of the machinery according to existing inventories for the cooperative machinery specifications

Nemecek, 2007; Mantoam, 2016; Tsatsarelis, 1991

| Phases of the Life Cycle of tractors | Total energy consumed per phase (MJ) |
|---|---|
| Assembly | 187.100 |
| Repair and maintanance | 102.905 |
| Disassembly | 1.810 |

- Energy for the machinery operation

R.Grisso, 2004; M. Fischer, 2009; Nemecek, 2007



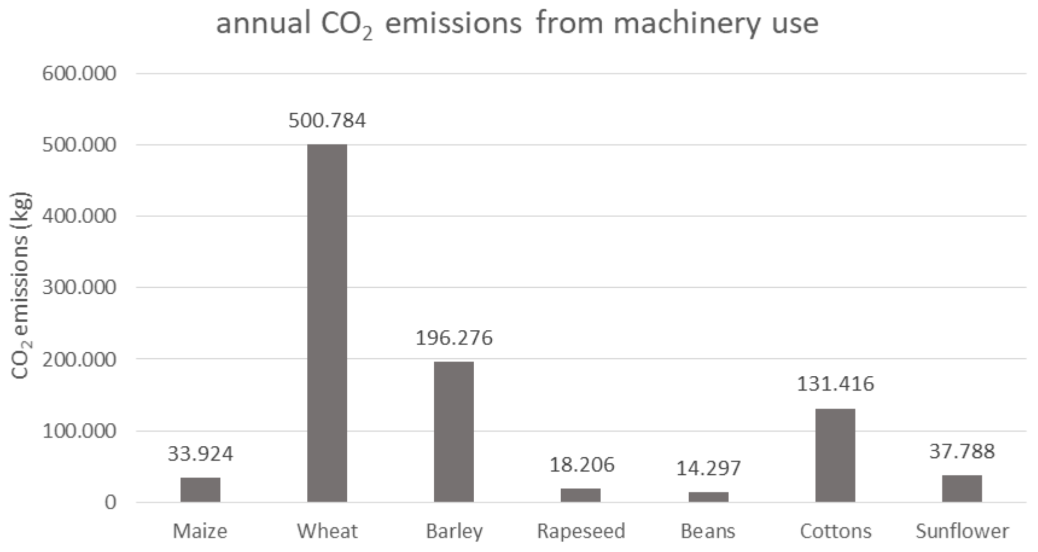
# $CO_2$ emissions from machinery – land use

- emissions for the life cycle of the machinery: 9000 kg $CO_2$

Nemecek, 2007; Mantoam, 2016;

- emissions for the machinery operation

EPA



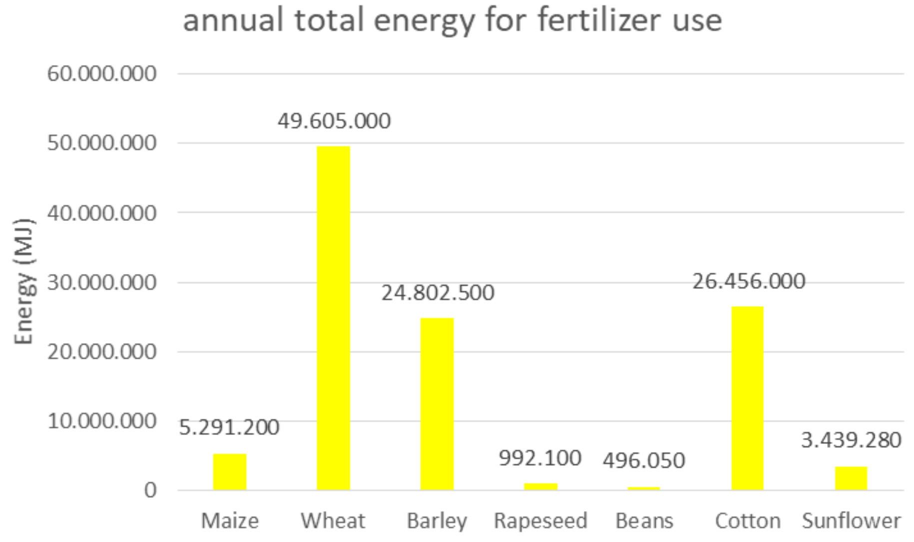
# energy for fertilizers and pesticides - land use

nitrates and urea

cooperative data

energy consumption: 66,4 MJ/kg

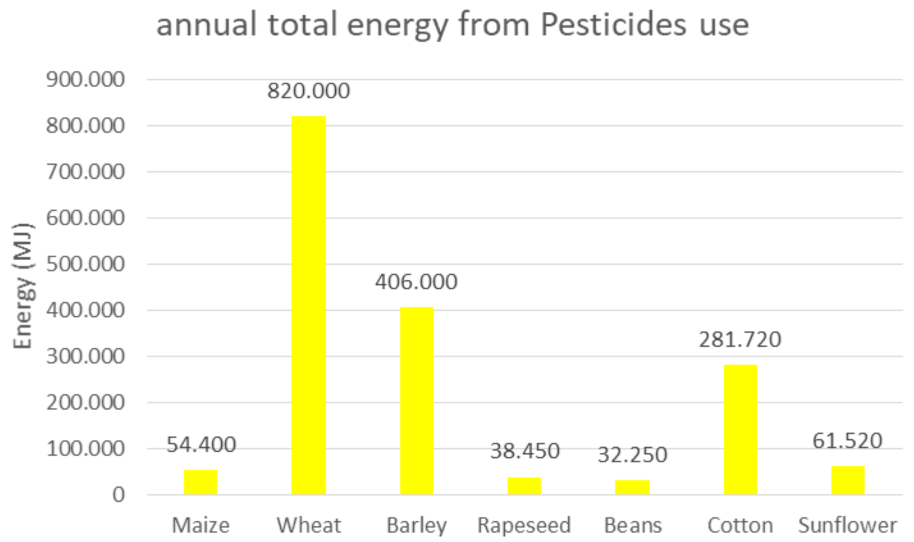
G. Unakitan, 2010



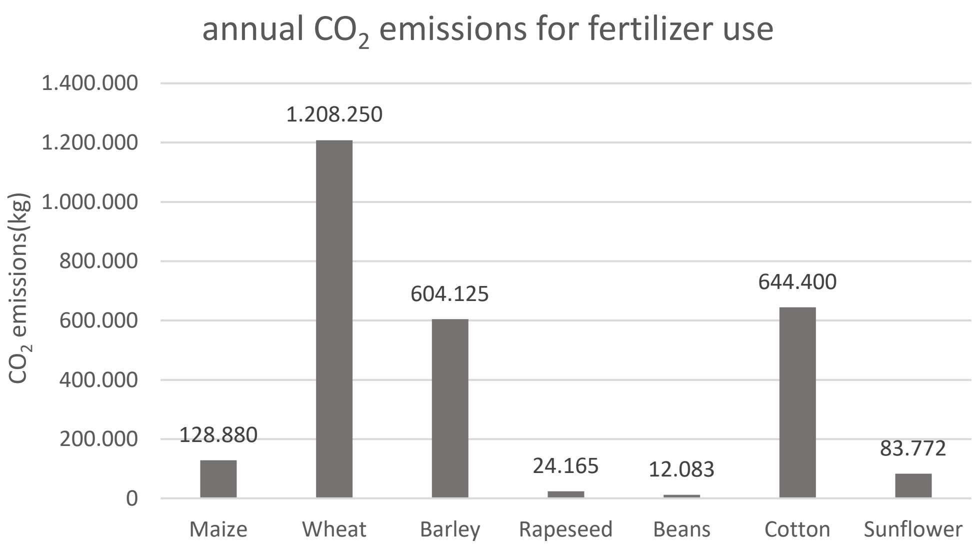

pesticides

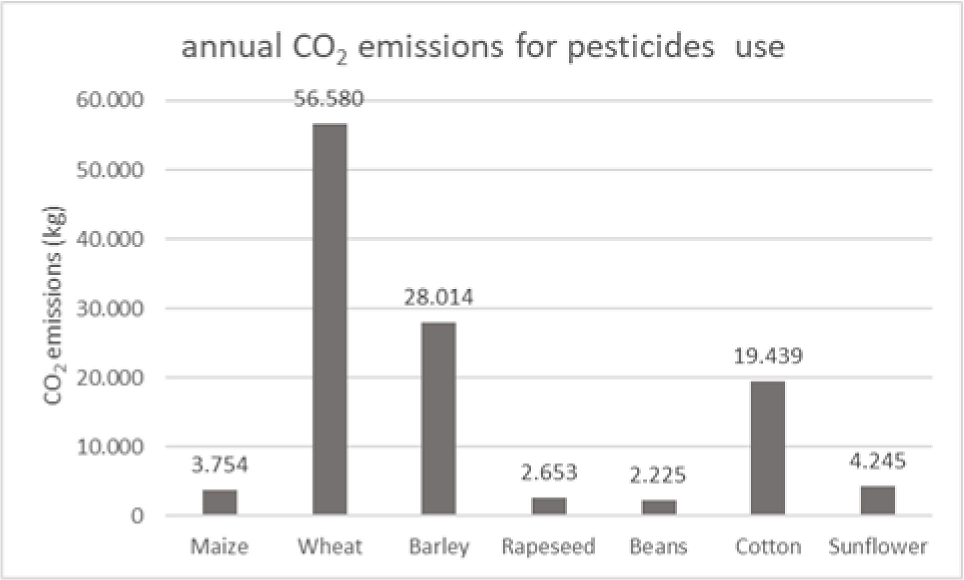
cooperative data

Audsley et al., 2009



# $CO_2$ emissions from fertilizers & pesticides – land use

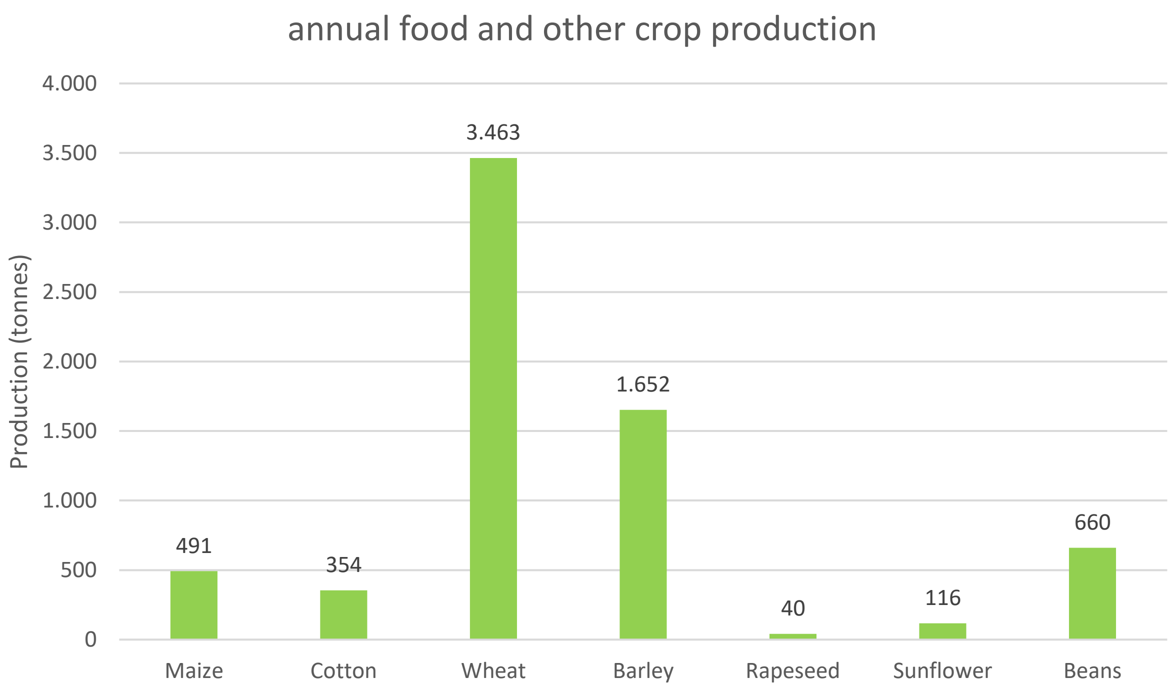


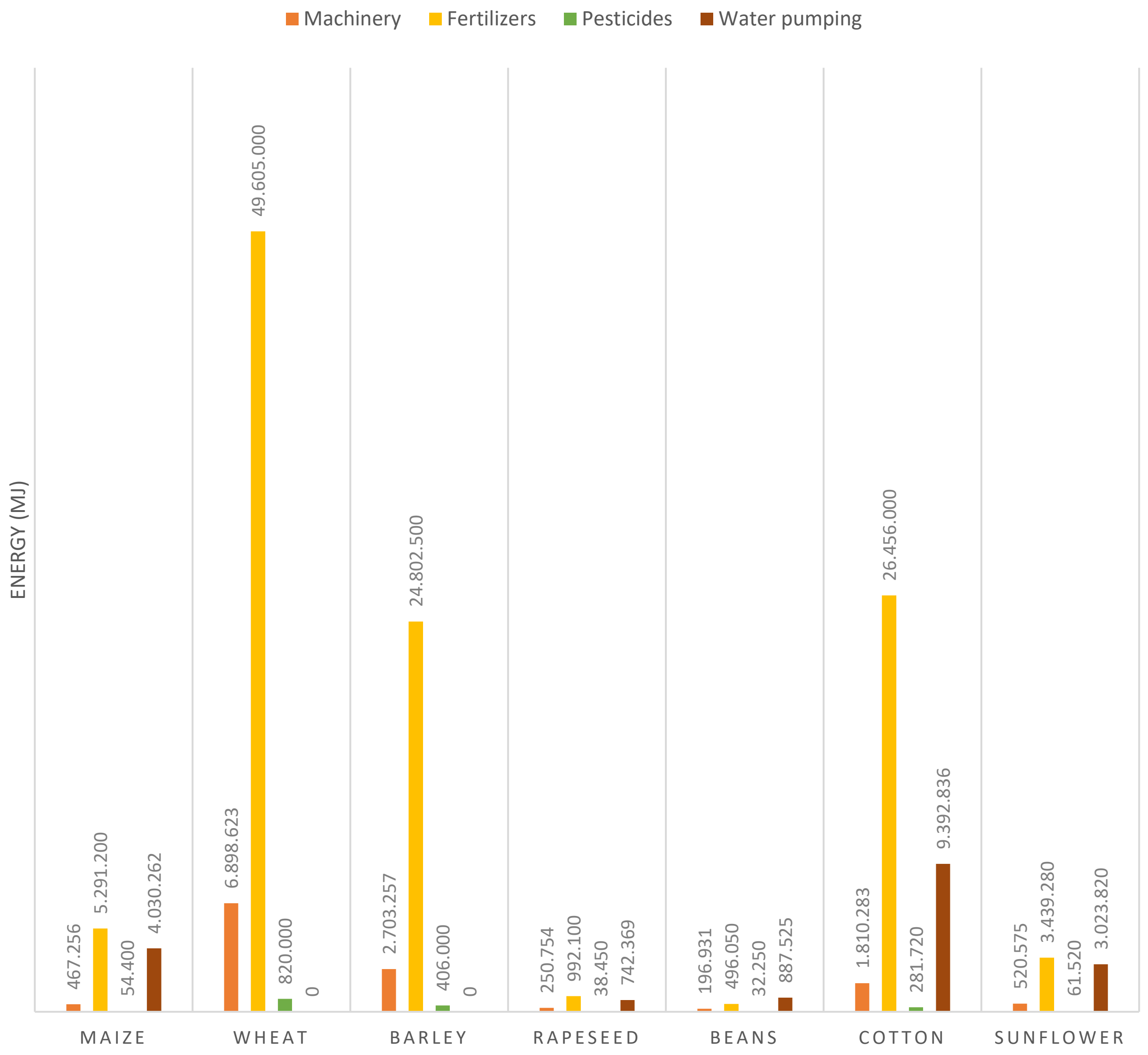
# land use – food production and other crop production

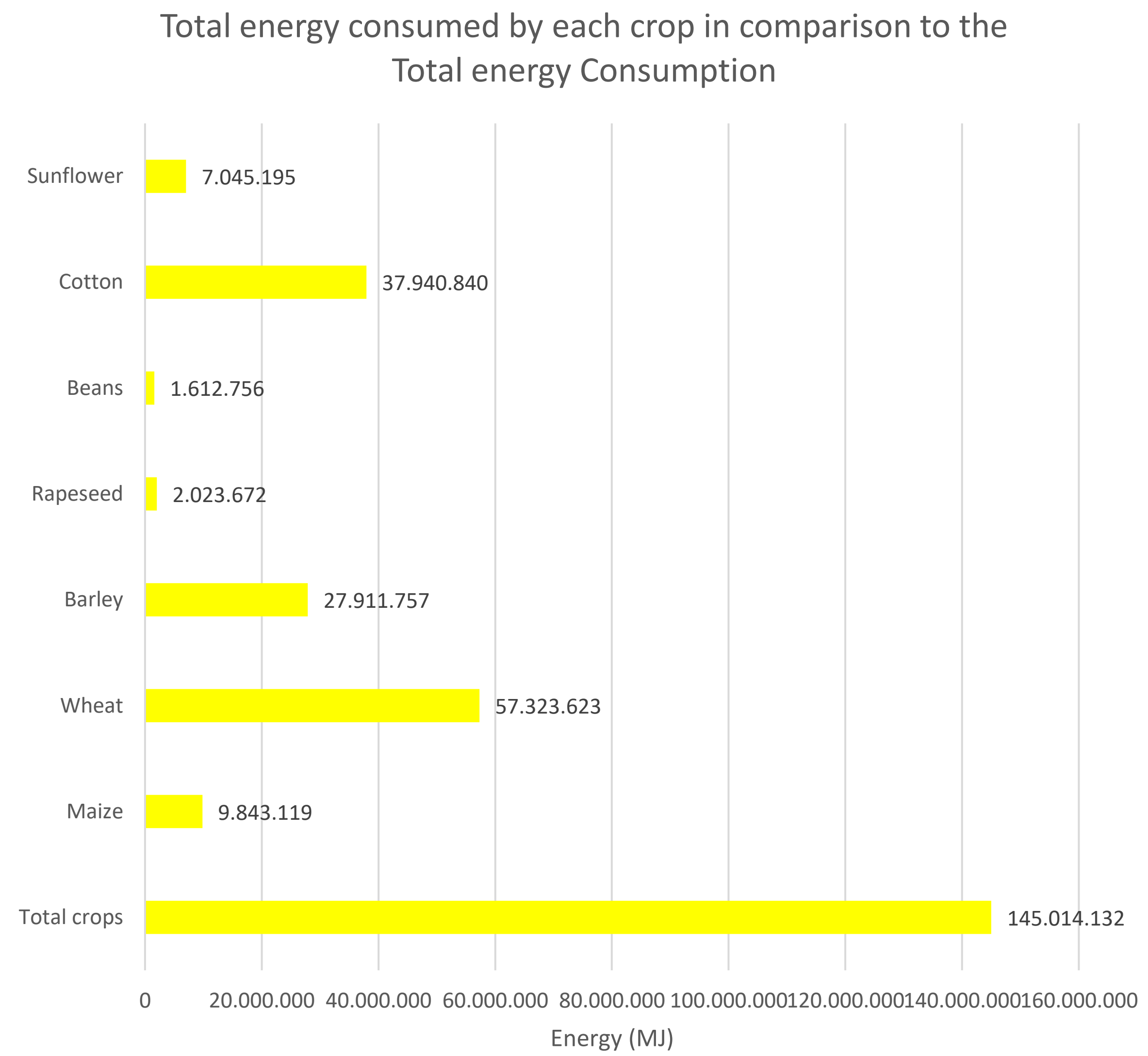
food production estimated according to ELSTAT, 2018 production yields for Thessaly

| THESSALY DISTRICT | | | |
|---|---|---|---|
| Crop | Area (stremmas) | Production (metr | Mean Production (metric tonnes/stremma |
| Maize | 233576 | 286838 | 1,228028565 |
| Cotton | 867465 | 307360 | 0,354319771 |
| Wheat | 873846 | 302595 | 0,34627955 |
| Barley | 329218 | 108793 | 0,330458845 |
| Rapeseed | 15387 | 3082 | 0,200298954 |
| Sunflower | 9107 | 3302 | 0,362578237 |
| Beans | 8082 | 1578 | 0,195248701 |

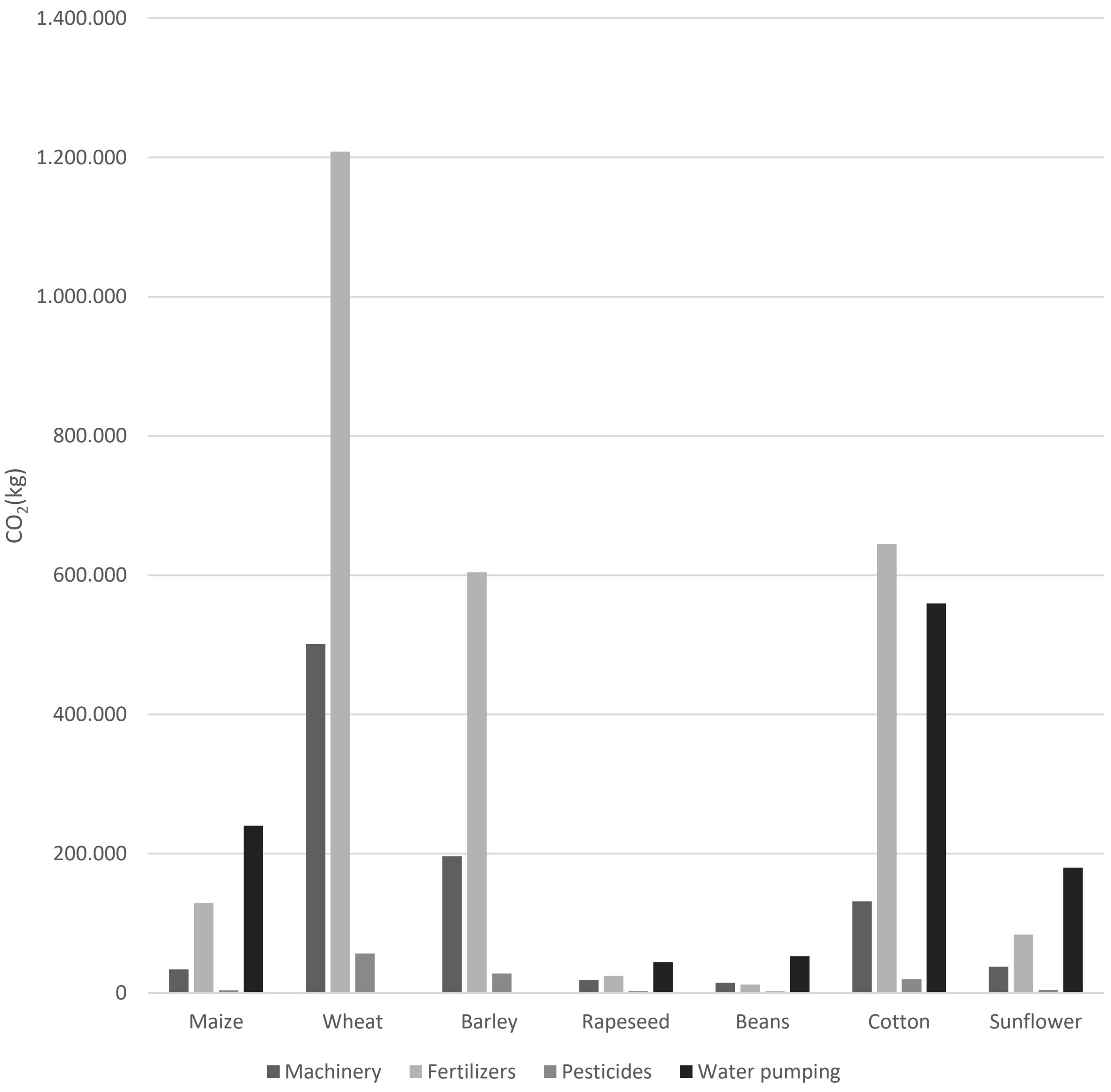


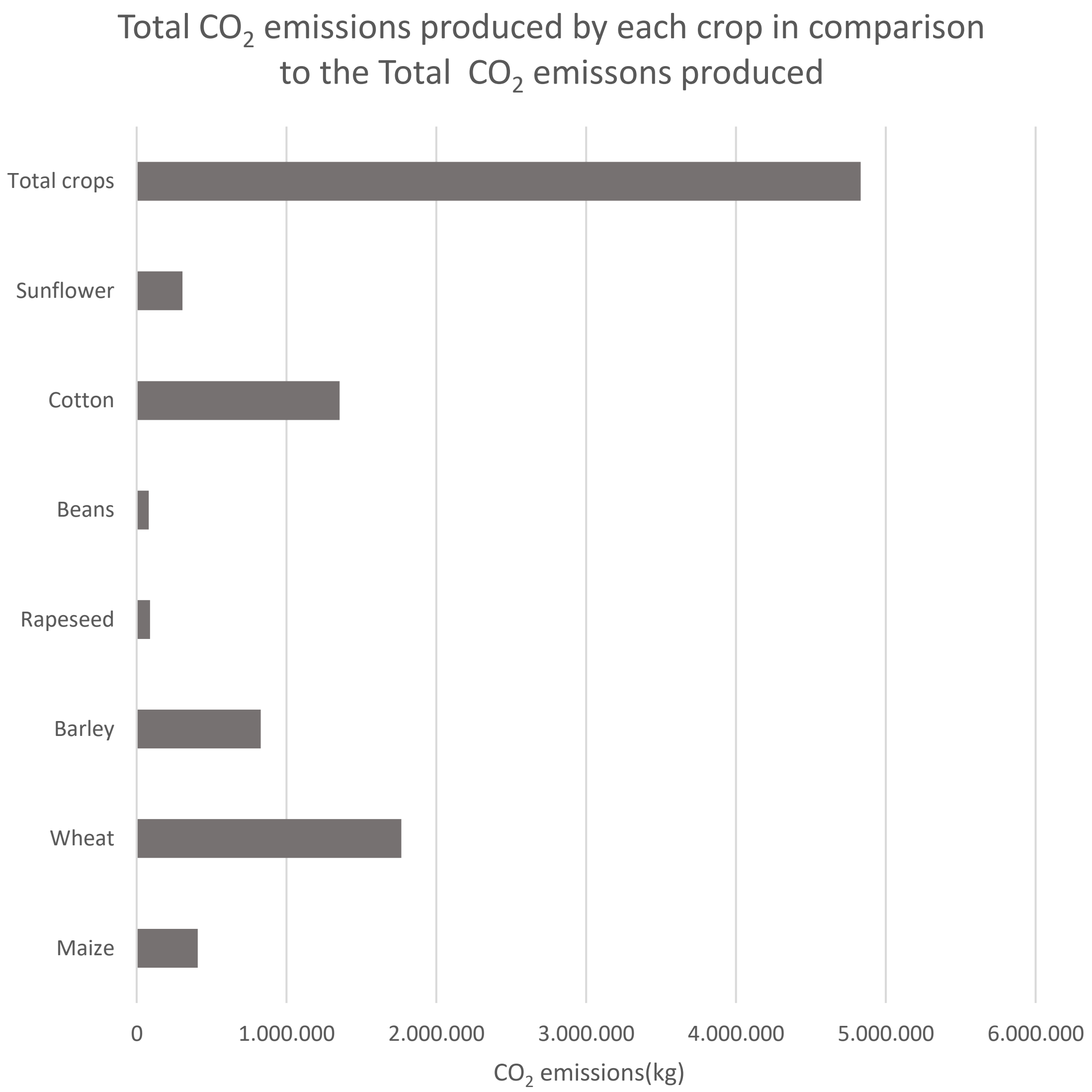
# total annual energy demand



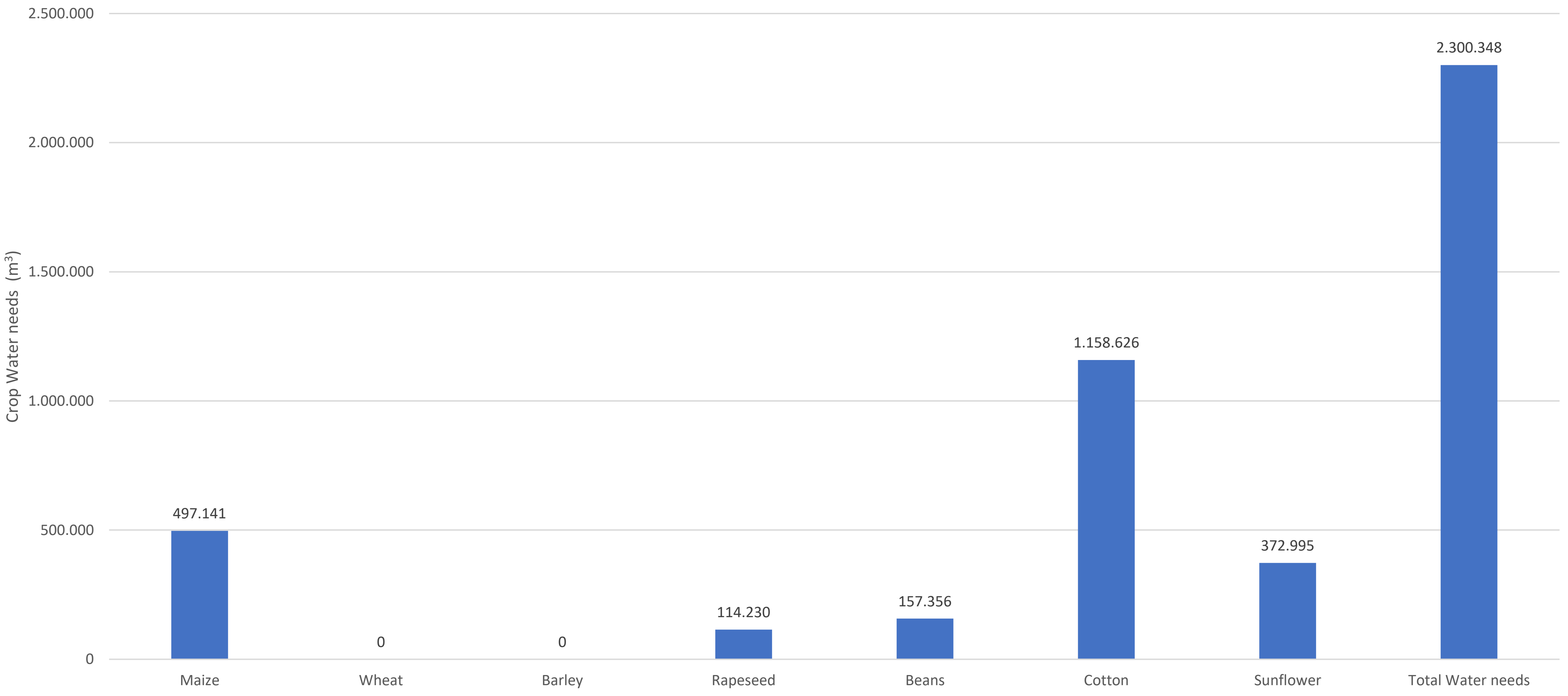



# total $CO_2$ emissions

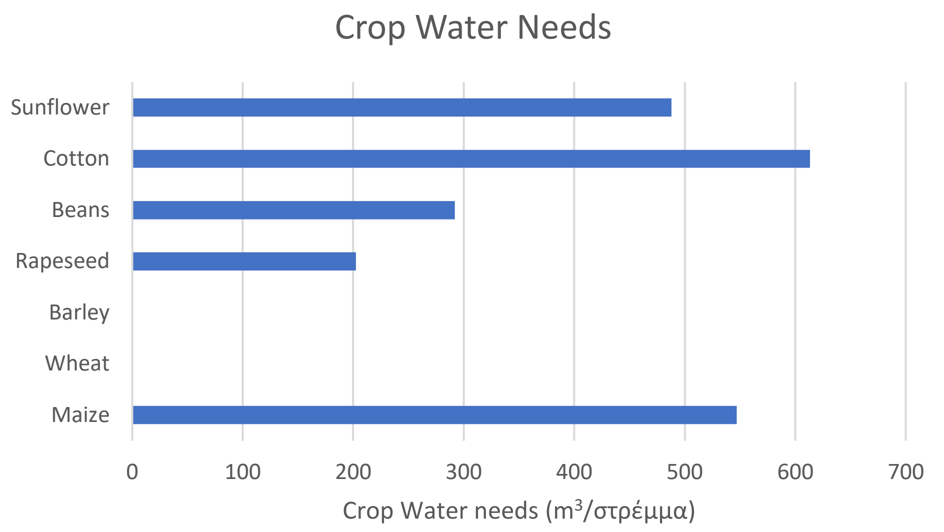


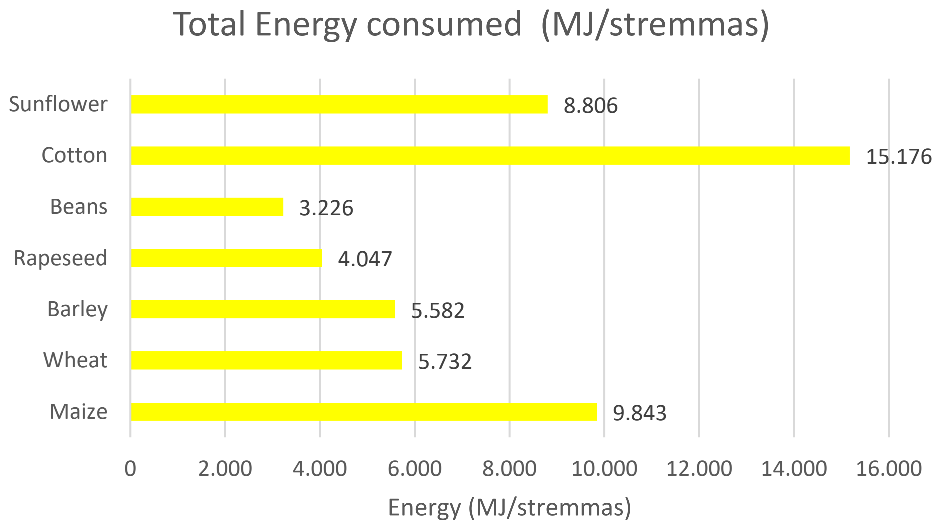



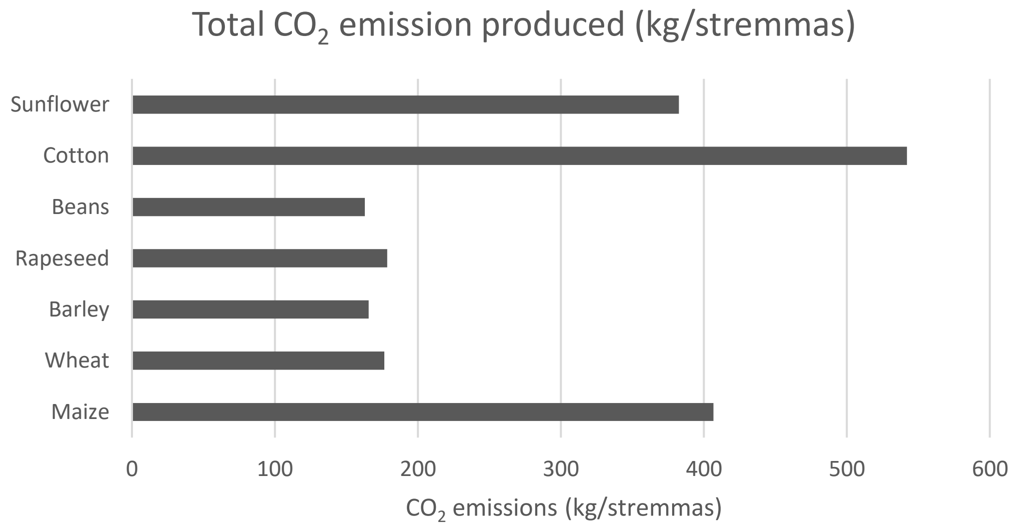
# total water demand



# WEF per land unit



# scenarios

reduction of

- sunflower
- rapeseed
- cotton
- maize

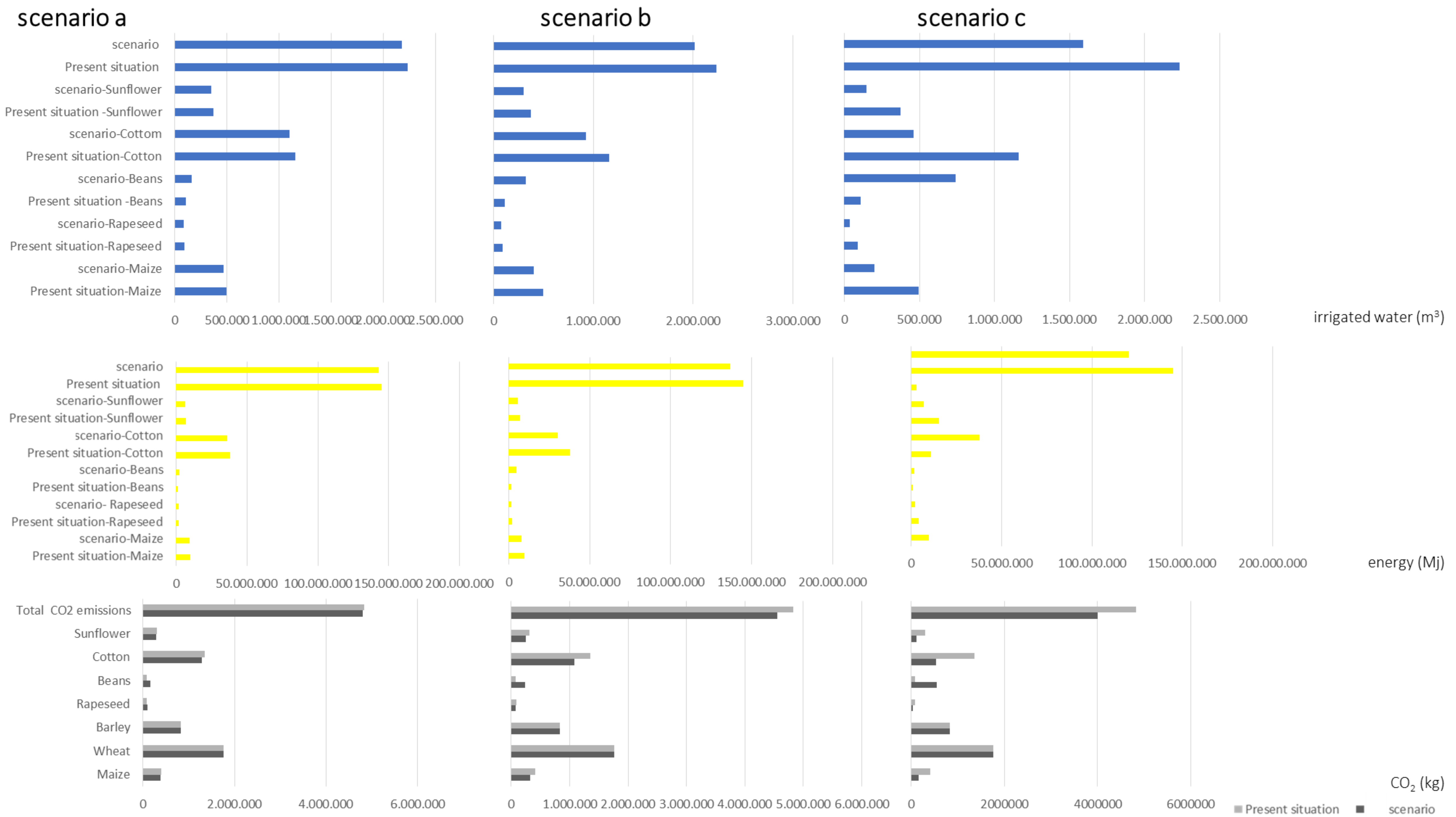
| | Scenario a | Scenario b | Scenario c |
|---|---|---|---|
| water | -2.4 % | -9.6 % | -28.8% |
| energy | -1.5 % | -5.7 % | -17.1 % |
| $CO_2$ emissions | -1.5% | -5.7% | -17.1% |

and shifting to beans production

a: 5%

b: 20%

c: 60%



scenario a
scenario b
scenario c
scenario
Present situation
scenario-Sunflower
Present situation -Sunflower
scenario-Cottom
Present situation-Cotton
scenario-Beans
Present situation -Beans
scenario-Rapeseed
Present situation-Rapeseed
scenario-Maize
Present situation-Maize
0
500.000
1.000.000
1.500.000
2.000.000
2.500.000
3.000.000
irrigated water (m³)
scenario
Present situation
scenario-Sunflower
Present situation-Sunflower
scenario-Cotton
Present situation-Cotton
scenario-Beans
Present situation-Beans
scenario- Rapeseed
Present situation-Rapeseed
scenario-Maize
Present situation-Maize
0
50.000.000
100.000.000
150.000.000
200.000.000
energy (Mj)
Total CO2 emissions
Sunflower
Cotton
Beans
Rapeseed
Barley
Wheat
Maize
0
2.000.000
4.000.000
6.000.000
1.000.000
3.000.000
5.000.000
2000000
4000000
6000000
CO₂ (kg)
Present situation
scenario

# Conclusions

- WEF Nexus: holistic, integrated, interdisciplinary approach
- resources consumption and emissions production can occur within and out of the system boundaries. Both should be considered
- cotton and maize are the most nexus intensive crops of the cooperative
- fertilizers production and water pumping are the greatest contributors to energy consumption and CO2 emissions
- legumes crops are a wise nexus solution
- a partial shift of crops to legume can save up to 28,8% water and 17.1 % energy and 17.1 % reduction in $CO_2$ emissions

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# thank you for your attention!