Title: Transforming olive grove conventional farming system into organic in Crete, using Integrated Natural Resources Management practices

Policy recommendation for sustainable use of natural resources in olive grove farming

SOQ-33306

Individual project

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Contents

1. Introduction

1.1 Olive farming sector in EU

The olive farming is an important agricultural sector in the European Union, particularly in the southern Mediterranean coastline countries. More than 95 % of the olive production in the EU-28 is concentrated in the Member States, Spain, Italy and Greece. The EU is the global leader in olive production, accounting for almost 70% of total worldwide output, while Greece is ranking 3rd higher olive oil producing country (Eurostat, 2013).

1.2 Olive farming key characteristics

-The olive tree, Olea Europea L. (Oleaceae), is a perennial sub-tropical tree and is cultivated in the temperate zone producing two main products, table olives and olive oil (Volakakis, 2010; Sfakiotakis, 1993).

-Olive tree is low demanding crop growing even in poor, stony soil, reaching full production within five to seven years, and playing an important environmental role (fixing soils, biodiversity, and landscape).

-Productivity depends on the soil and climatic conditions, olive variety, farming practices, alternate bearing, and farm structure fragmentation.

-Olive farming is a major feature of the heritage and socio-cultural life of Mediterranean regions (European Commission, 2012).

The dominant terms in the international literature are Conventional farming and Organic farming.

Conventional farming: Intensive-type farming, through the application of high-input systems that offer an increased yield (Pacini et al., 2003).

Organic farming: A farming type that avoids the use of chemical inputs (fertilizers and pesticides), and focuses on production with environmental and socio-economic benefits, using on-farm natural resources (Tzouvelekas et al, 2001).

The last two decades, the increasing society's concern for environmental pollution, and the demand for high-quality and safe foodstuff has led to a tendency for transition from conventional to organic farming

Integrated Natural Resources Management (INRM) is a tool that helps transition from Conventional to Organic Farming System utilizing greater efficiency of input resources in balance with the environment, in favor of humans and other species (Harwood, 1998).

1.3 Aim of the project

This project aims to transform the current olive grove conventional farming system into organic in Crete, using Integrated Natural Resources Management practices.

2. Methodology

Based on literature review, the current conventional practices were evaluated by Life Cycle Assessment (EPA, 2006).

This project used energy and air indicators for the evaluation of environmental implications (OECD, 2001). The environmental implications were measured as Energy Consumption (MJ/ha/yr) and Total GHG Emission (kgCO2eq/kg), while the socio-economic were measured as Total Gross Income and Gross Margin (€/ha/yr), and Return on Investment (%).

An organic farming model is proposed using INRM and same parameters were measured and compared for Technical Efficiency.

Some policy recommendation is given for sustainable transformation into organic olive farming.

3. Materials and methods

3.1 Cretan olive farming

A typical Cretan olive grove applying conventional farming system has been studied, given its production practices (Fig. 1).

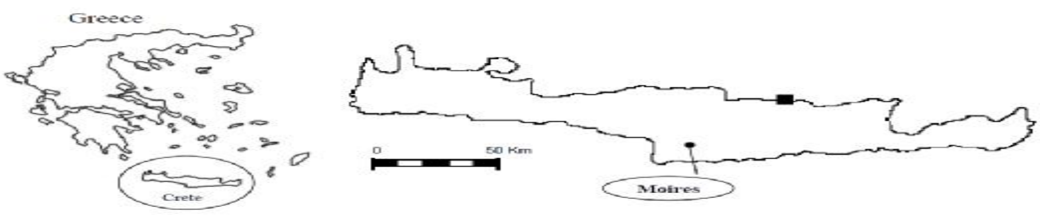


Figure 1. Map of the study area, Crete, Greece (Source: Volakakis, 2010)

The majority of Cretan rural population (95.000 families) is involved in the olive cultivation, covering 25% of the total island's area. A typical Cretan olive grove occupies area 1.6 - 3 ha, with a mean plant density of 200-250 plants/ha, at distance 6x6 m. "Koroneiki" variety occupies 85% of olive area offering high oil content 27% (Sfakiotakis, 1993). Organic olive farming represents 5% only. The agricultural practices of conventional vs proposed organic farming are shown in Table 1.

Table 1. Agricultural practices of conventional vs proposed organic farming

Agricultural practices	Conventional	Organic
Pruning	Every 3–5 years heavy pruning by pruning scissors and chain saws. Every 1–2 years they thin out the annual branches.	Incorporation of pruning residues into soil
Fertilizer application/2 yr Nitrogen (N) (kg/ ha/yr) Phosphorous (P_2O_5) (kg/ ha/yr) Potassium (K2O)(kg/ ha/yr)	Synthetic (750 kg/ha; (11% N, 15% P2O5, 15% K2O) 41.25 56.25 56.25	Biorgan (Organic) 1200 kg/ha; (4% N, 2% P2O5, 1.8% K2O) 24 12 10.8
Herbicides (kg ai/ha/yr)	4	-
Fungicides (kg ai/ha/yr)	-	-
Insecticides (kg ai/ha/yr)	3.5	Insect traps
Soil cultivation (Diesel use)	Every 2–3 years plowing at 15 cm and disk harrowing at 10 cm	Cover crop (legumes)
Weed control (Diesel use)	Herbicides, Cutting of weeds (1–3 times per year) using various types of machinery (driller, rotary tiller, field cultivator, disc harrow) 22.5 l/ha/yr	Animal grazing (sheep-poultry)
Irrigation	Electrical pumps Energy consumption 99	Same practice

(Electricity use)	kWh/ha/yr	
Harvesting (Olive mats)	Hit the trees with sticks, fruit fall down on olive mats and are collected by hand 2.75 kg/ha/yr	Same practices

The average yield of conventional farming reaches 6500 kg/ha/yr olives of "Koroneiki" variety, suitable for olive oil production. Based on the olive oil content 27%, this yield corresponds to 1755 kg/ha/yr olive oil. The current price for the conventional olive is € 2.5/kg (European Commission, 2012).

Figure 2. Olive grove in Crete, Greece (Y. Chasourakis)

3.1.1 Environmental and socio-economic implications

Conventional farming systems target on high yields (high profit) without consideration of the amount of inputs used during the cultivation period. These inputs consume significant amount of total energy with negative environmental and public health impacts, affecting biodiversity, soil erosion, nutrient leaching, water eutrophication, GHG emissions, Global warming and low quality food. According to the Energy Services Directive 2006/32/EC the end-use efficiency has to be improved either by reducing energy input or increasing input yield or by combination of both (European Union, 2010; AGREE, 2012).

3.1.2 Environmental implications

Conventional vs organic energy efficiency

The energy efficiency has been measured as Energy Consumption (MJ/ha/yr) and the Total GHG Emission (kgCO2eq/kg). The primary energy of each input is given in Table 2. Energy consumption and Total GHG Emission of Conventional vs Organic is given in Table 3.

Table 2. The primary energy of used inputs (Biograce V4, 2012)

Input	Primary Energy	Unit Primary Energy	Total GHG Emission	Unit GHG Emission
Plant[1]	2.61	MJ/kg	0.276	$kgCO_2eq/kg$ N
N Fertilizer[1]	48.99	MJ/kg	5.880	$kgCO_2eq/kg$ N
P_2O_5 Fertilizer[1]	15.23	MJ/kg	1.010	$kgCO_2eq/kg\ P_2O_5$
K_2O Fertilizer[1]	9.68	MJ/kg	0.576	$kgCO_2eq/kg\ K_2O$
Pesticides[1]	268.40	MJ/kg	10.970	$kgCO_2eq/kg$
Diesel Fuel[1]	49.99	MJ/kg	3.640	$kgCO_2eq/kg$
Electricity (GR)[2]	4.53	MJ_pNR/MJ	2.086	$kgCO_2eq/MJ$
Mean Electricity (EU)[1]	1.6	MJpNR/MJ	0.125	kgCO2eq/MJ

Table 3. Energy consumption and Total GHG Emission of Conventional vs Organic

Inputs	Unit	Conventional	Energy consumption MJ/ha/yr	Total GHG Emission kgCO2eq /ha/yr	Organic	Energy consumption MJ/ha/yr	Total GHG Emission kgCO2eq/ha /yr
Plants	n./ha	250			250		
Materials							
Fertilizers		(Synthetic)			(Organic)		
Nitrogen	kg/ha/yr	41.25	2020.84	242.55	24	1175.76	141.12
Phosphorus	kg/ha/yr	56.25	856.69	56.81	12	182.76	12.12
Potassium	kg/ha/yr	56.25	544.50	32.4	10.8	104.54	6.22
Pesticides							
Herbicides	kg ai/ha/yr	4	1073.6	43.88	-		
Fungicides	kg ai/ha/yr	-	-	-	-		
Insecticides	kg ai/ha/yr	3.5	939.4	38.4	-		
Irrigation							

Electricity use	kWh/ha/yr	99	448.5	206.5	99	448.5	206.5
Field operations							
Diesel use	l/ha/yr	22.5	1124.8	81.9	22.5	1124.8	81.9
Olive mats	kg/ha/yr	2.75			2.75		

Table 5. Energy consumption and Total GHG Emission of Conventional vs Organic

	Energy consumption (MJ/ha/yr)			
Inputs	Conventional	%	Organic	%
Nitrogen	2020,84	28,83	1175,76	38,7
Phosphorus	856,69	12,22	182,76	6,0
Potassium	544,50	7,77	104,54	3,4
Herbicides	1073,60	15,32	0	0
Fungicides	0	0	0	0
Insecticides	939,40	13,40	0	0
Electricity use	448,50	6,40	448,50	14,8
Diesel use	1124,80	16,05	1124,80	37,04
Total	7008,33	100	2587,86	100

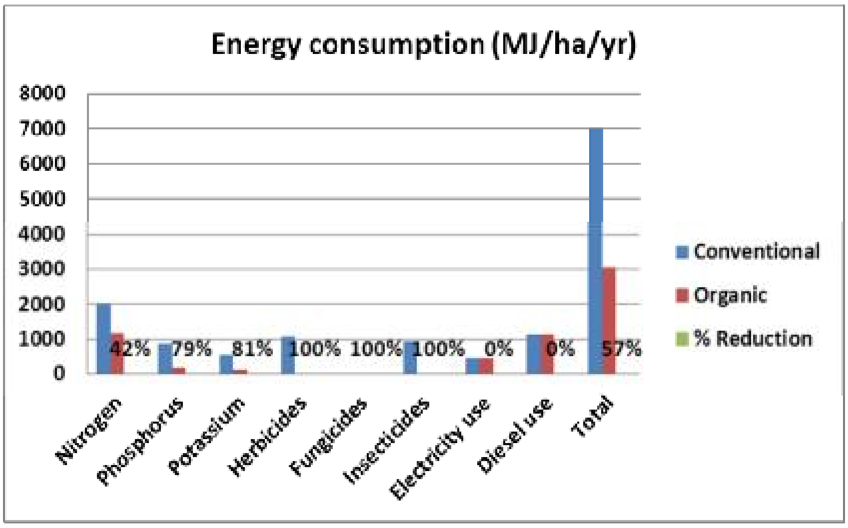


Figure 3. Energy consumption of Conventional vs Organic

Table 6. Total GHG Emission Conventional vs Organic

Total GHG Emission (kgCO2eq/ha/yr)			
	Conventional	Organic	% Reduction
Nitrogen	243	141	42%
Phosphorus	57	12	79%
Potassium	32	6	81%
Herbicides	44	0	100%
Fungicides	0	0	100%
Insecticides	38	0	100%
Electricity use	207	207	0%
Diesel use	82	82	0%
Total	702	448	36%

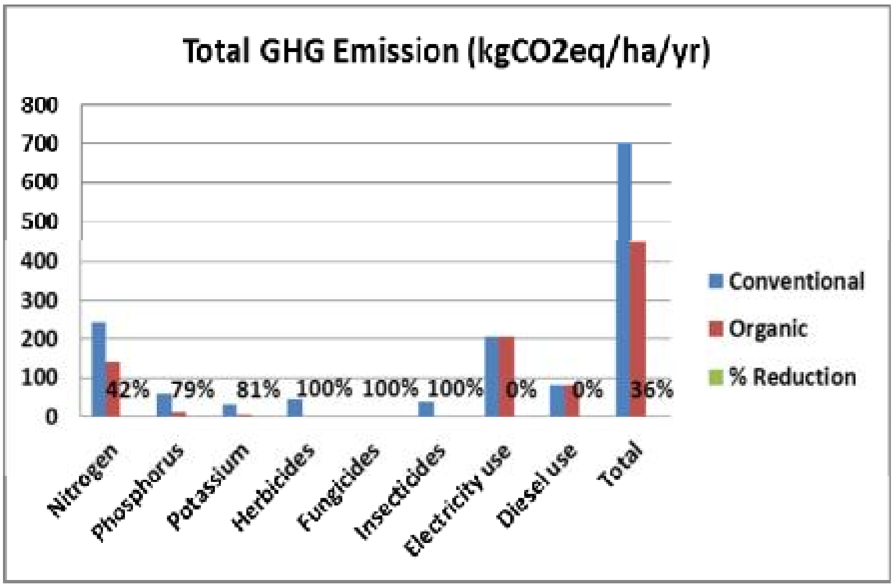


Figure 4. Total GHG Emission Organic vs Conventional

3.1.3 Socio-economic implications

Conventional and Organic farming output

The conventional output per hectare per year in terms of Yield, total gross income, gross margin and Return on Investment (ROI) is shown in Table 8.

Table 7. Conventional farming output

	Conventional Farm Output			
	1 Ha Olive Grove 250 trees			
Production Cost/ Expenses	Quantity	Unit Price	Total amount	Share
	kg/ha/yr	€/kg	€	%
N-P-K (11-15-15)	375	0,4	150	4%
Electricity (irrigation)	99	0,03	2,6	0%

Diesel	22,5	1,2	27	1%
Family Labor (€/day)	65	30	1950	57%
pesticides			1000	29%
Other expenses (milling, etc)			300	9%
Total production costs			3429,6	100%
Gross Income				
Yield (€/kg olive oil=kg olivesx27%)	1755	2,5	4387,5	
Total Gross Income			4387,5	
Gross Margin			957,9	
Return on Investment (ROI)			21,8%	

Table 8. Organic farming output

	Organic Farm			
	1 Ha Olive Grove 250 trees			
Production Cost/ Expenses	Quantity	Unit Price	Total amount	Share
	kg/ha/yr	€/kg	€	%
Vermicompost (4-2-1.8)	600	0,4	240	8%
Electricity (irrigation)	99	0,03	2,6	0%
Diesel	22,5	1,2	27	1%
Family Labor (€/day)	75	30	2250	77%
Other expenses (milling, etc)			400	14%
Total production costs			2919,6	100%
Gross Income				
Yield (€/kg olive oil=kg olivesx27%)	1404	3,5	4914	
Subsidies			415	
Total Gross Income			5329	
Gross Margin			2409,4	
Return on Investment (ROI)			45,2%	

3.2 Transformation to organic farming

Proposed organic farming model

Given the production results of conventional farming, certain organic practices have been proposed towards improved energy efficiency and better final output expressed in environmental and socio-economic values. It is proposed some conventional inputs be replaced by natural resources in the following olive cultivation and oil processing management.

Soil management: Replacement of tillage by cover crop (legumes) producing green manure that enhances soil fertility (nitrogen fixation), increases soil organic matter, water infiltration and water holding capacity, and thus preventing soil erosion, landscape maintenance. Pruning residues incorporation adds to above values.

Crop management: Replacement of chemical fertilizers and pesticides by natural resources, such as:

- Biodynamic fertilizers: The conventional currently used fertilizer is 750 Kg/ha/ 2 years of synthetic N-P-K (11-15-15). This is translated as N 41.25 kg/ha/yr, P2O 56.25 kg/ha/yr, and K2O 56.25 kg/ha/yr. This input is replaced by 600 kg/ha/yr Vermicompost (4-2-1.8) (organic compost produced by earthworms). This is translated as N 24 kg/ha/yr, P2O 12 kg/ha/yr, and K2O 10.8 kg/ha/yr. Additionally green manure from cover crop and pruning residues, and by-product manure from sheep or poultry supplements the lower quantity of organic N-P-K.
- Biodynamic weed control: Chemical herbicides are replaced by incorporation of sheep in combination with poultry grazing the weeds. This is the best animal component for the organic weed control of the olive grove. Additionally to weeding, they offer wool, meat, eggs and organic manure (faeces), contributing to increase of income, biodiversity, soil fertility, and decreasing environmental impacts. This way a closed cycle is created.
- Insect traps: Pesticides for the control of the main pest olive fruit fly, Bactrocera oleae (Rossi), are replaced by insect traps (Ecotrap, Elkofon, etc.) with satisfactory results (Therios, 2005).

Olive oil processing: Cold pressing is recommended to produce high quality extra virgin olive oil with added value. Processing Olive Mills Wastewater (OMW) by-product, so called “pomace”, can be transformed from a serious pollution factor to valuable organic natural resource for additional oil extraction, animal feed, fertilizer and fuel. Bulk packing should be replaced by small packing in labeled and QR-coded bottles to increase consumer’s awareness for nutritional healthy food and ecological life.

Marketing: EU certification for Product of Organic Farming, and Protected Designations of Origin/Protected Geographical Indication (PDO/PGI) increases olive oil traceability, identity of origin, consumer's concern for healthy food, potential for commercial brand name, and profitability.

Institutional knowledge: Farmers have to become more aware about organic farming practices through educational seminars organized by the public Authorities.

The closed life cycle of organic inputs and the Organic Olive Farm System Diagram are shown in Figures 5 and 6.

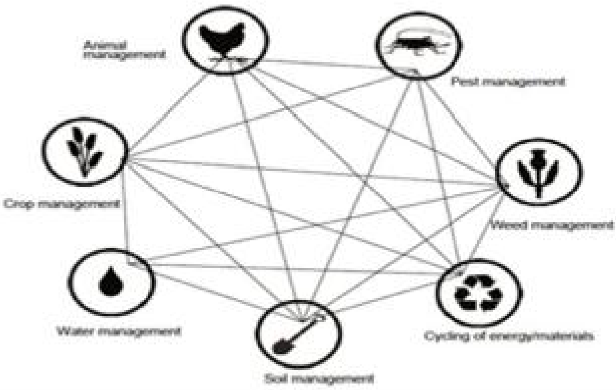


Figure 5: Principles of Agro-ecology (Source: Atelier Rabbit)

4. Results - Discussion

4.1 Organic vs Conventional farming

A comparison between the organic and conventional olive farming is illustrated below, based on received energy and economic output results.

4.1.1 Organic vs Conventional farming energy efficiency

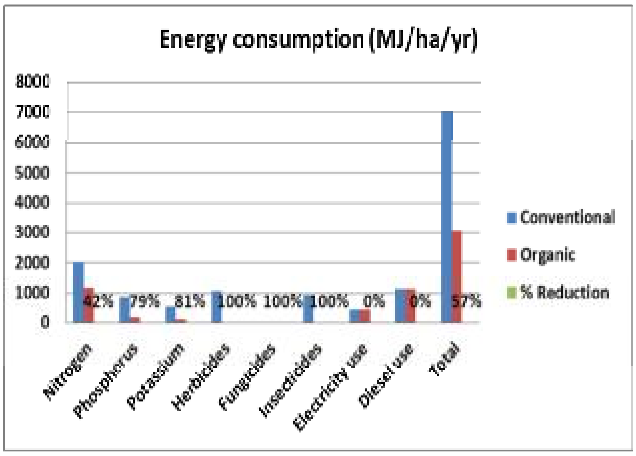
The comparison of Organic vs Conventional towards energy efficiency is shown in the following Table 13-Figure 8 and Table 14-Figure 9.

Table 13. Energy consumption
Organic vs Conventional

Energy consumption (MJ/ha/yr)			
	Conventional	Organic	% Reduction
Nitrogen	2021	1176	42%
Phosphorus	857	183	79%
Potassium	545	105	81%
Herbicides	1074	0	100%
Fungicides	0	0	100%
Insecticides	939	0	100%
Electricity use	449	449	0%
Diesel use	1125	1125	0%
Total	7008	3036	57%

Table 14. Total GHG Emission
Organic vs Conventional

Total GHG Emission (kgCO2eq/ha/yr)			
	Conventional	Organic	% Reduction
Nitrogen	243	141	42%
Phosphorus	57	12	79%
Potassium	32	6	81%
Herbicides	44	0	100%
Fungicides	0	0	100%
Insecticides	38	0	100%
Electricity use	207	207	0%
Diesel use	82	82	0%
Total	702	448	36%



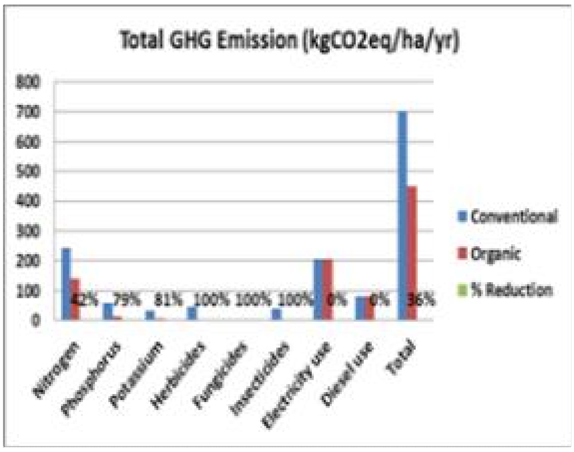


Figure 8. Energy consumption Organic vs Conventional

Figure 9. Total GHG Emission Organic vs Conventional

Remarks: The replacement of conventional inputs such as chemical fertilizers and pesticides by organic natural resources reduced the Energy consumption by 57% and the Total GHG Emission by 36%. This means that the replacement of chemical inputs by natural resources increased the Energy Efficiency of the olive grove by 57% and 36% respectively.

4.1.2 Organic vs Conventional farming economic output

A comparison between the two different farming systems was made based on the separate economic results of each system. Equal parameters were compared to identify which system has higher socio-economic efficiency. The yield in olives (kg/ha) and the economic output for both systems are shown in Table 15-Figure 10 and Table 16-Figure 11 respectively.

Table 15. Yield in Organic vs conventional

	Yield (kg/ha)		
	Conventional	Organic	% Reduction
Yield (kg olives)	6500	5200	20%

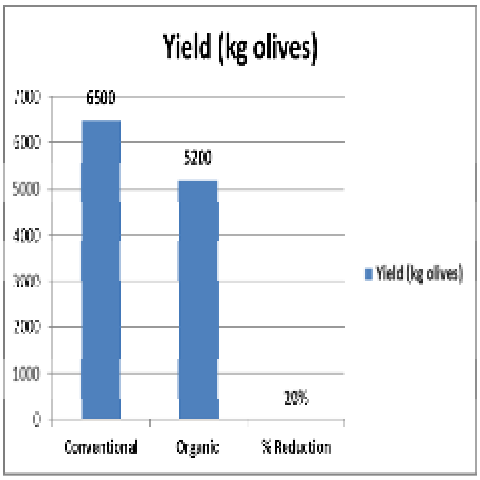
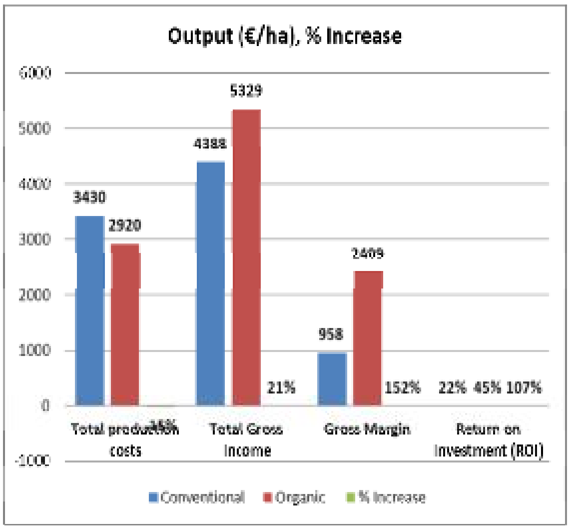


Figure 10. Yield in Organic vs conventional

Table 16. Yield in Organic vs conventional

Output (€/ha)			
	Conventional	Organic	% Increase
Total production costs	3430	2920	-15%
Total Gross Income	4388	5329	21%
Gross Margin	958	2409	152%
Return on Investment (ROI)	22%	45%	107%

Figure 11. Yield in Organic vs conventional



Remarks: Organic system decreases the yield in olives (kg/ha) by 20%. Nevertheless, Total Production Costs decreased by 15%, and the Total Gross Income, the Gross Margin and the Return on Investment (ROI) increased significantly by 21%, 152% and 107% respectively. Subsidies offered by CAP in organic farming only account for 17% on gross margin.

5. Policy Recommendation

The Technical Efficiency analysis showed that the proposed organic olive farming in Crete has better energy efficiency and economic output than the conventional. The 95% of Cretan farmers dealing with conventional olive farming can be motivated to transform it into the proposed organic model. The transition period might be fast (within 2 production seasons), as the proposed Integrated Natural Resources Management recommends practices that can be handled easily without high investment in time and funds. The main recommended practices are summarized as follows:

Soil management: Replacement of tillage by cover crop (legumes), incorporation of pruning residues

Crop management: Replacement of chemical fertilizers and pesticides by natural resources, such as:

- Biodynamic organic fertilizers: Vermicompost, green manure (cover crop and pruning residues), and by-product manure (sheep and/or poultry)
- Biodynamic weed control: Animal grazing (sheep and poultry)

- Insect traps

Olive oil processing: Cold pressing, Olive Mills Wastewater (OMW) utilization

Marketing: EU certification for Organic Farming, and Protected Designations of Origin/Protected Geographical Indication (PDO/PGI)

Institutional knowledge: Organic farming education

6. Conclusion

The proposed INRM in Cretan olive farming excluded the use chemical fertilizers and pesticides as main factors of negative socio-economic and environmental impact. INRM contributes to improvement of the ecological biodiversity and environmental externalities, thus improving the farm's performance in nutrient recycling, and pest control. INRM farming improved significantly the economic part as well, leaving more income and margin for the farmers, despite the lower yield. The proposed project for transformation of conventional olive groves into organic will help Cretan olive farmers to produce an added value product.

The organic olive farming system ensures socio-economic and environmental benefits, and justifies why organic production has to be stimulated.

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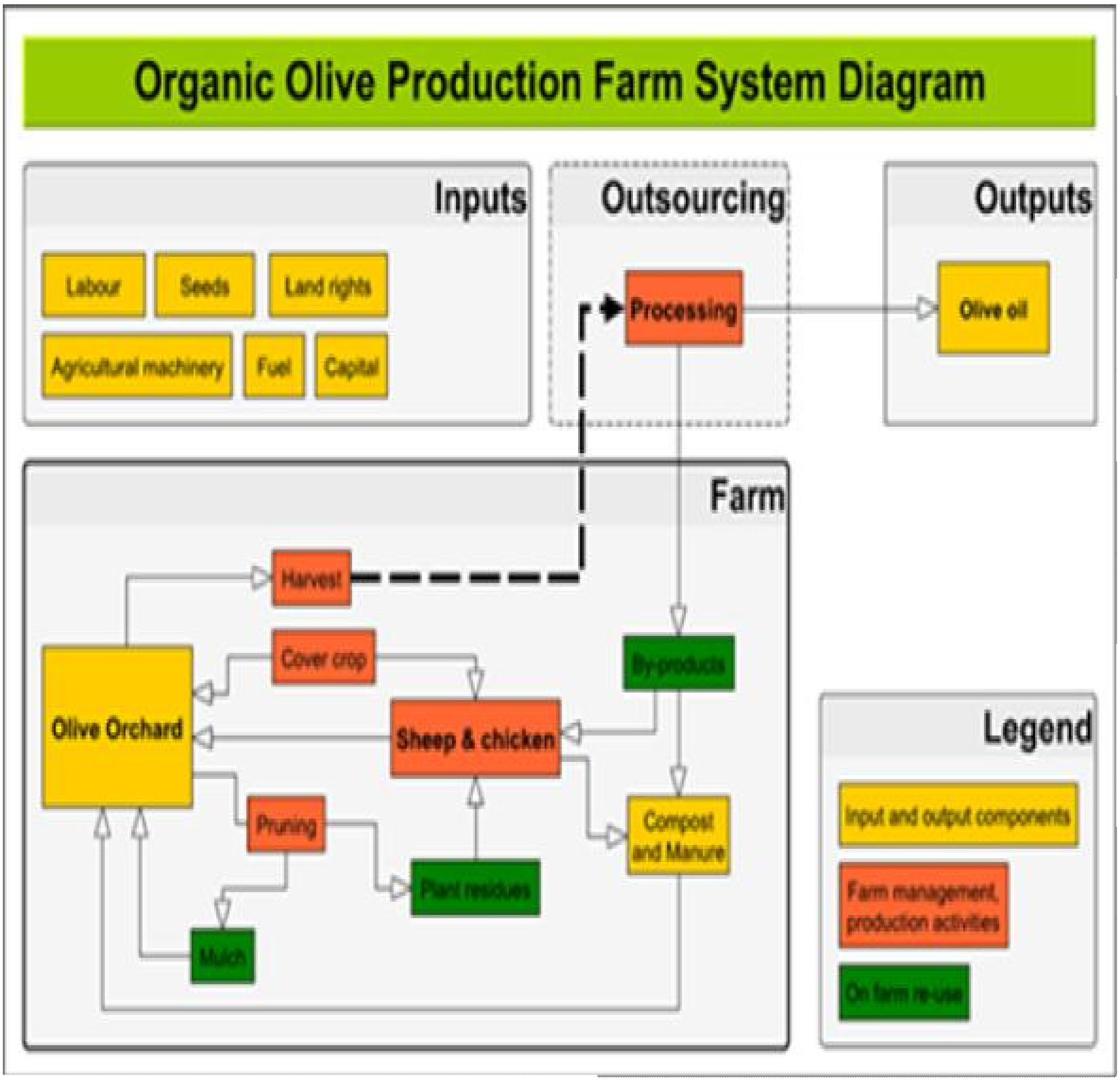
ANNEX I


Organic Olive Production Farm System Diagram
Inputs
Labour
Seeds
Land rights
Agricultural machinery
Fuel
Capital
Outsourcing
Processing
Outputs
Olive oil
Farm
Harvest
Cover crop
By-products
Olive Orchard
Sheep & chicken
Pruning
Compost and Manure
Plant residues
Mulch
Legend
Input and output components
Farm management, production activities
On farm re-use