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

for more information visit 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
Land uses: maize, wheat, barley, cotton, beans, rapeseed, sunflower

Energy for water pumping → Drillings → Precipitation → Drip irrigation → Water Losses

Energy for machinery → Drillings → Precipitation

Fertilizers and Pesticides → Drillings → Precipitation

CO₂ emissions → CO₂ emissions

ET → Food production

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

<table>
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<tr>
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<th>Maize</th>
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Maize Wheat Barley Rapeseed Beans Cotton Sunflower
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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 95 0 115 0
SEP 0 0 0 128 0 93 0
OCT 0 0 0 120 0 0 0
NOV 0 0 0 0 0 128 93
DEC 0 0 0 0 0 0 0

crop demands / stremma
Sim4Nexus database
Nexus_SDm
Laspidou et al, 2020

crop demands
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
CO₂ emissions for water pumping

Environmental Protection Agency:
1 MJ produces 0,0595 kg CO₂
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

- Energy for the machinery operation
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
CO₂ emissions from fertilizers & pesticides – land use

**Annual CO₂ emissions for fertilizer use**

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<th>Crop</th>
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**Annual CO₂ emissions for pesticides use**

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land use – food production and other crop production

food production estimated according to ELSTAT, 2018

production yields for Thessaly
### Total Annual Energy Demand

Total energy consumed by each crop in comparison to the total annual energy demand.

- **Sunflower**: 7,045,195 MJ
- **Cotton**: 37,940,840 MJ
- **Beans**: 1,612,756 MJ
- **Rapeseed**: 2,023,672 MJ
- **Barley**: 27,911,757 MJ
- **Wheat**: 57,323,623 MJ
- **Maize**: 9,843,119 MJ
- **Total Crops**: 145,014,132 MJ
total CO₂ emissions

Total CO₂ emissions produced by each crop in comparison to the Total CO₂ emissions produced.
Crop Water needs (m³)

- Maize: 497,141
- Wheat: 0
- Barley: 0
- Rapeseed: 114,230
- Beans: 157,356
- Cotton: 1,158,626
- Sunflower: 372,995
- Total Water needs: 2,300,348
scenarios

reduction of
• sunflower
• rapeseed
• cotton
• maize

and shifting to beans production

a: 5%
b: 20%
c: 60%

<table>
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<th>Scenario b</th>
<th>Scenario c</th>
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<td>-9.6 %</td>
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<tr>
<td>energy</td>
<td>-1.5 %</td>
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<tr>
<td>CO$_2$ emissions</td>
<td>-1.5%</td>
<td>-5.7%</td>
<td>-17.1%</td>
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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 CO₂ emissions
thank you for your attention!