

ECOIL LIFE 04/ENV/GR/000110

Life Cycle Assessment (LCA) as a decision support tool for the eco-production of olive oil



Completed and Ongoing Tasks in Cyprus



Marios Avraamides

Chania, 7 June 2006

Presentation Structure



1. Recording and assessment of existing situation
2. Development of the LCA methodology
3. LCA Modeling
4. Ongoing implementation of the LCA in Lythrodontas

Recording and assessment of existing situation



- Identification of the national legislation and standards
- Review of olive tree cultivation practices, olive milling processes and olive mill waste management practices
- Examination of success stories

Identification of national legislation and standards



- Cyprus Government Law No. 106(I)/2002 for the Pollution Control of Waters and Soil
- Code for Good Agricultural Practice (No. R.A.A. 407/2002)
- Use of sludge in agriculture – Regulations (R.A.A. 517/2002)
- Nitrate Pollution of Agricultural Origin - Regulations (R.A.A. 534/2002)
- Waste Disposal Permit for Olive Mills
- Action Program for the Nitrogen Sensitive Regions of Cyprus (Ordinance 41/2004)
- Nitrogen Sensitivity Zones and water categories that are subject or are possible to be subjected to nitrogen pollution (Ordinance 42/2004)
- Quality Control Inspection for Agricultural Products Laws of 2002-2004: application of Directives 1019/2002/EU and 2081/92/EU
- 1996 To 2004 Laws (Control and Sales) Associated With Food: Application of Directive 2000/13/EU by Ministry Of Health
- “E Elia” Guidelines Prepared For Olive Tree Growers
- 122 (I)/2004 – Application of Regulation (EC) No 761/2001 associated with EMAS

Preliminary review of current practices



- Olive varieties cultivated
- Olive oil processing practices
- Packaging and distribution





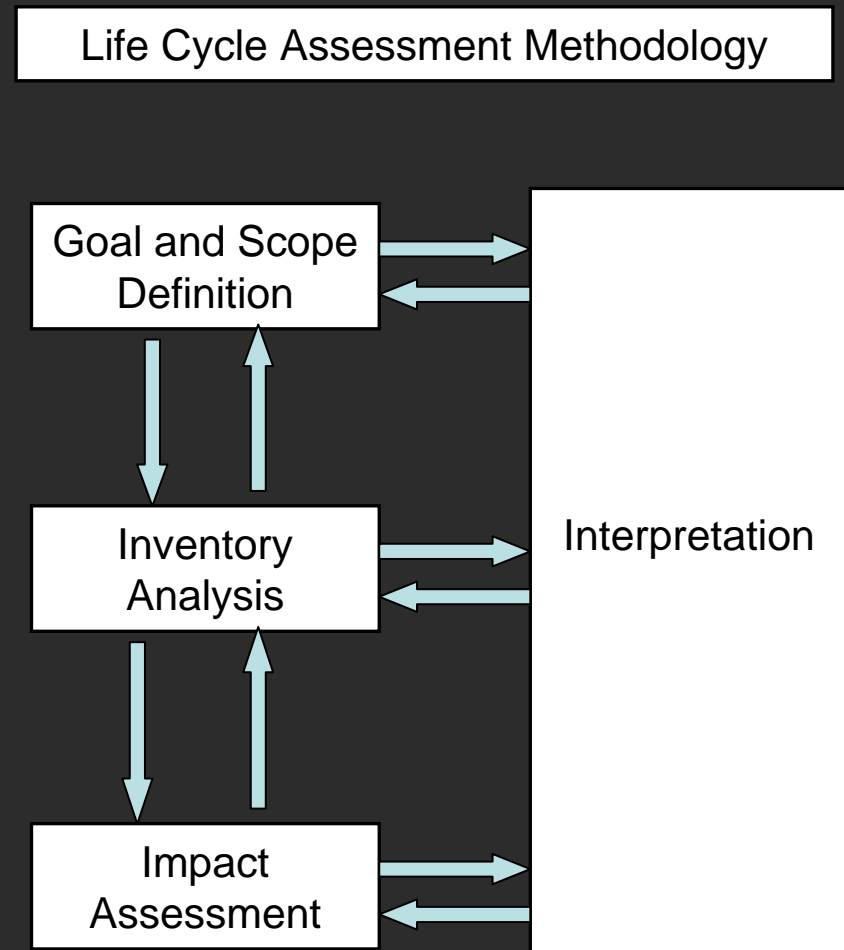
Examination of success stories

- LCC and LCA of extra-virgin olive oil: organic vs. conventional
- LCA of cane-sugar in the island of Mauritius
- LCA of beer production in Greece
- Screening LCA of tomato ketchup: a case study
- LCA of Danish milk – system expansion in practice
- LCA of bread production – a comparison of 8 different scenarios
- Environmental Management Practices in an Italian Coffee Company using LCA Methodology

Development of the LCA Methodology



- Goal and Scope Definition
- Inventory Analysis
- Impact Assessment
- Interpretation



The Goal of the Study



“To develop a DST for the improvement of the environmental profile of olive oil production”

The Goal of the Study



- **DST? How?**

By developing and implementing a LCA, which will identify the “hot spots” of the olive oil production cycle in each region

- **Olive oil production cycle? Which one?**

The most characteristic production chain in each region

- **And then? What?**

Identify improvement opportunities and prescribe preventive measures



The Scope of the Study

- The Product

Extra virgin olive oil (Council, 2003)

- The System

29 unit processes preliminarily identified

- Reference Flow

1 litre of extra virgin olive oil

The Scope of the Study



System Boundary defined and justified...

- Production, transportation, replacement and maintenance of capital goods are excluded
- Transportation of personnel and labour activities are excluded
- Processing of low quality olives and olive oil is excluded
- Pomace oil extraction is excluded
- Packaging, distribution, use and end-of-life stages are excluded

The Scope of the Study



Process No.	Background Process	Foreground Process
1	Electricity production	Irrigation
2	Irrigation water supply	Fertiliser application
3	Fertiliser production	Pesticide application
4	Transportation of fertilisers to farm	Herbicide application
5	Pesticide production	Soil management
6	Transportation of pesticides to farm	Olive tree planting
7	Herbicide production	Olive Tree cultivation
8	Transportation of herbicides to farm	Pruning
9	Transportation: Olive farm to production unit	Olive collection
10	Water treatment	Olive purification
11	Water supply	Olive grinding
12	Wastewater supply through network	Oil extraction
13	Wastewater treatment (public)	On-site liquid waste treatment
14	Solid waste treatment	Pomace processing
15		Storage of olive oil

*Data collection
planned and quality
requirements set...*

[illegible]

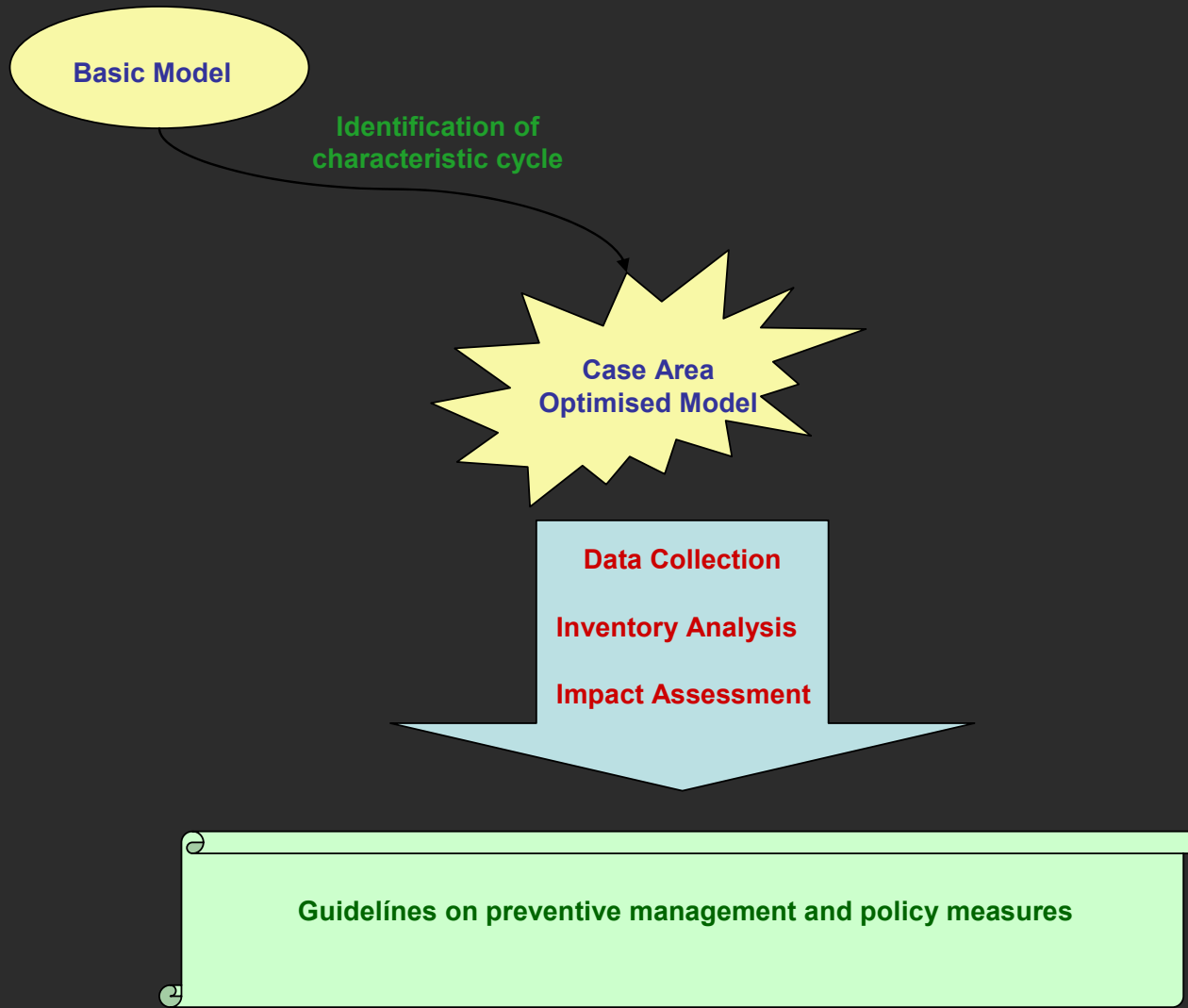
The Scope of the Study



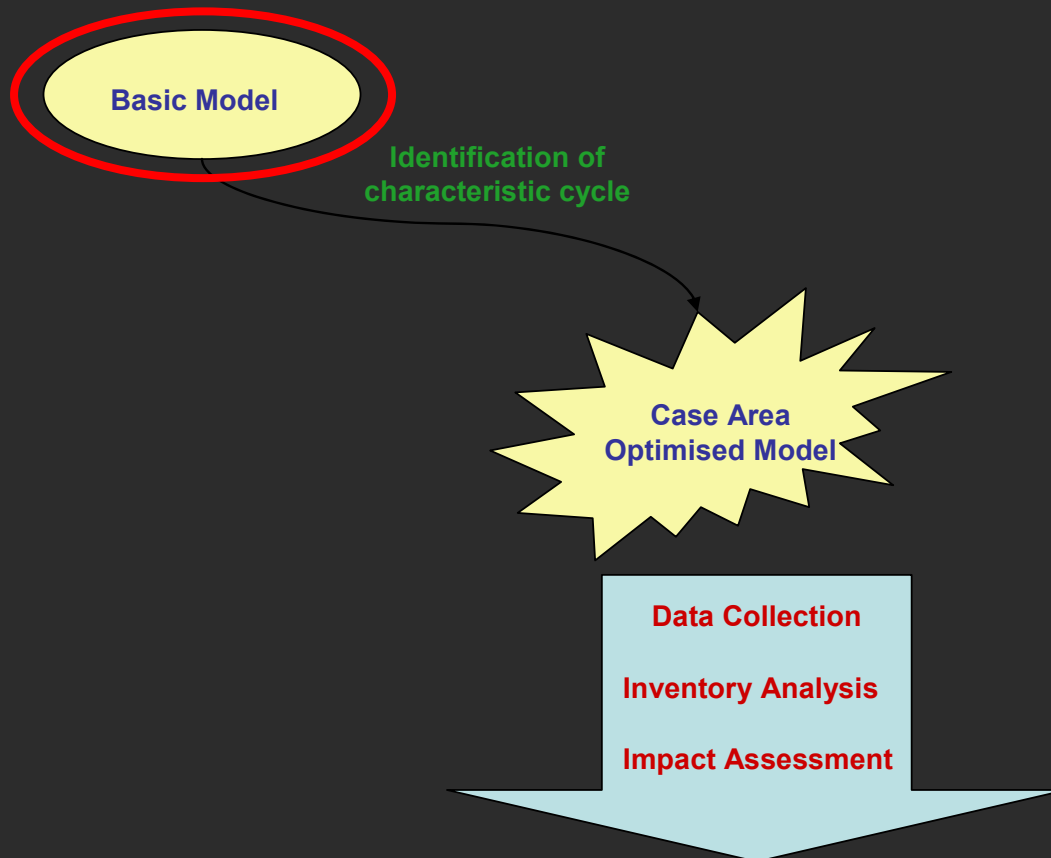
Two standard impact assessment methods selected...

- Eco-indicator 99
- CML 2 baseline 2000

The Way Forward?

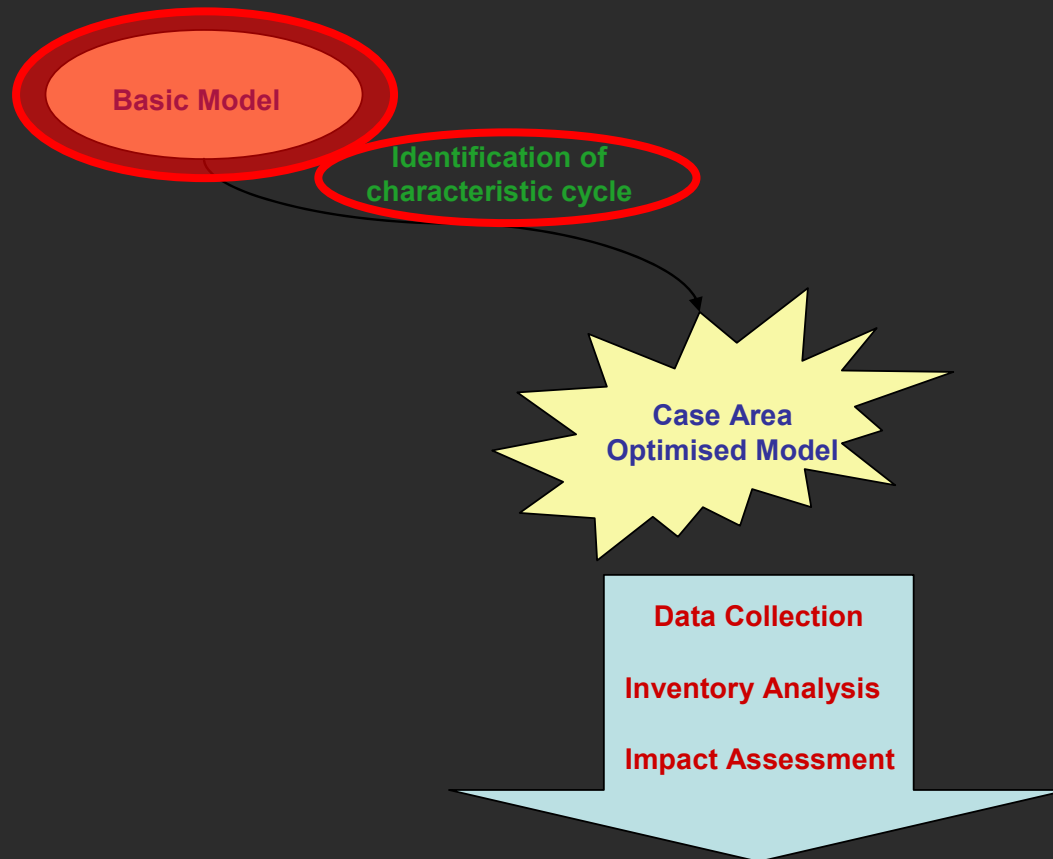


The Way Forward?



Guidelines on preventive management and policy measures

The Way Forward?

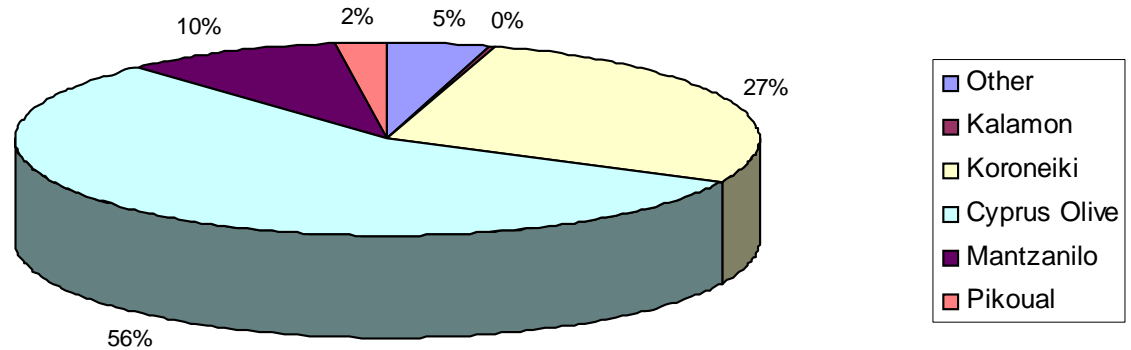


Guidelines on preventive management and policy measures

Identification of characteristic cycle



Determination of the characteristic olive variety



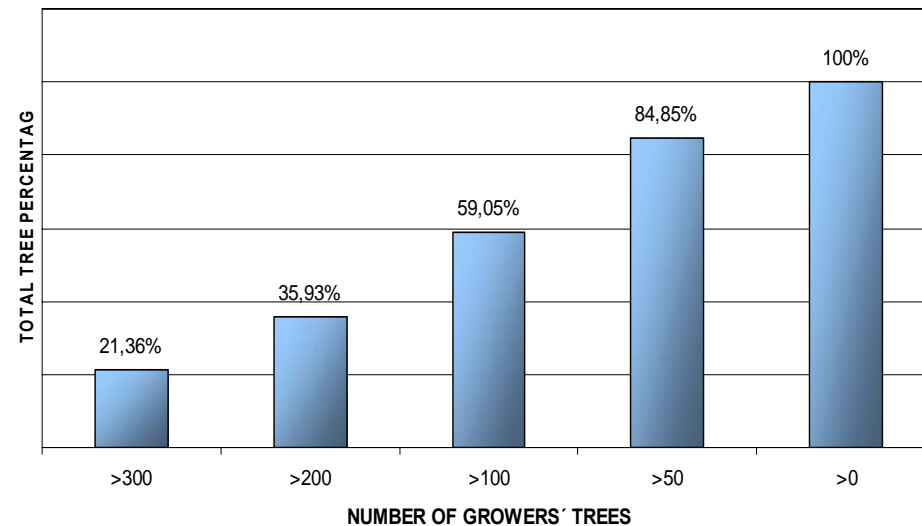
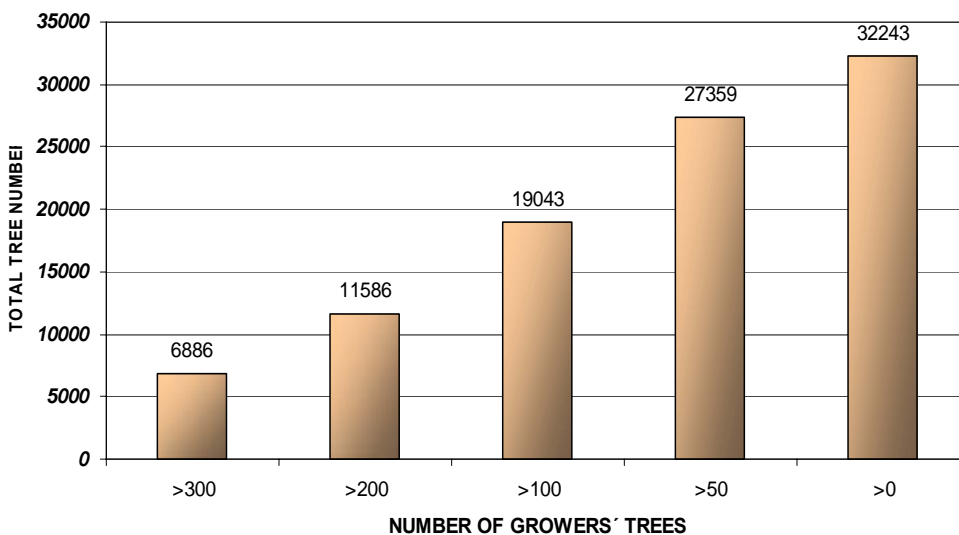
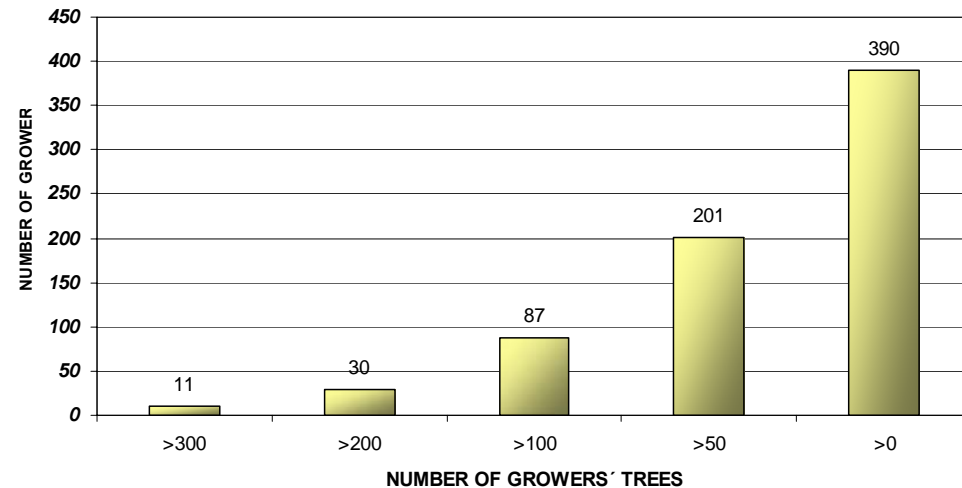
➤ *Cyprus Olive is the characteristic variety considered in the analysis for Lythrodontas*

Identification of characteristic cycle



Determination of the data sample

- Few large growers, many small growers
- From 626 trees/person to 25,8 trees/person
- Contact 87 largest growers (59% trees)
- Aim to obtain data from a minimum of 25% trees



Identification of characteristic cycle



- Questionnaire covering all stages of agricultural production of olives was prepared to answer:
 - Whether a stage (e.g. irrigation, fertilisation etc) is used
 - Which particular technique is used
 - Provide quantitative data on the main product outputs normalised by the reference flow (1 litre of olive oil)

- 29 successful personal or telephone interviews
- Covering 8150 trees (25.3% of Cyprus olive trees in Lythrodontas region)
- Calculation of standard deviation by two methods accounting the variability of quantities and error

Questionnaire 1

ECOL
LIFE04 ENV/GR/110

3. CULTIVATION DETAILS		
3.1 Geographical position	Lythrodontas wider region	
3.2 Variety	Cyprus Olive	
3.3 Number of trees		
3.4 Cultivation area	=m ²	
3.5 Mean olive production per year	=kg/year	
3.6 Mean olive oil production per year	=litres/year	
3.8 Maximum age of trees	=years	
3.9 Planting method		
3.10 Planted trees per litre of oil	=no of planted trees/litre	(3.3)/[(3.6)*(3.8)]
3.11 Use of cultivated land per litre of oil	=m ² /litre	(3.4)/[(3.8)*(3.6)]
4. TILLAGE		
4.1 Applicable?	YES / NO	
4.2 Frequency	=No/year	
4.3 Method		
4.4 Land tillage per litre of oil	=m ² /litre	(3.4)*(4.2)/(3.6)
5. WATER IRRIGATION		
5.1 Applicable?	YES / NO	
5.2 Water origin	Bore-hole / Public water supply (Water Board) / Recycled	
5.3 Irrigation method	Flood/ Furrow / Sprinklers/ Hanging drippers/ Surface drip/ Sub-surface drip	
5.4 Distance of cultivation from source	=metres	
5.5 Types of mechanical equipment (e.g. pumps)		
5.5 Irrigation frequency	=no/year	
5.6 Amount of water consumption each time	=m ³	
5.7 Amount of water consumption per year	=m ³ /year	(5.5)*(5.6)
5.8 Amount of water consumption per litre of oil	=m ³ /litre	(5.7)/(3.6)



Identification of characteristic cycle

Planting the Trees

- Propagation from cuttings
- Digging holes of dimensions 60cmx40cm with a spade (no mechanical equipment)
- After the hole is filled with soil the tree is irrigated (water use)
- The empty buckets are reused (no waste)



Soil Management

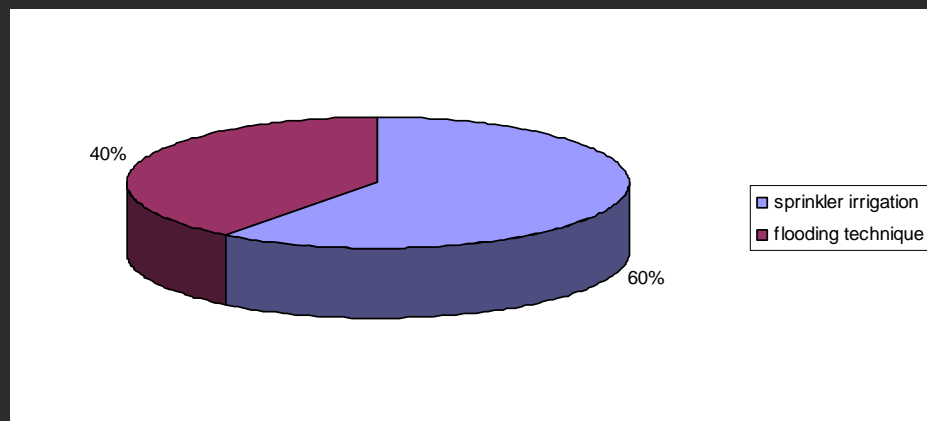
- Use of chisel-plough attached to 45hp tractors (diesel consumption)
- 68% of trees ploughed twice per year



Identification of characteristic cycle

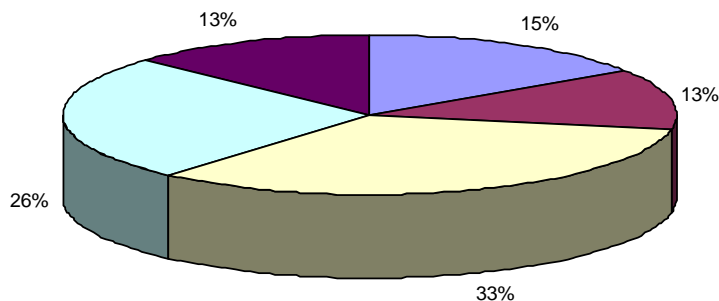
Agricultural water supply and irrigation

- 50% are irrigated
- Irrigation water pumped from boreholes inside the orchards
 - 70% electric pumps
 - 30% diesel pumps
- 60% irrigated by sprinklers



Fertiliser application

- 33% use 20-10-10 NPK fertiliser
- Applied by hand to the root



■ None ■ Ammonium fertiliser (21-0-0) ■ Compound NPK fertiliser (20-10-10) ■ Manure ■ Other

Identification of characteristic cycle

Fertiliser production and transportation

- Dense granular compound comprising of ammonium nitrate, ammonium sulphate, monoammonium phosphate (MAP), diammonium phosphate (DAP) and potassium sulphate
- Produced in Kavala
- Packaged in 50kg polypropylene mesh bags
- 1138km by freight ship (Kavala – Limassol)
- 100 km by 16-tonne lorry (Limassol – Nicosia)
- 40 km by private pick-up vehicles (<3,5 tonnes) (Nicosia – Lythrodontas)

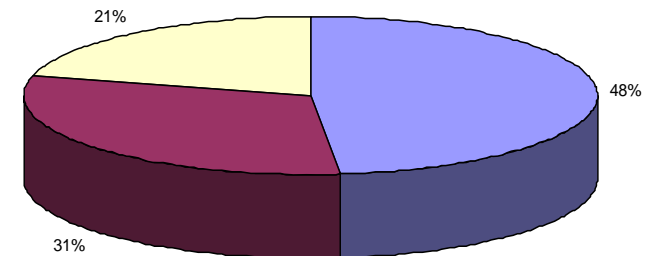


Identification of characteristic cycle



Pruning and residue waste management

- 48% use hand-held petrol chainsaw
- Every tree is pruned 0.74 times/year on average (approx. 3 times every 4 years)
- Pruning residue incinerated in open fires nearby



■ Petrol chainsaw ■ Compressed air chainsaw (connected to tractor) □ Manual Techniques (saw, scissors)

Herbicide application

- 86% control weeds through tillage (only 14% apply herbicides)

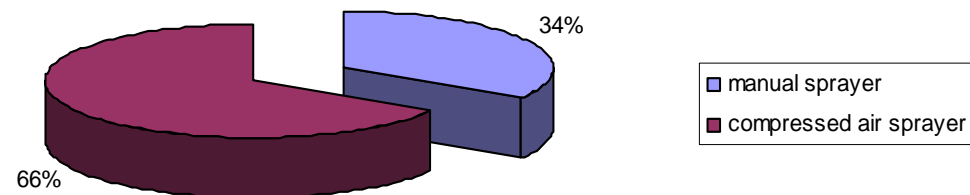
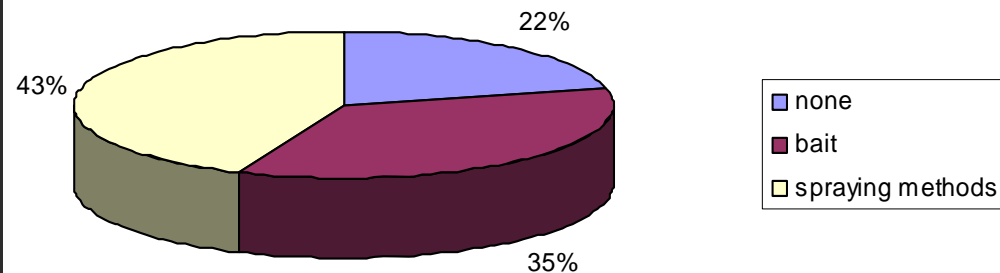


Identification of characteristic cycle



Pesticide application

- 78% use pesticides (43% apply by spraying techniques)
- 66% use compressed air sprayers (connected to agricultural tractors)
- Vast majority use a product with 40% dimethoate (active ingredient)



Identification of characteristic cycle



Pesticide production and transportation

- Composition: 40% Dimethoate, 20% xylene, 25% cyclohexanol, 5% emulsifiers
- Produced in Denmark
- 6672 km by freight ship (Copenhagen - Thessaloniki)
- 17 km by 16-tonne lorry (Th. port – Sindos)
- Packaged in 1-litre polyethylene (PE) bottles
- 17 km by 16-tonne lorry (Sindos – Th. port)
- 1210 km by freight ship (Thessaloniki - Limassol)
- 100 km by 16-tonne lorry (Limassol – Nicosia)
- 40 km by private pick-up vehicles (<3,5 tonnes) (Nicosia – Lythrodontas)

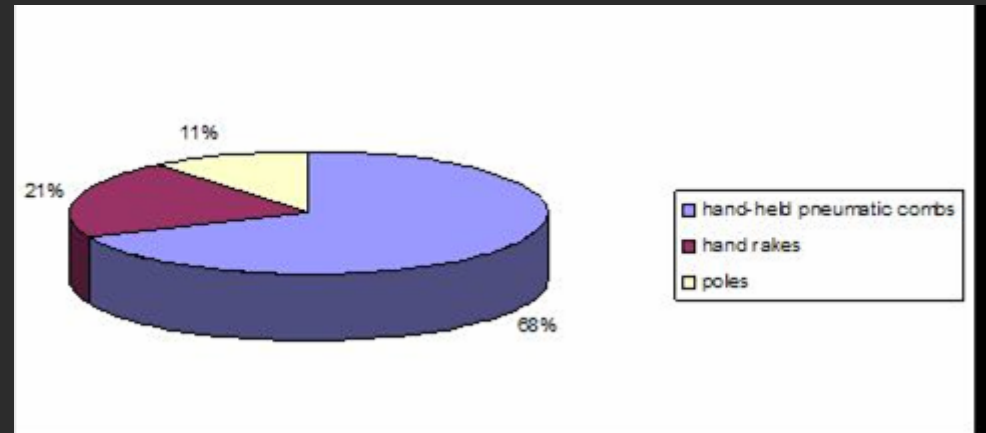




Identification of characteristic cycle

Collection

- 68% use hand-held pneumatic combs and underlying nets (reusable)



Transportation of olives to processing unit

- 2.1 km (average) by private pick-up vehicles (<3,5 tonnes)

Identification of characteristic cycle



Olive oil processing

- 74.4% use exclusively the local processing unit
- Neighbouring plants have the same process chain
- No pre-processing storage
- No on-site liquid waste treatment
- No pomace processing



Identification of characteristic cycle



Water supply and treatment

Dipotamos Dam



Pump Station



Kornos Water Works



Pump Station



Stavrovouni
reservoir



Lythrodontas Processing Unit

Mallia reservoir

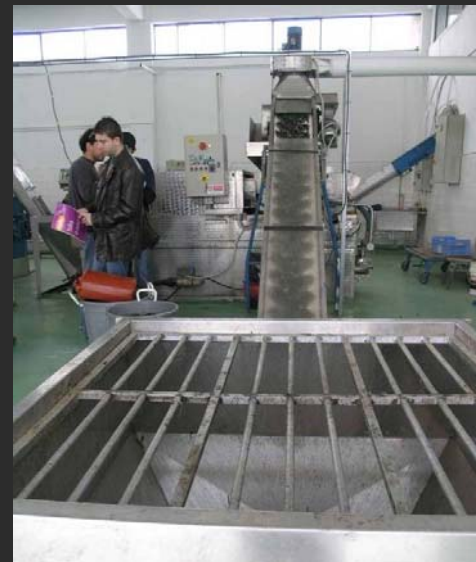
Pump Station



Identification of characteristic cycle

Olive purification

- Electric inclined conveyor into electric washing machine
- Leaves, dust etc removed by suction (disposed to agricultural land)
- Olives sprayed with water (recycled)
- Olives weighed by electronic machine



Olive grinding

- Olives ground (water addition)
- Malaxing (warm water addition)

Identification of characteristic cycle



Oil extraction

- 3-phase centrifuge decanter
- Pomace left to dry and used as a fuel (recycling)
- Liquid waste disposed to a drying pond
- Centrifuge oil separation



Identification of characteristic cycle

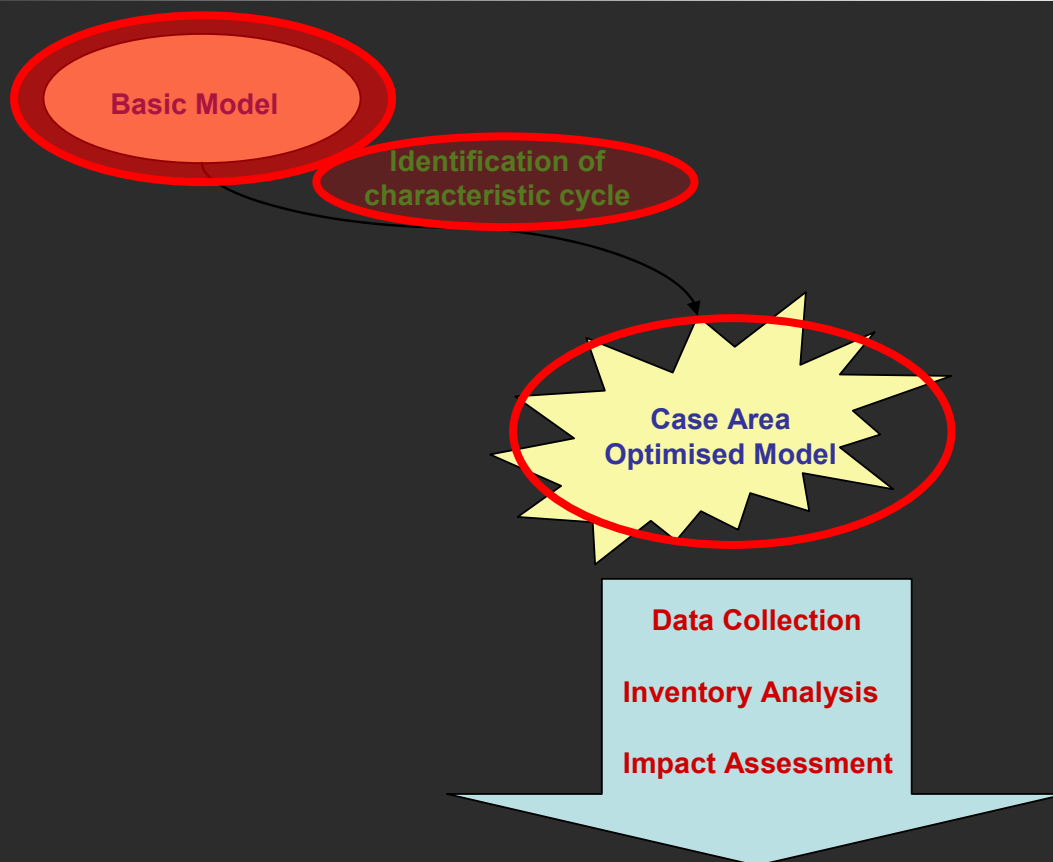


Oil storage

- Stored in plastic containers at room temperature (no energy requirements)
- Acidity test

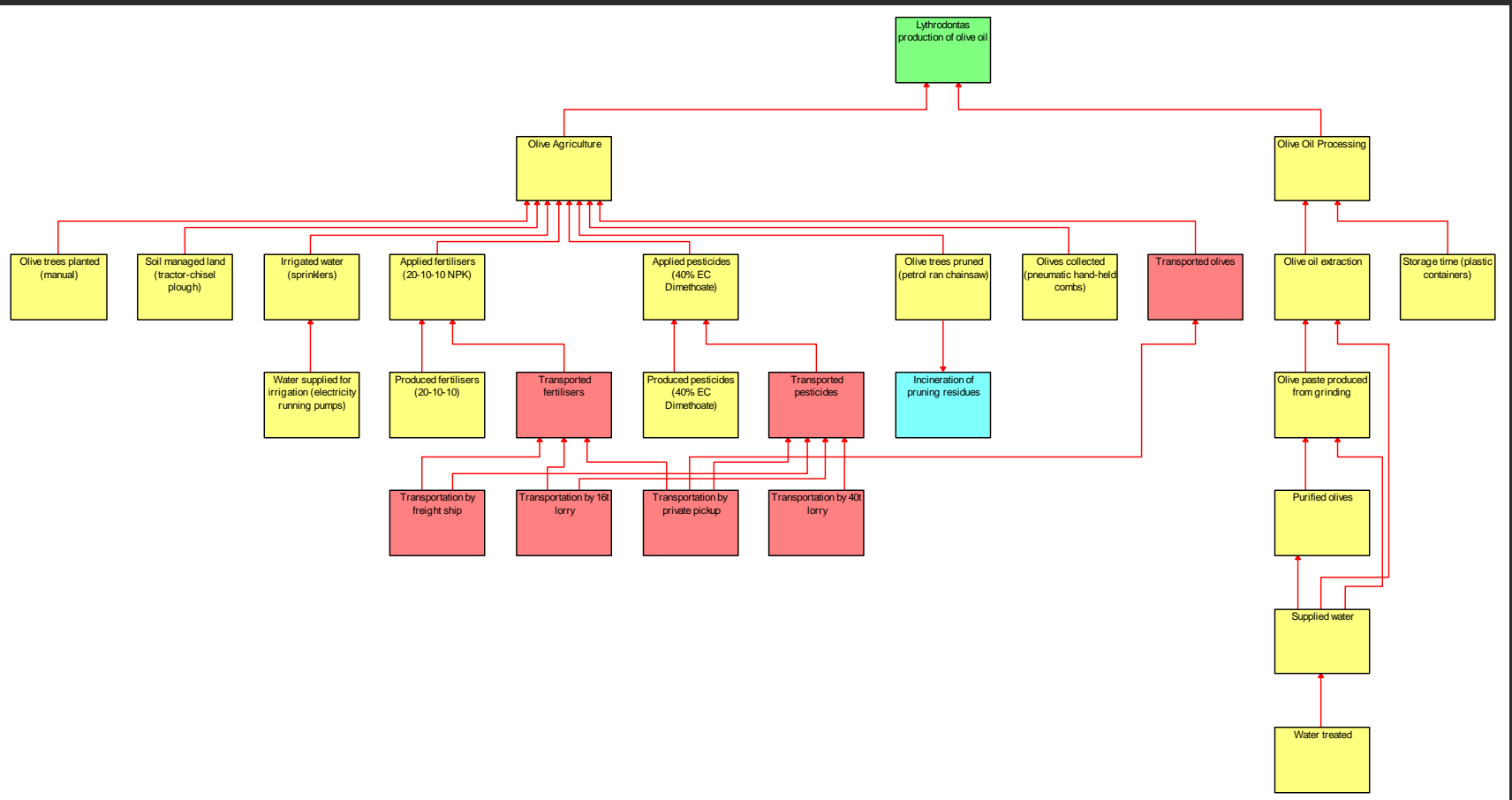


The Way Forward?

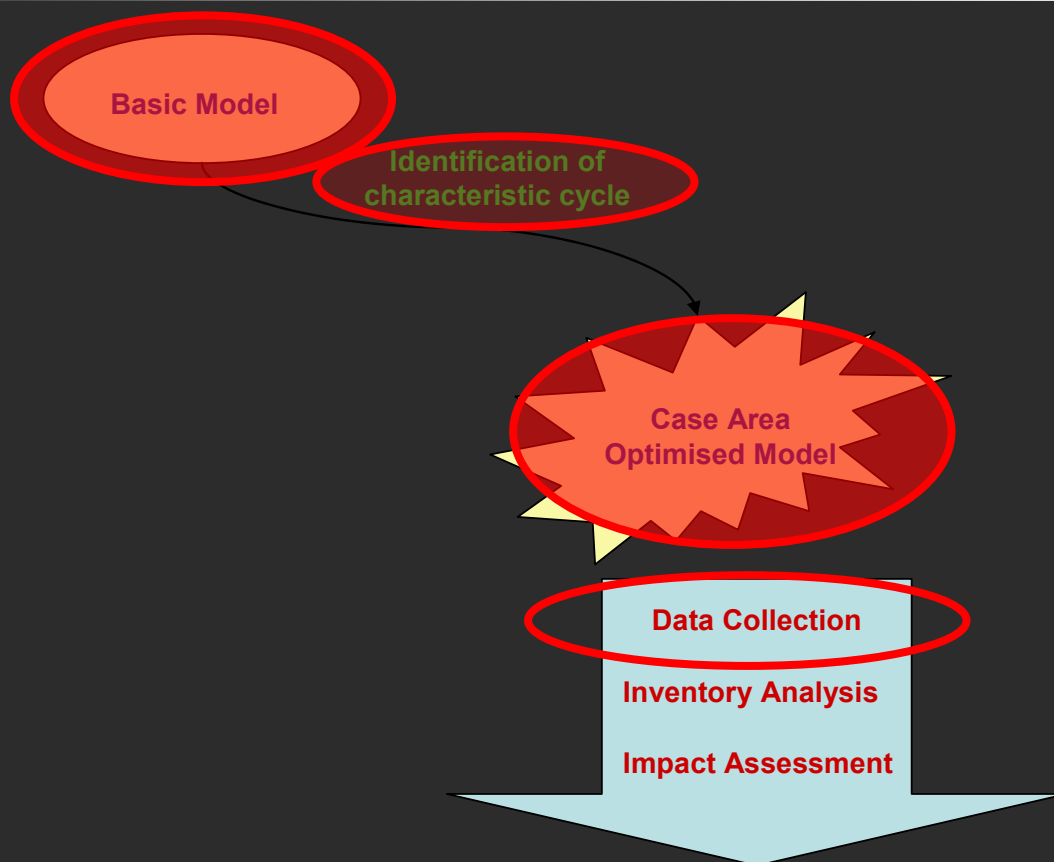


Guidelines on preventive management and policy measures

The Lythrodontas Characteristic Model



The Way Forward?



Guidelines on preventive management and policy measures

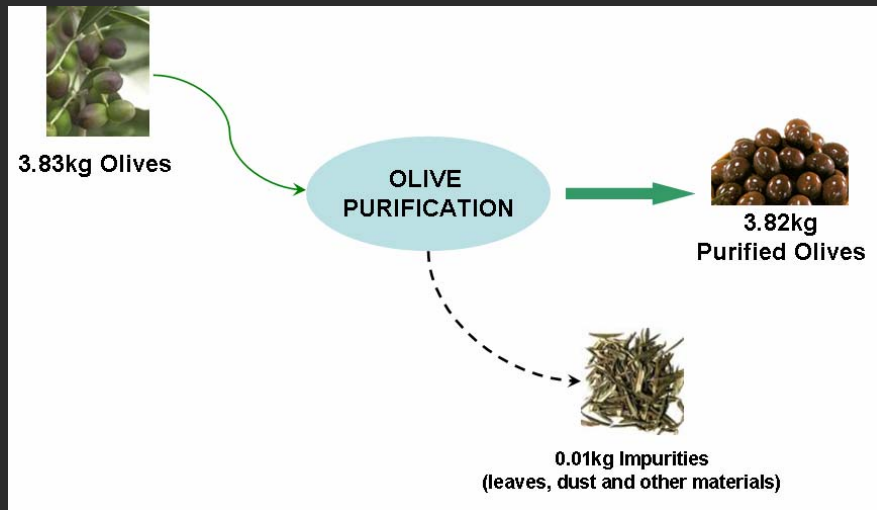
Data Collection



	Tree-weighted Average		Standard Deviation 1*		Standard Deviation 2*		Minimum value		Maximum value	
Average number of trees planted per litre of olive oil produced	0,01		0,04		0,05		0,0002		0,25	
Average land area used per litre of olive oil produced (in m ²)	0,45		0,84		0,84		0,02		3,47	
Average amount of olives per litre of olive oil produced (in kg)	4,41		0,40		0,44		3,33		5	
Average number of pruned trees per litre of olive oil produced	0,35		0,31		0,40		0,03		2	
Average land tillage area per litre of olive oil produced (in m ²)	96,38		57,75		65,07		16,1		286,7	
Average amount of Ammonium fertiliser used per litre of olive oil produced (in kg)	0,87		0,60		0,67		0,046		2,22	
Average amount of pesticide applied per litre of olive oil produced (in kg)	0,04		0,04		0,05		0,003		0,13	
Average amount of water consumed per litre of olive oil produced (in m ³)	Sprinklers method 1,40	Flood method 1,56	0,66		0,84		0,63		2,56	

<i>Operations</i>	<i>Diesel consumption (l/ha)</i>	<i>Energy consumption (kcal/ ha)</i>
<i>Mouldboard plough</i>	16.81	256,669
<i>Cultivator</i>	5.61	52,285
<i>Disk harrow</i>	6.55	61,046
<i>"Chisel" plough</i>	8.89	82,855
<i>Harrow</i>	3.37	30,476
<i>Pass with no soil tillage</i>	0.94	8,761

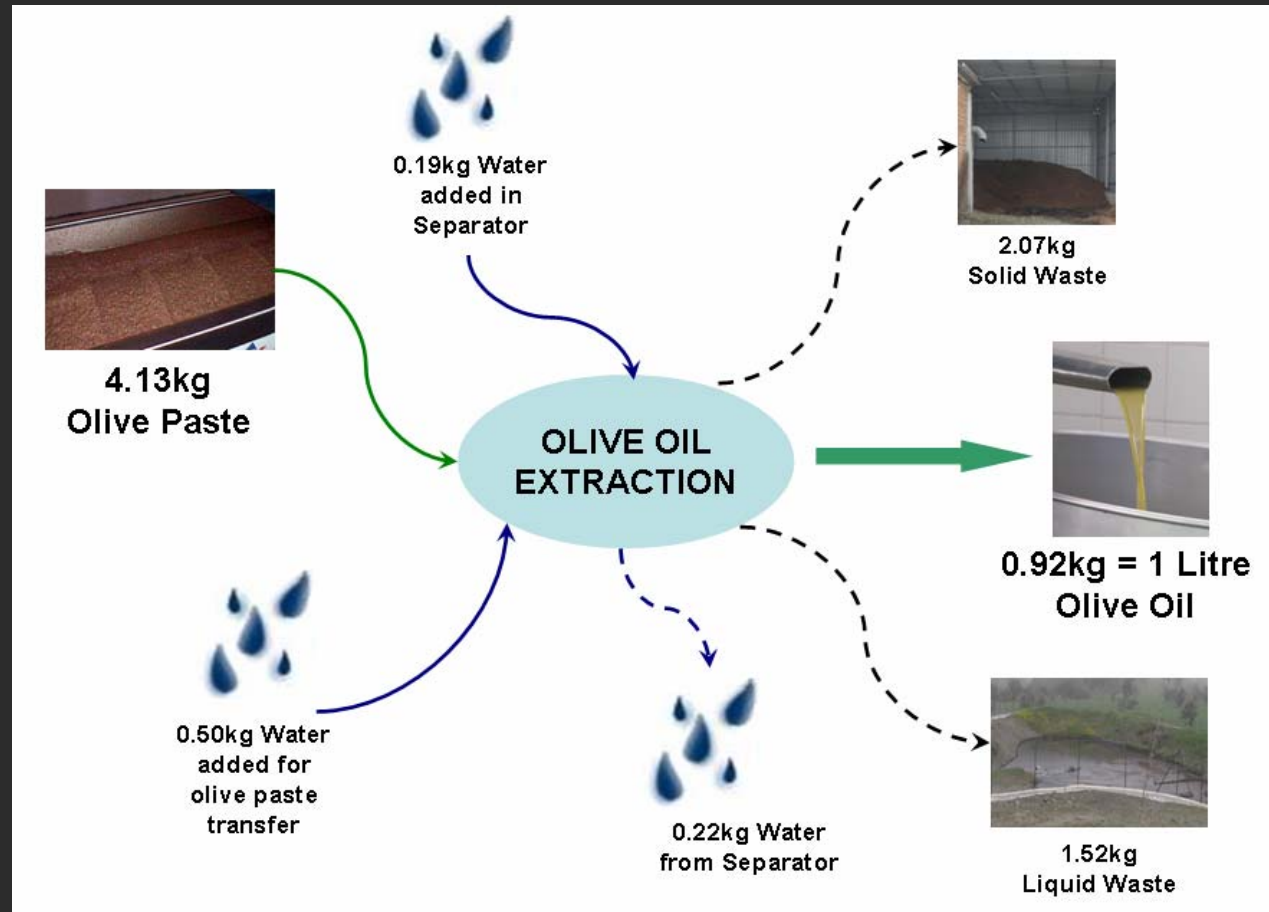
Data Collection



Mass measurements



Data Collection



Data Collection



Energy flows

Μηχάνημα	Power in kW	h:operation time (for reference flow)	E in kWh
Coveyor	1	2/26*60	1.15×10^{-3}
Washing Machine	1.5	2/60	1.92×10^{-3}
Olive Grinder	2	3/60	3.85×10^{-3}
Malaxer	3.5	45/60	0.1
Decanter	22.5	5/60	0.07
Separator	7.5	3/60	0.01
Liquid waste pump	2	22/60	0.03
Olive paste pump	0.5	3/60	7.69×10^{-4}
Pomace pump	1	5/60	3.08×10^{-3}

Data Collection



PROCESS DOCUMENTATION

PROJECT Life Cycle Assessment (LCA) as a Decision Support Tool (DST) for the ecoproduction of olive oil

TASK Data Collection for LCA implementation in Lythrodontas Region

PROCESS NAME XXXXXXXX



INPUTS

PROCESS NAME XXXXXXXX

NAME OF DATA COLLECTION

PROCESS NAME XXXXXXXX

DATE

DATA SOURCE

TIME PERIOD Select from drop-down list

COLLECTION METHOD

GEOGRAPHY Select from drop-down list

DATA REFERENCES

TECHNOLOGY Select from drop-down list

VALIDATION INFORMATION

MULTIPLE OUTPUT ALLOCATION Select from drop-down list

COMMENT

CUT-OFF RULES Select from drop-down list

SYSTEM BOUNDARY Select from drop-down list

BOUNDARY WITH NATURE Select from drop-down list

DATA QUALITY INDICATORS



ES)	compartment	Amount	Unit	Distribution	SD*2	Min	Max	Comment
	Select from drop-down list			Select from drop-down list				
	Select from drop-down list			Select from drop-down list				
	Select from drop-down list			Select from drop-down list				
	Select from drop-down list			Select from drop-down list				
	Select from drop-down list			Select from drop-down list				
	Select from drop-down list			Select from drop-down list				
	Select from drop-down list			Select from drop-down list				

OUTPUTS



PROCESS NAME XXXXXXXX

PRODUCTS AND CO-PRODUCTS

Name	Amount	Unit	Allocation %	Waste Type	Comment

WASTES

Name	Amount	Unit	Distribution	SD*2	Min	Max	Waste treatment	Comment
			Select from drop-down list					
			Select from drop-down list					

EMISSIONS TO AIR

Name	Sub-compartment	Amount	Unit	Distribution	SD*2	Min	Max	Comment
Select from drop-down list	Select from drop-down list			Select from drop-down list				
Select from drop-down list	Select from drop-down list			Select from drop-down list				
Select from drop-down list	Select from drop-down list			Select from drop-down list				
Select from drop-down list	Select from drop-down list			Select from drop-down list				

EMISSIONS TO WATER

Name	Sub-compartment	Amount	Unit	Distribution	SD*2	Min	Max	Comment
Select from drop-down list	Select from drop-down list			Select from drop-down list				
Select from drop-down list	Select from drop-down list			Select from drop-down list				
Select from drop-down list	Select from drop-down list			Select from drop-down list				
Select from drop-down list	Select from drop-down list			Select from drop-down list				

EMISSIONS TO SOIL

Name	Sub-compartment	Amount	Unit	Distribution	SD*2	Min	Max	Comment
Select from drop-down list	Select from drop-down list			Select from drop-down list				
Select from drop-down list	Select from drop-down list			Select from drop-down list				
Select from drop-down list	Select from drop-down list			Select from drop-down list				
Select from drop-down list	Select from drop-down list			Select from drop-down list				

NON-MATERIAL EMISSIONS

Name	Amount	Unit	Distribution	SD*2	Min	Max	Comment
Select from drop-down list			Select from drop-down list				
Select from drop-down list			Select from drop-down list				
Select from drop-down list			Select from drop-down list				
Select from drop-down list			Select from drop-down list				

