lcafood 2010

VII international conference on life cycle assessment in the agri-food sector

bari, italy • september 22 • 24 2010

editors
Bruno Notarnicola
Ettore Settanni
Giuseppe Tassielli
Pasquale Giungato

proceedings • volume 2



UNIVERSITÀ
DEGLI STUDI DI BARI
ALDO MORO

POSTER SESSION B
LCA and Footprinting

Challenges in the comparability of carbon footprint studies of food products
Hannele Pulkkinen, Juha-Matti Katajajuuri, Jouni Nousiainen, Frans Silvenius 65

Putting allocation into effect for carbon footprints of composed feed products
Tommie Ponsioen, Hans Blonk 71

Development and harmonisation of a Finnish methodology for the calculation of footprints of food products
Juha-Matti Katajajuuri, Hannele Pulkkinen, Merja Saarinen, Frans Silvenius, Pauliina Nurmi 77

Integrated assessment of sustainability of the homemade production of beer: comparison of the methodologies of Life Cycle Assessment and *Bilan Carbone®*
Katia Zavaglia, Yvan Deloche 82

Outline of the Finnish system of certified Carbon Footprints of food products
Merja Saarinen, Mikko Hongisto, Kirsi Usva, Ari Nissinen, Juha-Matti Katajajuuri 88

Carbon footprint of four different Brazilian chicken feed scenarios
Rodrigo Augusto Freitas de Alvarenga, Vamilson Prudêncio da Silva Júnior, Sebastião Roberto Soares 94

Comparison of LCA and EFA for the environmental account of fruit production systems: a case study in Northern Italy
Alessandro K. Cerutti, Marco Bagliani, Gabriele L. Beccaro, Cristiana Peano, Giancarlo Bounous 99

Calculation and verification of carbon footprint in agricultural products
Juan A. Polo, Juan A. Salido, Anxo Mourelle 105

POSTER SESSION C
Primary sector and energy crops

Life cycle assessments of biodiesels: *Jatropha* versus palm oil
Wouter M.J. Achten, Joana Almeida, Pieter Vandenbempt, Evelien Bolle, Vincent Fobelets, Louis V. Verchot, Virendra P. Singh, Erik Mathijs, Bart Muys 113

LCA evaluation of 3 organic crop rotations
Lucia Coletto, Stefano Bona, Sara Gabriella Sandrini, Alessandra Brigi, Giulia Florio 119

Life Cycle Assessment of the tomato production
Giulio Mario Cappelletti, Giuseppe Martino Nicoletti, Carlo Russo 125

Product Categories Rules for flowers production
Claudia Attanasio, Massimo Guido, Antonella Lomoro 131

Integrated assessment of the nutritional and environmental performance of horticulture in Mediterranean area with compost or mineral fertilizers
Julia Martínez-Blanco, Pere Muñoz, Assumpció Antón, Massimo Castellari, Joan Rieradevall 137

The environmental implications of agriculture: from food miles to Life Cycle Assessment
Riccardo Vecchio 143

Life Cycle Assessment Analysis of greenhouse tomato production in Turkey
M. Nisa Mencet, Cengiz Sayin 149

Life Cycle Assessment of tomato and potato farming in the Autonomous Community of the Basque Country
Susana Etxebarria, Saioa Ramos, Jaime Zufía 154

POSTER SESSION D
Animal production

Life cycle assessment of Australian egg production
Stephen Wiedemann, Eugene McGahan, Elizabeth Zadow 163

Environmental impacts from capital goods in LCA of meat products
Hanne Møller 169

Life cycle assessment of cow and goat milk chains in France
Claver Kanyarushoki, Hayo M.G. van der Werf, François Fuchs 174

Transport energy for Swedish locally produced dairy cow feed
Ingrid Strid 180

The challenges of comparing the environmental impacts of butter and margarine in Western Europe
Nicole Unger, Katarina Nilsson, Anna Flysjö, Jennifer Davis, Sarah Sim, Simon Bell 186

LCA of high quality milk: main indicators and benefits due to company environmental improvement
Mirella Di Stefano, Vittorio Zambrini, Fabrizio Boeri, Marco Montani 192

Life Cycle Assessment applied to two French dairy systems
Armelle Gac, André Le Gall, Hayo M.G. van der Werf, Christelle Raison, Jean-Baptiste Dollé 198

Using environmental constraints to formulate low-impact poultry feeds
T.T.H. Nguyen, I. Bouvarel, P. Ponchant, H.M.G. van der Werf 203

Life Cycle Assessment of milk production in Argentina: one first approach
Oscar Pastorutti, Candela Cortabarría, Leila Schein, Liliana Saucede 209

Life cycle comparisons of greenhouse gas emissions from pasture-based dairy production of Ireland
Mingjia Yan, James Humphreys, Nicholas M. Holden 215

Using LCA in a forecasting method for reducing environmental impact of dairy farms
Aurélie Wilfart, David Duchène, Jérôme Barbier, Hayo M.G. van der Werf, Michael S. Corson and Joël Aubin 221

Life Cycle Assessment analysis of greenhouse tomato production in Turkey

M. Nisa Mencet[*,1], Cengiz Sayin[2]

[1] Ph. D. Candidate, Akdeniz University, Faculty of Agriculture, Department of Agricultural Economics, Antalya, Turkey
[2] Prof. Dr., Akdeniz University, Faculty of Agriculture, Department of Agricultural Economics, Antalya, Turkey

ABSTRACT

Tomato production in greenhouses has been rapidly increasing for the last decade in Turkey. The volume of tomato production in Turkey, which is the fourth biggest tomato producer country in the world, is approximately 10 million tones. Fresh vegetables consumption is essential for balanced and healthy daily diet. Tomato is one of the most important vegetables for human health because it contains lycopene and on the other hand tomato has special flavor especially for Mediterranean cuisine. Although it has a high value for human nutrition, some chemical inputs, which are hazardous, are emitted to soil, water, air etc during the production process. The objective of this study relies on applying LCA methodology to agriculture and, focusing on environmental burdens of tomato production in greenhouses in Turkey. The data for this study is collected from tomato producers who produce tomato conventionally in greenhouses in Antalya Region. The survey is made by talking to producers and their advisers; they filled out the questionnaire about input material usage during the production process. The expected contribution of this study is the use of LCA methodology and tools, to create a discussion on sustainable production and production methods.

Keywords: LCA for agriculture, tomato production, questionnaire, Turkey.

1. General information

Greenhouse tomato production has been rapidly increasing for the last decade in Turkey. The volume of tomato production in Turkey, which is the fourth biggest tomato producer country in the world (FAOSTAT, 2009), is approximately 10 million tones. Besides many advantages of greenhouse production system, this system creates landscape changes, ecosystem flux variations and rising on the energy inputs and residue generation occurs (Parrado and Bojaca, 2009). Also this production system is often perceived as an artificial process, characterized by low nutritional quality of the final product and the heavy usage of chemical inputs (Muñoz et al., 2008). Today, production techniques are more advanced and sometimes new technologies brings pollution by heating boiler in greenhouses (especially coal usage), emissions from fossil-fuel combustion by transport and trucks etc. While getting fresh vegetables for daily diet, production techniques may give harm to environmental components (mostly to soil, water, product, air, human etc.)

The scope of Life Cycle Assessment (LCA) studies and its components are highly diverse. LCA methodology application on agriculture sector is essential to explore environmental side effects of production. Despite many restrictions to find accurate agricultural data, it is also hopeful to use some databases (e.g Eco Indicator 99 (H) LCA Food V2.02 etc.) to make LCA analysis.

Searching environmental burdens in tomato production is aimed in this study. There are environmental costs to the new generation on earth, and techniques to be used for decreasing environmental friendly methods. The objective of this empirical study, is determining the

* Corresponding Author e-mail: nmencet@akdeniz.edu.tr

main factors of environment pollution, caused by the tomato production in greenhouses, by using LCA methodology.

2. Material and method

This study has arisen from the regional environmental assessment need for agricultural products. The main source of this study consists of the original data collected from tomato producers in Antalya province in Turkey. Tomato is the most prefered vegetable because of its marketing facitilites and high profit margin. Tomato needs more fertilizers and pesticides than the other vegetables in this region. Antalya is the biggest tomato producer region in Turkey (1.712.000 tones and 18% of total tomato production in Turkey). Therefore, while the quantity of production rises, the amount of input rises as well.

The method of this study was based on LCA, to explore environmental affects from the production stages. Life cycle inventory analysis is the first part of this study. Then, collected data was analyzed according to the impact categories. According to Nemecek and Erzinger (2005), due to the large number of influencing factors (climate, soil, farm size and type etc.) the production situations and emissions are highly variable. Finding proper data for evaluating the environmental impacts of the products is relatively difficult outside of Europe, U.S. and Japan. Available databases are not suitable for LCA analysis of agricultural products in Turkey. Because, the structure, production type, product variety, inputs, environmental conditions, climatic characteristics etc. vary. Since agricultural production doesn't have an homogeneous structure, there is an high diversification between the regions. Therefore, making LCA studies for agriculture is not easy (Weidema and Meuesuen, 2000). Most of the literature sources related to LCA, refers that the survey methods needs more time, labor and budget. This fact is also valid for Turkey. Turkish producers have a small scale structure and this makes the data collection more difficult. To handle this problem, sampling method is used in this study and the survey is conductued for tomato producers. Therefore, a 'face to face' interviews have been done with producers. At first, preliminary questionannaire was applied to check whether the question works or not. The biggest and most serious problem was, collecting fertilizer and pesticide data from producers because most of the producer don't keep records. Sampling area is 65550 m2 and producers grow tomato either in plastic greenhouses or glass greenhouses. Producers produce tomato two season cycles in a year. They generally plant nurseries (small plants) in the soil by the the mid August and they start to harvest after 70-100 days following and it continues till January. After that, producers make preparations and plant the nurseries (not seeds) by February and start harvesting by March until June.

The functional unit is determined as 'kg' according to the LCA litterature for tomato cultivation. Nemecek and Erzinger (2005) is defined the system boundry as the 'production process'. System boundry excludes wastes by the production. Also, carbon fixation by plant in agriculture, is not considered as a negative emission (Anonymous, 2009). In this study, SimaPro 7.1 is used and the study discusses the results of tomato production variables entered into this LCA Software. Eco Indicator 99 (H) LCA Food V2.02 database results is used for emission for this study.

Greenhouses are defined as means of overcoming climatic adversity, using a free energy source, the sun (Hanan, 1997). However, only some parts of the world, heating may not be required. Mediterranean countries are one the place that solar energy is very convenient for providing energy. Anton et al., (2003) and Anton et al. (2005) indicated that almost all producers don't use heating materials because of the production period in traditional greenhouses especially in Mediterranean countries. Therefore, environmental burdens have arisen from heating, are highly limited. Producers in the research area also declared that there

is no need for heating. But it isn't the same everywhere in Antalya region. They apply solarization during summer before planting the plants, so, plants are stronger against the diseases and it indirectly reduces the heat needed. Plastic cover (nylon) for soil is used for solarization to eliminate the pathogens. However, plastic materials pollute the environment (indicated in the next section of the study) as much as the other products. After the solarization process, plants are ready to plant out.

Many substances are considered as an "inventory" part of LCA. However, some of them are not included in the impact assessment side. Some inputs and materials do not have important effects. For example, the pesticides, the fungicides and the other chemical substances used for pathogens and viruses in plants, could not be included to LCA. The emissions in database don't exist to analyze the impact assessment. Electricity is not included in inventory analysis due to traditional greenhouses that doesn't need much electricity for machine usage and water pumping. Also, it is assumed that, the water quality is the same in every field. The quantity of water is estimated roughly according to the characteristics of the region.

3. Results and discussion

The basis of any LCA is creating a model which contains the amounts of all inputs and outputs of processes that occur during the life cycle of a product (Anonymous, 2009). Impact assessment has been applied with the variable entries in the inventory database. The categories were depicted in Figure 1 as percentages of damage assessment and listed in Table 1 as values with equivalent units.

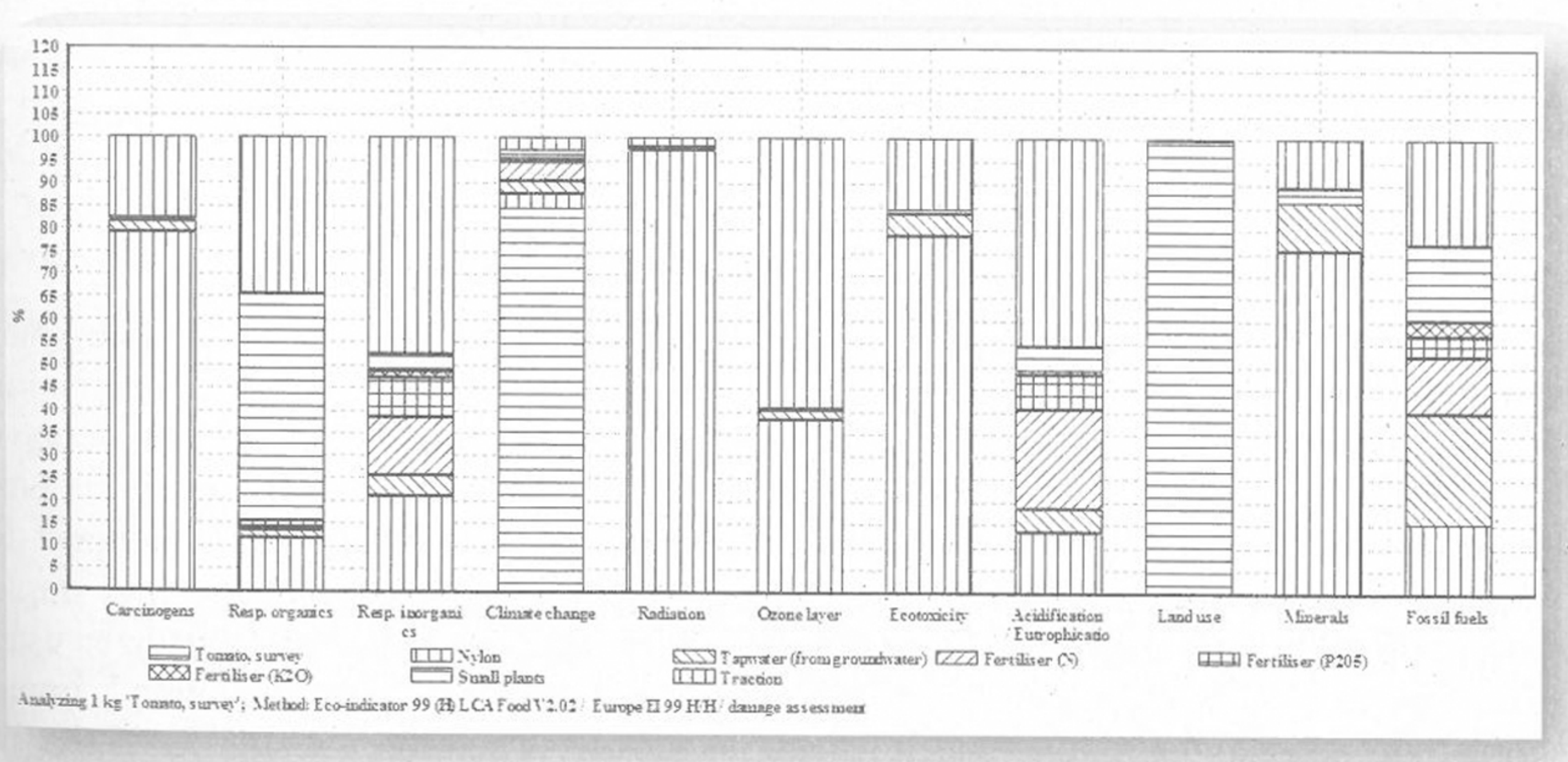


Figure 1: Percentage of damage assessment of material used for tomato production (SimaPro 7.1)

It is mentioned in a Final Report of Concerted Action, as a general rule, "the emissions associated with Nitrogen (N), Phosphorous (P2O5) and Potassium (K2O) should be allocated according to recommended quantity for each crop" (EU Commission, 2003). Hence, the fertilizers were allocated to active ingredients which are based on N, P and K. Acidification/ Eutrophication (CML) is occurred by 22% Fertilizer (N), 15% Nylon, 45% Traction and the others. Therefore, if we exclude the traction, Fertilizer (N) and Fertilizer (P2O5) will have the highest percentage for causing to CML respectively. Ozone layer depletion is 60% nylon (plastic), 37%fossil fuel used in traction process and 3%. Respitory organics has occurred

because of small plants were plant out by traction process. About climate change, fertilizers (N) percentage (5%) was found relatively lower than the expected in this study. Nylon usage has the highest ratio (75%) to cause Carcinogens and Radiation (97%) Fossil fuels depletion is caused by the different sources as tapwater (25%), traction (23%), small plants (21%), nylon (15%) and fertilizers (K2O and P2O5) respectively. Ecotoxicity is also caused by the nylon usage. It can be mentioned that nylon has the highest environmental burdens. If another material is found (except nylon or plactic) for solarization of soil, this impact will be reduced (Figure 1). Damage categorization is explained with values in Table 1 which has the same results in Figure 1.

Table 1. Analyzing 1 kg 'Tomato, survey' with Impact Categories (SimaPro 7.1)

Impact category	Unit	Nylon	Tapwater	Fertiliser (N)	Fertiliser (P205)	Fertiliser (K2O)	Traction
Fossil fuels	MJ surplus	0,0056068	0,009041594	0,00447548	0,00166347	0,00120012	0,0084331
Minerals	MJ surplus	3,45E-05	4,79E-06	0	0	0	4,82E-06
Land use	PDF*m2yr	0,0001557	6,81E-06	0	0	0	1,67E-05
Acidification/ Eutrophication	PDF*m2yr	8,85E-05	3,74E-05	0,00014446	4,98E-05	6,72E-06	0,0003035
Ecotoxicity	PDF*m2yr	0,000102	6,33E-06	1,84E-10	1,54E-10	6,60E-11	2,02E-05
Ozone layer	DALY	4,31E-12	2,08E-13	0	0	0	6,70E-12
Radiation	DALY	1,21E-10	7,12E-13	0	0	0	2,46E-12
Climate change	DALY	1,16E-09	9,77E-10	1,42E-09	1,99E-10	1,36E-10	1,00E-09
Resp. inorganics	DALY	3,19E-09	6,79E-10	1,92E-09	1,29E-09	2,11E-10	7,22E-09
Resp. organics	DALY	8,03E-12	1,25E-12	5,83E-13	6,00E-13	1,90E-13	2,35E-11
Carcinogens	DALY	2,79E-10	8,57E-12	1,84E-13	8,01E-14	5,77E-14	6,29E-11

4. Conclusions

In this study, tomato production is assessed according to the life cycle assessment approach in this study. Although, there are numerous studies about N-use investigations (Bentrup et al., 2004), there are no studies or reports about LCA applications in the scope of agriculture yet in Turkey. This study is prepared to attract attention to the environmental pollution caused by agriculture and to obtain portable data. This study was conducted for only traditional tomato cultivation in greenhouses. The results show that the first impact category called "acidification" is occurred mostly from traction (%45) and fertilizer usage (%25) respectively. "Carcinogens and radiation" and "ozone layer depletion" impact categories are consists of nylon (plastic) material mostly. Therefore, beside fertilizers the other substances also should be evaluated if data are available to make analysis.

In this study, raw materials and the energy resources (environmental input) is included to LCA analysis. The lack of the study is, pesticide contribution to environmental damage and waste management analysis. Also other substances like fertilizers and building materials would be added to inventory analysis. The production process of the tomato does not generate co-products so allocation rule was not applied. As Anton et al., (2003) indicated in her study, there is a need to develop more knowledge on transfer factors taken into account local conditions and type of application for each pesticide. It is also essential that soilless culture in modern greenhouses should be examined and compared (by LCA) in two different systems. Because, inputs as technology, labor, natural resource usage differs from traditional

and modern greenhouses. LCA studies need local databases , and local areas need more LCA studies to reduce the environmental damages in many production or service sectors. For further studies, more databases should be created for Turkey by different projects.

***Acknowledgement**: Authors would like to thank to TUBITAK to support the project "Ecologic, Economic and Policy Analysis of Greenhouse Tomato Production Systems: Antalya Province Case". Software (SimaPro 7.1) is obtained by SETAC/UNEP.*

5. References

Anonymous (2009): SimaPro Life cycle inventory analysis http://www.pre.nl/Life_cycle_assessment/life_cycle_inventory.htm [Accessed 13.11.2009]

Antón A., Castells F., Montero J.I., Muñoz P.: (2003): Most significant substances of LCA to Mediterranean Greenhouse Horticulture, Life Cycle Assessment in the Agri-food sector Proceedings from the 4th International Conference, October 6-8, 2003, Bygholm, Denmark.

Antón A., Castells F., Montero J.I., Muñoz P. (2005): LCA and tomato production in Mediterranean greenhouses. *International Journal of Agricultural Resources, Governance and Ecology*, 4(2), pp. 102 - 112.

Bentrup F., Küsters H., Kuhllman H., Lammel J. (2004): Environmental impact assessment of agricultural production systems using the life cycle assessment methodology: I. Theoretical concept of a LCA method tailored to crop production. *European Journal of Agronomy*, 20(3), pp. 247-264.

FAOSTAT (2009): Statistic web site. http://faostat.fao.org/site/567/DesktopDefault.aspx?PageID=567#ancor

Hannan J.J. (1997): Greenhouses, Advanced Technology for Protected Horticulture, Book Collins, CRC Press. CO.

Muñoz P. Antón A., Nuñez M., Paranjpe A., Ariño J., Castells X., Montero J.I., Rieradevall J. (2008): Comparing the environmental impacts of greenhouse versus open-field tomato production in the Mediterranean region. *Acta Horticulture*, 801(2), pp. 1591-1596.

Nemecek T., Erzinger S. (2005): Modelling representative life cycle inventories for Swiss Arable Crops, *Int J LCA*, 10(1), pp.1-9.

Parrado C.A., Bojaca C.R. (2009): Environmental Impact of Greenhose Tomato Production Strategies Using Life Cycle Assessment Approach, ISHS Acta Horticulture 821: 125-132. International sysmposium on tomato in the tropics. http://www.actahort.org/books/821/821_13.htm Accessed 13.11.2009

Weidema B.P., Meeusen M.J.G. (2000): Agricultural data for Life Cycle Assessment, Concerted Action PL-97-3079 of the EU Food and Agricultural Programme (FAIR), Agricultural Economics Research Institute (LEI),The Hague.