

CARBON FOOTPRINT OF APPLE AND PEAR: ORCHARDS, STORAGE AND DISTRIBUTION

Figueiredo, F. [1] Castanheira, É.G.[1] Feliciano, M.[2] Rodrigues, M. Â.[2] Peres, P.[2] Maia, F.[2] Ramos, A.[3] Carneiro, J. [3], Vlad, C.[1] and Freire, F.[1]

[1]University of Coimbra Portugal
[2]Polytechnic Institute of Bragança
[3]Agrarian School of Castelo Branco

ENERGY for SUSTAINABILITY 2013
SUSTAINABLE CITIES: DESIGNING FOR PEOPLE AND THE PLANET
SEPTEMBER 8-10, COIMBRA - PORTUGAL

Summary

1. Introduction

- Background and Motivation
- Main goal

2. Life-Cycle Model and Inventory

- Life Cycle model
- Inventory

3. Results

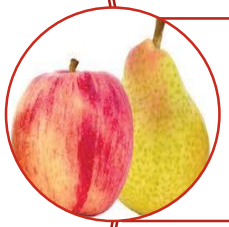
- Carbon footprint – Agricultural phase
- Carbon footprint – Storage and Distribution

4. Conclusions

Background and Motivation

LCA

Life-cycle assessment is an established tool to assess the potential environmental impacts of products;



Apple and pear represent 51% of fresh fruit orchards in Portugal;

Studies

No LCA was so far published for these types of fruits in Portugal. Some studies were performed for apple in several countries and two LCAs were published for pear in China and Switzerland.

Main goal

- **The main objective of this paper is to present a life-cycle (LC) greenhouse gas (GHG) assessment of 3 apple and 1 pear production systems in northern and central Portugal.**
  - Make a comparative inventory analysis for the two types of fruit;
  - Identify the LC phase of fruit production with higher environmental performance;
  - Identify the processes with more contributors to the GHG emissions.

Aiming at improving the environmental performance of fruit production systems in Portugal

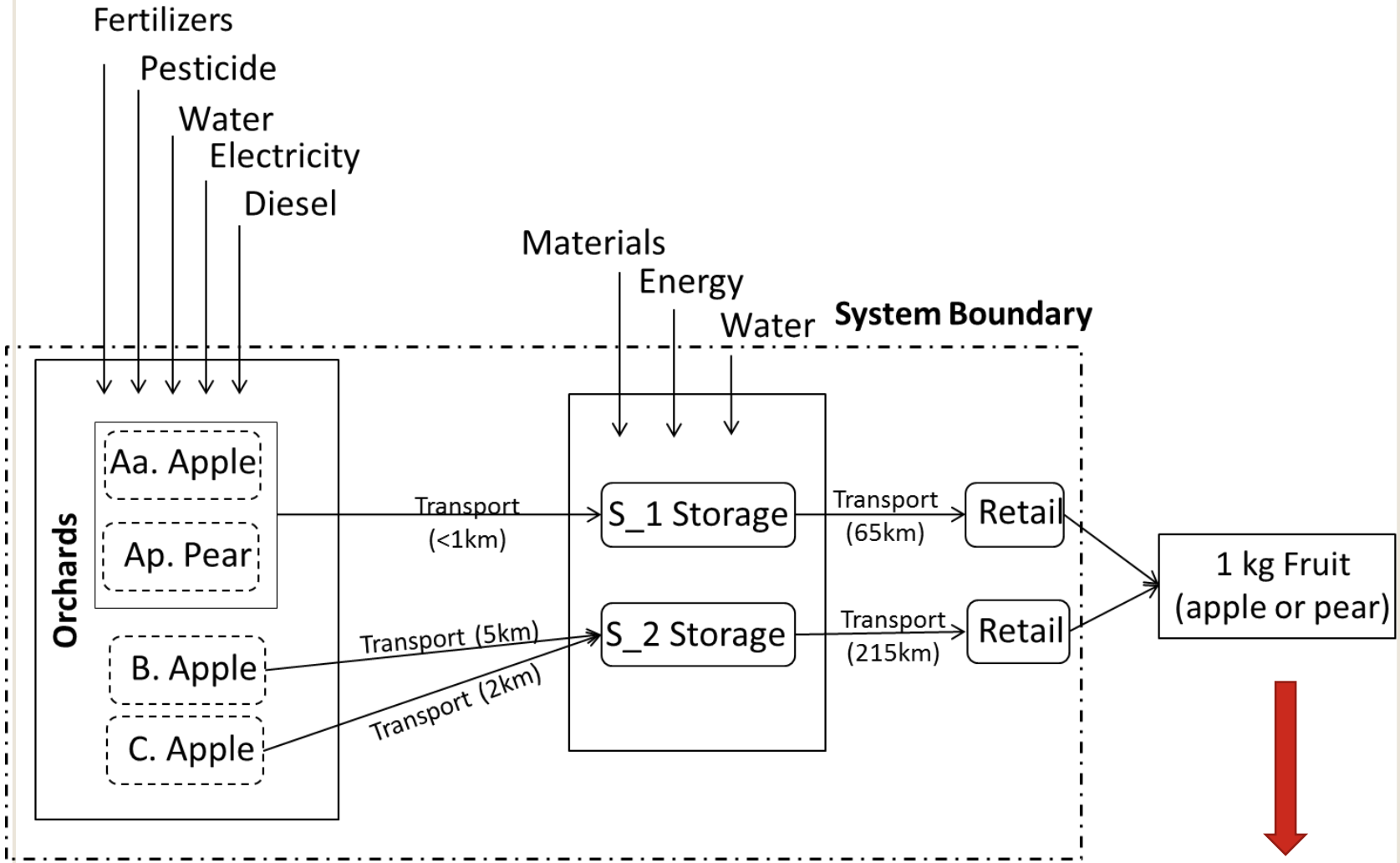
Life Cycle model

- **Four different LC inventories for orchards were implemented**

- Two ("A") in central Portugal.
  - Orchard A produced apples ("Aa": 22 ha) and pears ("Ap": 7.4 ha);
- Two ("B" and "C") in northern Portugal.
  - Orchards B (13 ha) and C (11 ha) produced apples.

- **Two different LC inventories for cold storage were implemented in the same regions (S1 and S2).**

Life Cycle model



FU: 1 kg Fruit (distributed at retail)

Inventory

Orchards

	Apple					Pear	
Orchard	Aa		B		C	Ap	
Inputs/ha	2010	2011	2010	2011	2011	2010	2011
Fertilizers							
N (kg)	51.8	56.9	72.5	38.9	27.0	46.4	50.9
N organic (kg)	2.3	17.7	13.0	-	3.0	2.0	15.8
P (kg)	195.5	66.2	170.1	48.6	75.0	175.0	59.3
K (kg)	42.5	80.5	237.9	83.9	152.5	38.0	72.0
CaO (kg)	230.0	27.1	121.8	14.4	325.0	205.9	24.3
MgO (kg)	-	-	92.6	-	102.0		
Ca (kg)	139.9	82.2	-	-	-	125.2	73.6
B (kg)	0.8	1.2			0.9	0.7	1.1
Pesticides							
Fungicides (kg)	22	31.7	3.5	4.5	5.6	19.7	28.4
Insecticides (kg)	8.6	20.8	25	7.8	21	7.7	18.6
Herbicides (kg)	6.7	1.76	4	2.4	1.8	6.0	1.6
Growth regulators (kg)	3.7	2.77	-	0.1	-	3.3	2.5
Pesticides unspecified (g)	0.16	220	-	-	100	0.1	190
Irrigation							
Water (m^3)	2000	2000	2160	2160	4500	2000	2000
Energy							
Electricity (kWh)	2778	2574.9	692.3	692.3	2600.0	2487.1	3608.3
Diesel (L)	516.6	687.5	143.6	142.8	318.2	462.5	615.5
Yield/ Production							
Apple (t)	50	50	30	28	50	-	-
Pear (t)	-	-	-	-	-	35	45

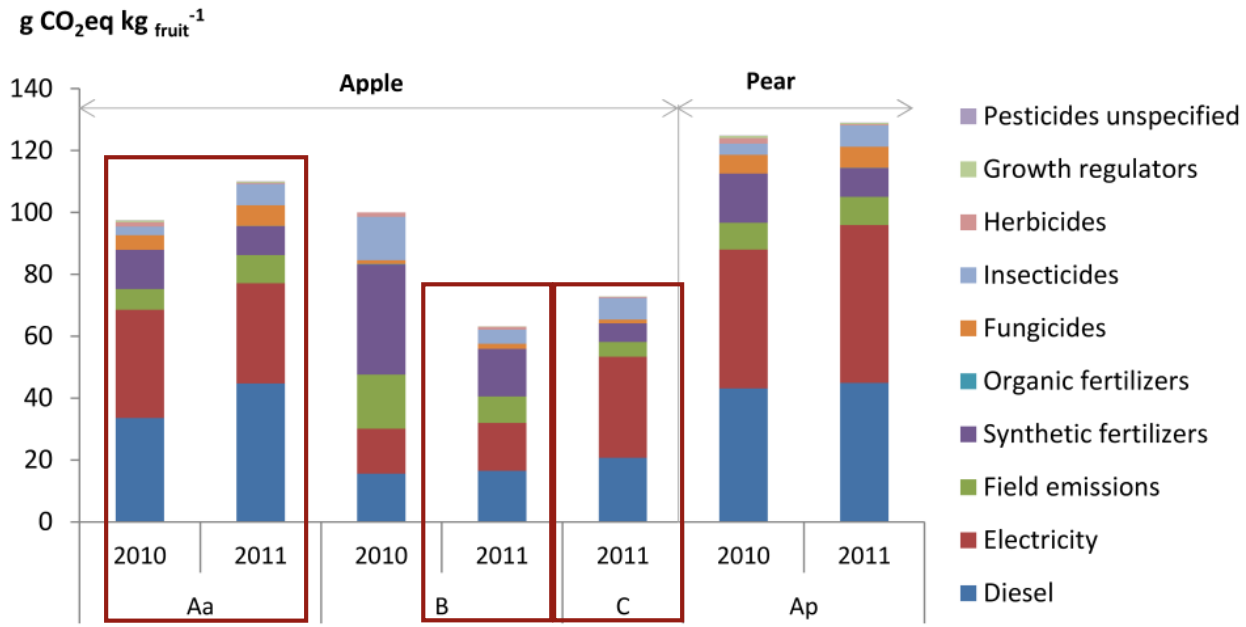
Fruit picking was done manually with a couple of local workers

The energy required for this commute during the short collecting season was negligible and thus ignored.

Storage

Storage	S_1		S_2	
Inputs	2010	2011	2010	2011
Electricity (kWh)	0.11	0.10	0.21	0.10
Propane (g)	-	-	0.07	0.04
Glycol (ml)	-	-	0.02	0.01
Boxboard (kg)	0.05	0.05	-	-
Water (L)			0.07	0.04

Carbon footprint – Agricultural phase

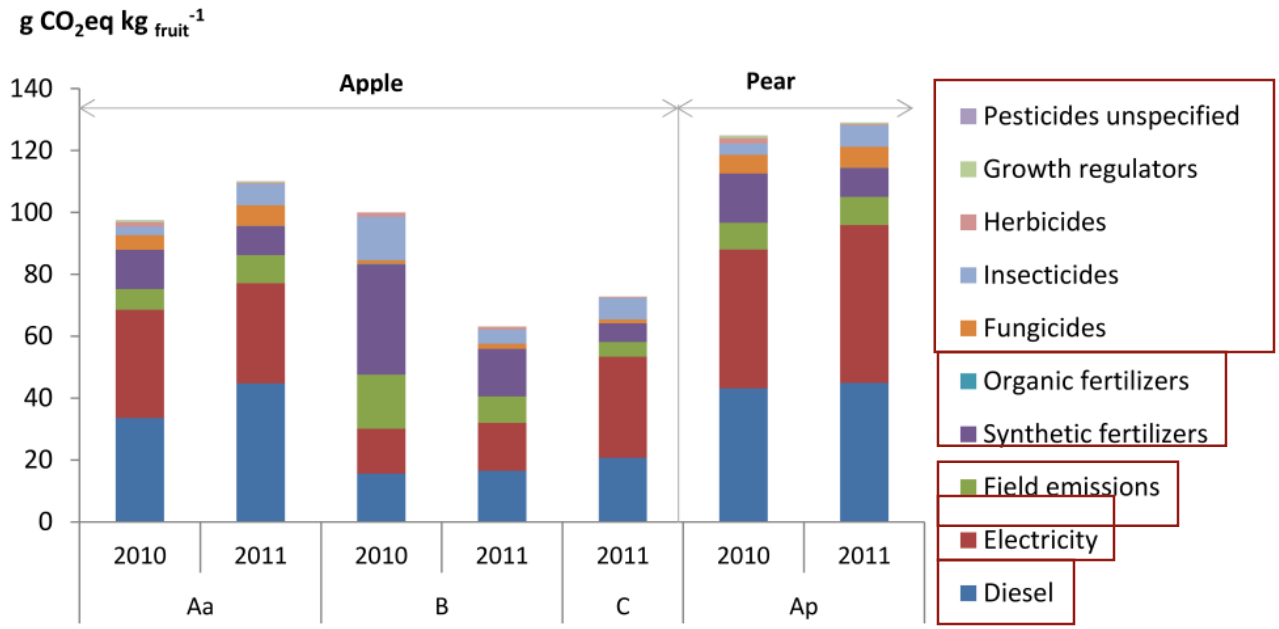


- The lowest farming emissions were calculated for apples produced by orchard B in 2011 followed by:
  - C (+13%) and A (+ 35% in 2010 and + 43% in 2011).
- Cultivation of pears (Ap) induced slightly higher emissions than apple cultivation

Essentially due to:

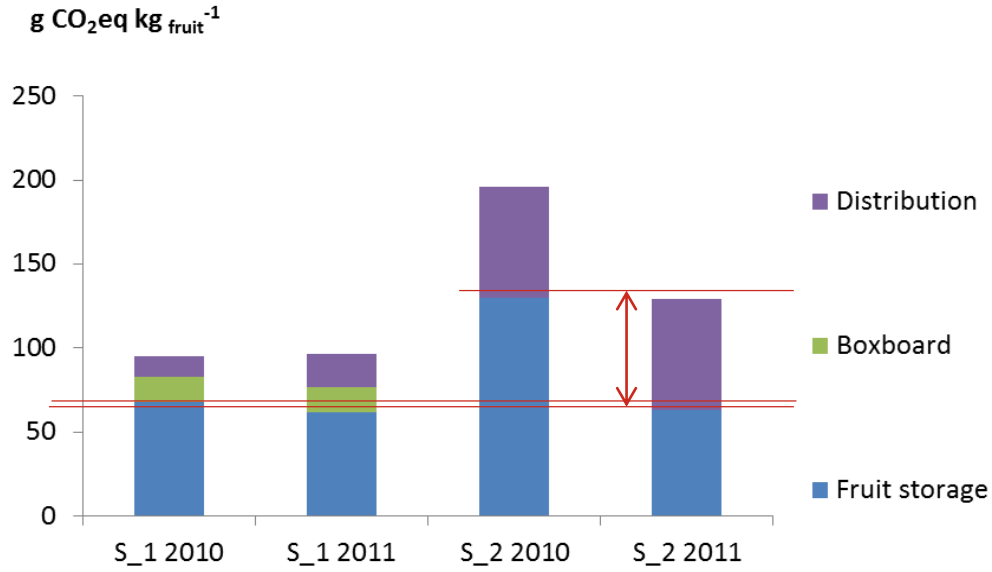
- Lower productivity per hectare (as compared to Aa and C); or
- Higher energy consumption (as compared to B).

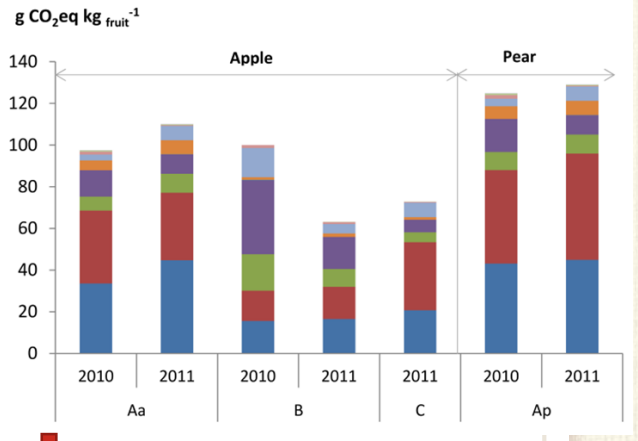
Carbon footprint – Agricultural phase



- The contributors to the cultivation phase were:
  - Diesel consumption for agricultural operations (16% to 40%);
  - Electricity used for irrigation (15% to 45%);
  - Production of fertilizers (7% to 36%);
  - Fertilization field emissions (7% to 18%);
- Production of pesticides represent less than 17% in all orchards.

Carbon footprint – Storage & distribution





192 and 229
g CO_2eq kg_{fruit}^{-1}

- The 2011 storage emissions were very similar for the two companies;
- Significant reduction in S_2 storage emissions from 2010 to 2011 due to the major changes in the ventilation system;
- The long-term storage of apples and pears is responsible for significant emissions due to high electricity requirements;
- The GHG emissions in distribution were about 2-4 times higher for S_2 compared with S_1.

Conclusions

- The GHG emissions (direct and indirect) of the cultivation phase, which ranges from 63 and 129 of total emissions;
- S_1 storage accounting for 30% to 38% and S_2 storage 31% to 33% of the total LC emissions;
- Distribution from the storage S_1 represents less than 9% of the total LC emissions, while distribution from S_2 accounts for around 30%.
- The cumulated GHG emissions of production, storage, and distribution for apple and pear varied between 192 and 229 g CO_2eq kg_{fruit}^{-1};

- Our results are consistent with previous LCA studies for fruit orchards in other countries (previous LCA studies: 82-364 g CO_2 kg_{fruit}^{-1}).

Thank you!

Questions and Comments

Center for Industrial Ecology

http://www2.dem.uc.pt/CenterIndustrialEcology

Faculty of Sciences and Technology

University of Coimbra.

This research was supported by project ECODEEP (Eco-efficiency and Eco-management in the Agro Industrial sector, FCOMP–05–0128–FEDER–018643) and the Portuguese Science and Technology Foundation projects: MIT/SET/0014/2009, PTDC/SEN-TRA/117251/2010.