Proactive Producer and Processor Networks for

Troodos Mountains Agriculture

3PRO-TROODOS

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Contents

1. Introduction

In the marketplace, origin-linked products can secure premium prices, provided they are clearly differentiated and identifiable to consumers. Certified quality labels and origin-linked brands are tools that can help mountainous producers to unlock the value added of these types of products and promote mountainous farming. A voluntary quality certification scheme has been developed with farmers in the Troodos Mountains as part of the 3PRO-TROODOS Project (WP5). Technologies that can support farmers with the sustainable production of mountain products and help them adapt to climate change have also been tested with farmers in the project (WP6). Work Package 7 (WP7) aims to assess the costs and benefits of two agricultural technologies and the direct and indirect socioeconomic effects of voluntary quality certification schemes on the Troodos Mountains region.

The Socioeconomic Impact Analysis report (D7.1) consists of two main parts:

1. Cost-benefit analysis of the 3PROTROODOS technologies, namely, crop protection nets and wireless soil moisture sensors for irrigation scheduling (Task 7.1)
2. Assessment of the economy-wide effects of Troodos voluntary certification scheme on local economy (Task 7.2).

2. Cost-benefit analysis of 3PROTROODOS technologies

2.1 Cost-benefit analysis (CBA)

A financial cost-benefit analysis is employed in 3PRO-TROODOS to compare the costs and benefits of applying (i) protection nets and (ii) wireless soil moisture sensors for irrigation scheduling at different pilot plots, namely between pilot plots on which these techniques applied and those plots in which they did not apply. The associated costs and benefits are quantified in monetary terms after adjusting for the time value of money. The Net Present Value (NPV) indicator is applied to calculate the present value of future costs and benefits and to estimate the net margin of the innovation technologies.

Calculating net present values involves calculating the cash flows of implementing the technology for each year, discounting them to present value and subtracting the establishment cost (initial investment) from the sum of the technology's discounted cash flows.

The formula for NPV is as follows (Boardman et al., 2017):

$$NPV = \frac{Cash\ Flow_1}{(1+r)^1} + \frac{Cash\ Flow_2}{(1+r)^2} + \cdots + \frac{Cash\ Flow_n}{(1+r)^n} - Establishment\ Cost \quad (1)$$

where *n* is the number of years; *r* is the discount rate.

The technology is profitable for the farmer at a particular rate of interest if the NPV is positive.

Alternative scenarios are formulated in this report to compare the profitability of the examined technologies under different conditions.

2.2 CBA application to fruit tree protection nets technology

The controlled testing of protection nets took place in a pilot cherry orchard in Potamitissa and Kannavia (D6.4); Figure 1.

We developed two baseline scenarios (BS):

i. uncovered orchard (no protection nets; BS1)
ii. uncovered orchard considering the effects of climate change (BS2)

Then we developed three scenarios for the covered orchard (with protection nets):

i. covered orchard (S1)
ii. covered orchard and removal of subsidization of the installation cost of nets (S2)
iii. covered orchard with a doubling of the installation cost of nets (S3).

The assumptions and the calculated NPVs for each scenario are presented in Table 1. The primary data used for the calculation of the discounted cash flows are presented in detail in Table A1 (Appendix A).

Figure 1: Protective nets in Potamitissa cherry orchard

Table 1. NPVs of protective nets under alternative scenarios; uncovered orchards (baselines) in red & covered orchards in blue

	Uncovered orchard (BS1)	Uncovered orchard and climate change effects (BS2)	Covered orchard (S1)	Covered orchard and removal of subsidization of nets installation cost (S2)	Covered orchard with a doubling of the nets installation cost (S3)
Assumptions	(a) no cost for nets;	(a) no costs for nets; (b) total yield loss every 4 years during the examined twelve-year period due to extreme weather events (i.e., hail, frost, high temperatures); (c) Cyprus Agricultural Payments Organization (CAPO) compensation equal to 80% of the loss of physical production or yield	(a) establishment cost of nets: 6,255 €/decare; (b) subsidization of the installation cost of nets: 3,000 €/decare (c) yield increases by 10% compared to BS1; (d) fruit prices increase by 20% compared to BS1; (e) labour and machinery cost declines by 10% compared to BS1; (f) irrigation cost declines by 25% compared to BS1.	(a) no subsidization of the installation cost of nets; (b) the rest similar to S1	(a) establishment cost of nets: 12,510 €/decare; (b) the rest similar to S1
NPVs	21,910 €/decare	20,527 €/decare	**29,075 €/decare**	26,075 €/decare	22,820 €/decare
Period			12 years (2019-2030)		

*Interest rate: 6%; an interest rate sensitivity analysis between 3-9% did not alter the results.

The NPV of the covered orchard (S1) is significantly higher than the NPV of the uncovered orchard (BS1) indicating the financial viability of investing in protection nets in Troodos mountains. The NPV of the covered orchard even with the removal of the subsidization of the installation cost of nets (S2) remains significantly higher than the uncovered orchard (BS1). Investing in protection nets remains also marginally viable under the extreme scenario of a doubling of installation cost (S3) highlighting the great potential of this innovation technology for Troodos agriculture. As expected, the viability of the technology is getting even higher if in the baseline scenario (uncovered orchard) we consider the negative effects of climate change (BS2).

2.3 CBA application to wireless soil moisture sensors for irrigation scheduling technology

This innovation technology includes the installation of soil moisture sensors and meteorological station (Figure 2), with a decision support App, to advise farmers when and how much water to apply to prevent crop water stress and reduce irrigation water losses. Irrigation advice is based on soil water content and soil water holding capacity and field parameters (crop stress fraction, wetted area). The system supports the use of a meteorological station to support the fine-tuning of the field parameters, based on water balance computations, and to provide additional field-based information to farmers (see D6.1).

Considering the small and highly non-uniform plots in the mountains, the technology can cover an area of approximately 2 decares and the technology testing with farmers in Troodos revealed a reduction in irrigation water use of 15-30% (D6.3).

Figure 2: Establishment of soil moisture sensors and meteorological station in Dymes-Potamitissa plum orchard

The financial costs and benefits of the baseline scenario of implementing the technology are presented in Table 2.

Table 2. Financial costs and benefits data of the wireless soil moisture sensors for irrigation scheduling (Scenario 1).

Costs:	Benefits:
A) Equipment and installation cost: • logger: 600€ • six soil moisture sensors: 600€ (100€ each) • meteo station (temperature, relative humidity, rain gauge): 450€ • sim card: 30€ • field installation (2 people, 1 day + travel to/from field, pole, brackets): 150€ • **total installation cost: 1830€** B) Operational cost: • Battery change (in the third year): 20€ • Annual subscription cost (mobile network and decision support services fees): 120€	• annual irrigation water use (1320 m^3 for 2 decares) • annual irrigation water saving (10%): 132m^3 • irrigation water price: 0.35€/m^3 • **annual financial benefit: 46.2€**
Period: 5 years (2019-2023)	

In total six scenarios are developed:

i. S1: Baseline scenario (10% water savings)
ii. S2: System without meteo station
iii. S3: Maximum improvement of farmers practices (20% water savings)
iv. S4: Water price increase for full cost recovery of water services (0.50 €/m^3)
v. S5: Low water prices (0.25 €/m^3)
vi. S6: Maximum subsidization of technology to become economically viable

The calculated NPVs for all scenarios are presented in Table 3.

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Table 3. NPVs of wireless soil moisture sensors for irrigation scheduling technologies under alternative scenarios; the changes in parameters under each scenario are indicated in red.

	Irrigation water use reduction (%)	Irrigation water use reduction (m^3)	Water price (€/m^3)	Installation cost (€)	NPV (€)
S1	10	132	0.35	1830	**-1,790**
S2	10	132	0.35	1380	**-1,340**
S3	20	264	0.35	1830	**-1,630**
S4	10	132	0.50	1830	**-1,721**
S5	10	132	0.25	1830	**-1,836**
S6	10	132	0.35	160	**0**
Period	5 years (2019-2023)				

*Interest rate: 6%; an interest rate sensitivity analysis between 3-9% did not alter the results.

The financial analysis of the alternative scenarios involves a negative NPV, which indicates that wireless sensor irrigation scheduling technologies are not a viable investment option for the mountainous agriculture in Troodos. The technology can become profitable for Troodos agriculture under a large subsidization scheme. In particular, the installation cost of the technology should be subsidized by more than 90%, that is, 1,670€. For the system without the meteo station (S2), a subsidy of 1,220€ is required, respectively.

Further research and development could be undertaken to increase the benefits of the technology by integrating flow meters and valves in the sensor observation system, such that the farmers can remotely control their irrigation applications. This could reduce the number of field visits, fuel costs and car wear and tear along the mountain roads and tracks. It could also facilitate the scheduling of irrigations in the early monitoring hours with low evaporation losses.

3. Economy-wide assessment of Troodos voluntary certification scheme

3.1 Input-output analysis

In the second part of the socioeconomic impact analysis report, we develop a regional input-output (IO) model to estimate the direct and indirect effects of Troodos voluntary certification scheme on local economy in terms of generated output and employment.

IO analysis is a quantitative technique for analysing the interdependence of production sectors in an economy (Miller and Blair, 2009). An IO table identifies the major sectors in a national and/or regional economy and records the financial flows among them over a stated time period (usually a year). IO multipliers can provide an effective tool for impact analysis by estimating the economy-wide effects of an initial change in the final demand for the output of a particular sector.

3.2 Regionalization process

We apply employment-based location quotients, namely, the cross-industry location quotient (*CILQ*) to adjust the national technical IO coefficients to regional scale. The *CILQ* formula for sectors *i* and *j* is defined as follows (Giannakis and Bruggeman, 2017):

$$CILQ_{ij}^{T} = \left[\frac{E_i^T / E_i^N}{E_j^T / E_j^N}\right] \qquad (2)$$

where E_i^T and E_j^T are employment in sectors *i* and *j* in Troodos region *T*; E_i^N and E_j^N are employment in sectors *i* and *j* at the national level; sector *i* is assumed to supply inputs to sector *j*.

If $CILQ_{ij}^{T}$ is less than one, the industry *i* is perceived less capable of satisfying regional demand for its output and the national technical coefficients will be adjusted downwards by multiplying them by the $CILQ_{ij}^{T}$. The national technical coefficients will not be adjusted if $CILQ_{ij}^{T} \geq 1$.

3.3 Application of the Troodos input-output model

The national symmetric IO table for the year 2018, that is the latest available (Cystat, 2022a), was used to construct the Troodos regional IO table. We then used the 'make' and 'use' matrices of the 3-digit input-output model for Cyprus (Cystat, 2022a) to disaggregate the agricultural sector to four farming systems: (a) non-perennial crops, (b) perennial crops, (c) livestock, (d) other agricultural sectors (planting material, hunting etc.). The RAS technique was applied to balance the 68-sector classification (4 agricultural and 64 non-agricultural sectors) of the Cyprus national IO table (Giannakis and Mamuneas, 2018). The final scheme of the national IO table was aggregated into 20 sectors (Table A2).

The $CILQ$ technique was applied to construct the Troodos input-output table using sectoral national and community employment data, which were obtained from the Statistical Service of Cyprus (Cystat, 2022b). Specifically, we used the mountainous communities, which are included in Annex IV (areas of natural constraints) of the 2014-2020 Rural Development Programme of Cyprus[1] to define the Troodos mountain region. The list of the selected mountainous communities was prepared using the altitude and the slope that were calculated based on the agricultural area of 2014. Specifically, the average altitude and the average slope of an individual plot declared in the 2014 CAPO database was calculated and then by weighting the area of each plot, the average altitude and the average slope of each community were calculated.

3.4 Troodos input-output multiplier analysis

The IO multiplier analysis identified the most important sectors of economic activity in Troodos region with regards to their capacity to enhance output and employment generation. Table 4 reports the output multipliers which express the regional significance of the backward linkages of each sector. The highest output multipliers are observed for construction (2.07) and water supply (1.77). The meaning of the output multiplier of the construction sector is that an increase in the final demand for the products and services of the sector by-1-million-Euro induces an increase in the total output of Troodos economy by 2.07 million Euro. The highest backward linkages among the farming systems are created by livestock (1.56), while for the perennial and non-perennial crop sectors the multiplier effects are relatively low.

[1] http://www.paa.gov.cy/moa/paa/paa.nsf/All/F6BC6C5062E25774C22580600040A2EE?OpenDocument

Table 4. Output multipliers for Troodos sectors of economic activity (2018)

n/n	Sectors	Output Multipliers
1	Non-perennial crops	1.18
2	Perennial crops	1.14
3	Livestock	1.56
4	Other agricultural sectors	1.33
5	Forestry	1.02
6	Fisheries	1.10
7	Mining	1.24
8	Manufacturing	1.55
9	Electricity, Gas	1.09
10	Water Supply	1.77
11	Construction	2.07
12	Trade	1.36
13	Transportation	1.53
14	Accommodation & Food	1.44
15	Financial and Insurance Services	1.53
16	Real Estate	1.26
17	Public Administration	1.13
18	Education	1.15
19	Health	1.27
20	Other Services	1.37

The employment multipliers for Troodos sectors of economic activity are shown in Table 5. The most labour-intensive sectors, i.e., those with high direct employment multipliers, are the perennial (27.3) and non-perennial (23.9) crop farming systems. As such, for every 1-million-Euro increase in the final demand for the products of the perennial crop system, 27.3 jobs are created within the sector but only 1.8 jobs in the rest local economic sectors, i.e., in total 29.1 new jobs are created in the economy. Contrary to the low indirect employment effects of the perennial and non-perennial crop systems, livestock creates the highest indirect effects on Troodos employment. Specifically, for every 1-million-Euro increase in the final demand for the products of the sector, 17.1 jobs are created in Troodos economy of which 9 are directly created within the sector and 8.1 jobs are indirectly generated in the interrelated sectors. The construction sector creates the largest indirect employment effects for every unitary injection in local sectors' final demand.

Table 5. Employment multipliers (direct & indirect) for Troodos sectors of economic activity (2018)

n/n	Sectors	Employment Multipliers		
		Direct Multiplier	Indirect Multiplier	Total Multiplier
1	Non-perennial crops	27.3	1.8	29.1
2	Perennial crops	23.9	1.4	25.3
3	Livestock	9.0	8.1	17.1
4	Other agricultural sectors	17.1	3.7	20.8
5	Forestry	10.2	0.2	10.4
6	Fisheries	8.0	0.9	8.9
7	Mining	17.8	2.3	20.1
8	Manufacturing	9.1	6.6	15.7
9	Electricity, Gas	6.6	1.6	8.2
10	Water Supply	6.4	5.8	12.2
11	Construction	9.4	11.0	20.4
12	Trade	23.4	2.8	26.2
13	Transportation	4.4	4.3	8.7
14	Accommodation & Food	15.6	4.2	19.8
15	Financial and Insurance Services	4.0	4.6	8.6
16	Real Estate	1.1	1.9	3.0
17	Public Administration	21.3	1.7	23.0
18	Education	23.0	1.4	24.5
19	Health	18.0	3.1	21.1
20	Other Services	10.8	3.8	14.6

3.5 Economy-wide effects of Troodos voluntary certification scheme

The estimated input-output multipliers for the perennial farming system were used to measure the economy-wide effects of increasing the added value of the local mountain agricultural products in terms of generated output and employment. Several studies have indicated that quality labelling enjoys a greater premium in the market (Loureiro et al., 2002; Maliotis, 2020). Here, we assume an increase in the price of the certified Troodos fruit products by 5-10% relative to the non-certified products.

In particular, the increase in the price of the certified Troodos fruit products by 5% and 10%, based on the input-output multiplier analysis, would result in:

- the increase of the total output of the local economy by 0.3% and 0.6%, respectively.
- the creation of 20 (19 direct) and 39 (37 direct) new jobs in the economy, respectively.

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4. Conclusions

The results of the cost-benefit assessment of the 3PROTROODOS technologies revealed that protective nets are a viable investment for Troodos agriculture. Investing in protective nets in Troodos is viable even if the subsidization of installation cost is removed or the cost of installation increases, highlighting the great potential of this technology for Troodos agriculture. On the contrary, investing in irrigation scheduling technologies can be a viable investment option for Troodos agriculture under a large subsidization scheme of the system.

The assessment of the economy-wide effects of Troodos voluntary certification scheme showed that an increase in the price of the certified Troodos fruit products by 5-10% would increase the output of Troodos economy by 0.3% to 0.6%, respectively. It would additionally result in the creation of 20 and 39 new jobs in the local economy, respectively, the majority of which however would be generated inside the agricultural sector. Considering the large backward linkages and interrelationships of the manufacturing sector in Troodos economy, the certification of local food manufacturing products would create greater multiplier benefits to the local economy in terms of output and employment generation.

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Appendix A

Table A1. Costs and revenues of covered tree orchard for the year 2019 (year 1).

	2019
Gross Revenue (€/decare)	**4862.50**
Yield (kg/decare)	875.00
Price (€/kg)	5.50
Decoupled (per area) subsidy (€/decare)	50.00
Nets establishment cost	**6255.00**
Poles (€/decare)	875.00
Anchors (€/decare)	500.00
Wire ropes (€/decare)	1250.00
Plastic hats €/decare)	200.00
Tensioners triple (€/decare)	200.00
Tensioners double (€/decare)	150.00
Net (€/decare)	880.00
Screws & plastic hooks (€/decare)	200.00
Labour cost (€/decare)	2000.00
Subsidization of nets establishment cost (€/decare)	**3000.00**
Labour and machinery cost (€/decare)	**256.00**
Labour (εργατικά) (€/ decare)	208.00
Machinery (€/ decare)	48.00
Other variable cost (€/decare)	**507.25**
Fertilizers (€/decare)	185.00
Plant protection (€/decare)	170.00
Irrigation (including energy) cost (€/decare)	152.25

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Table A2. NACE codes of sectors of economic activity of Troodos input-output table for 2018.

n/n	Sector	Description NACE[2]
1	Non-perennial crops	A1.1
2	Perennial crops	A1.2
3	Livestock	A1.3
4	Other agricultural sectors (planting material, hunting etc.)	A1.4
5	Forestry	A2
6	Fisheries	A3
7	Mining	B
8	Manufacturing	C
9	Electricity, Gas	D
10	Water Supply	E
11	Construction	F
12	Trade	G
13	Transportation	H
14	Accommodation & Food	I
15	Financial and Insurance Services	K
16	Real Estate	L
17	Public Administration	O
18	Education	P
19	Health	Q
20	Other Services	J, M, N, R, S, T, U

Source: Eurostat (2008).

[2]NACE: Statistical classification of economic activities in the European Union.