PROCEEDINGS

International conference on Life Cycle Assessment as reference methodology for assessing supply chains and supporting global sustainability challenges

LCA FOR "FEEDING THE PLANET AND ENERGY FOR LIFE"

Stresa, 6-7th October 2015
Milano, Expo 2015, 8th October 2015

Edited by Simona Scalbi, Arianna Dominici Loprieno, Paola Sposato

EXPO MILANO 2015

European Commission

ENEA
Italian National Agency for New Technologies, Energy and Sustainable Economic Development

Rete Italiana LCA

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Introduction

Life cycle assessment for supporting the transition towards eco-efficient agriculture and food systems

The Universal Exposition EXPO 2015 in Italy had as central theme “Feeding the Planet, Energy for Life”, one of the major sustainability challenge for the future. Ensuring sustainable human development means being able to feed a planet with increasing population, decoupling the development from environmental impact and answering the evolving energy demand. Nowadays, Food and Energy supply chains are associated with complex and intertwined environmental and socio-economic impacts.

The identification of solutions towards sustainability in the food and energy sectors need to rely on integrated appraisal methodologies for comparing possible alternatives, avoiding burden shifting geographically, temporally and along supply chains.

Therefore, Life cycle assessment (LCA) represents a reference methodology that helps analyzing supply chains toward achieving sustainability objectives, including improved agriculture, food production and consumption as well as more efficient energy conversion and use.

The Italian LCA network and the Joint Research Centre of the European Commission jointly organize a conference during EXPO 2015, discussing the role of LCA on the EXPO 2015 topics and presenting latest research in the field.

The studies presented in the conference, reported in these proceedings, demonstrate the relevance of Life cycle thinking and assessment as key elements towards sustainable solutions and ecoinnovation for global food challenges. An increasing global population, an evolution in consumers’ needs and the changes in consumption models pose serious challenges to the overall sustainability of food production and consumption. In defining solutions to major global challenges, life cycle thinking and life cycle assessment are applied for : i) the identification of hotspots of impacts along food supply chain with a focus on major global challenges; ii) the comparison of options related to food supply chain optimizations (increase of productivity, reduction of food losses, etc) towards sustainable solutions; iii) assessment of future scenarios both related to technological improvement, behavioral changes and under different environmental conditions (e.g. climate change); iv) assessment of social impacts associated to consumption patterns.

Analyzing these challenges from a global/ continental perspectives, major improvements are needed both in life cycle inventories - related to data availability, quality and representativeness-, and in life cycle impact assessment– where the enhancement of impact modeling for water, land use, resource and toxicity are fundamental for robust assessment of alternatives.

Due to the variety of challenges and perspectives, several methodologies are needed to answer different sustainability questions. For example, exploring concepts such as “water food energy nexus”, in light of promoting circular economy, means to optimize production of food and energy on one hand and to reduce (food)waste on the other hand. This requires a transition towards systemic thinking, where impacts of global production and consumption patterns remain within the carrying capacity of the planet, namely the sustainability thresholds identified as planetary boundaries.

This systemic thinking entails the identification of complementarity amongst methodologies and the critical analysis of their pros and cons for supporting decision making.

We hope that the concepts and the case studies presented at the conference and in these proceedings could further support cross fertilization among different science domains (such as technological, environmental, social and economic ones) towards a sustainable “today and tomorrow” in feeding the planet.

Serenella Sala and Paolo Masoni

Conference program

6th OCTOBER 2015

Stresa, Grand Hotel Bristol

08:15 - Registration

08:45 - Welcome
Serenella Sala *(European Commission, Joint Research Centre, IES)* and Paolo Masoni *(Rete Italiana LCA and ENEA)*

09:00 - **LCA as methodology for Better Regulation**
Constantin Ciupagea *(European Commission, Joint Research Centre, IES)*

09:15 - **Towards eco-efficient agriculture and food system: the special issue of the journal of cleaner production (JCP)**
Donald Huising *(editor in chief JCP)*

Session 1.1 Consumption trends and sustainability of future development

Chairs: Erwan Saouter and Constantin Ciupagea

09:30 - **The European State and Outlook 2015 - Key findings related to the food supply chain**
Ybele Hoogeveen *(European Environment Agency)*

09:45 - **Tomorrow's healthy Society: research priorities for foods and diets**
Sandra Caldeira *(European Commission, Joint Research Center, IHCP)*

10:00 - **Framing the role of LCA in integrated assessment tools for transition to sustainable food and agriculture: the case of livestock supply chains**
Camillo De Camillis *(Food and Agriculture Organization of the United Nations)*

10:15 - **Environmental Impact of the European Food Basket using LCA**
Serenella Sala *(European Commission, Joint Research Center, IES)*

10:30 - **Environmental Implications of Dynamic Policies on Food Consumption and Waste Handling in the European Union**
Michael Martin *(IVL-Swedish Environmental Research Institute)*

10:45 - **Discussion**

11:00 *Coffee Break and Poster Session*

Session 1.2. Product Environmental Footprint in the food sector

Chairs: Bruno Notarnicola and Hayo Van der Werf

11:20 - **ENVIFOOD Protocol: Facilitating consumer choice for more sustainable products**Erwan Saouter *(European Commission, Joint Research Center, IES)*

11:35 - **Developing Product Environmental Footprint Category Rules for Olive Oil**
Hanna Tuomisto *(European Commission, Joint Research Centre, IES)*

11:50 - **Pesticide emissions in the Environmental Product Footprint – Lessons learnt from refined sugar from sugar beet**
Alessandra Zamagni *(Ecoinnovazione)*

12:05 - **Nestlé Ecodesign Tool: Recent Developments that can contribute to improving the Product Environmental Footprint Initiative**
Urs Schenker *(Nestlé Research Center)*

12:20 - **Five crucial complicating issues for harmonising environmental footprints of food and beverage**
Tommie Ponsioen *(PRé Consultants)*

12:35 - **Environmental impacts of different dairy farming systems in the Po Valley**
Alessandro Agostini *(European Commission, Joint Research Center, IET)*

12:50 - **Discussion**

13:00 - *Lunch and Poster Session*

Session 1.3. Inventories and database for LCA and footprints of food chains

Chairs: Paolo Masoni and Ulf Sonesson

14:30 - **Life Cycle Inventory database for seafood products**
Sophie Omont *(CYCLECO Bureau d'études)*

14:45 - **Towards the Global Reference for Feed LCA data: the Global Feed LCA Institute**
Nicolas Martin *(European Feed Manufacturers' Federation)*

15:00 - **The World Food LCA Database: a global inventory database for the food sector**
Simone Pedrazzini *(Quantis)*

15:15 - **Creating coherent life cycle databases for ecodesign and product declaration of agro-industrial products: how to implement methodological choices**Patrik Mouron *(Agroscope)*

15:30 - **Wheat of today and tomorrow: an assessment of current LCI inventories**
Sara Corrado *(Agrisystem UCSC)*

15:45 - **Discussion**

16:05 - *Coffee break and Poster Session*

Session 1.4. LCA and footprints to assess food production chains

Chairs: Vito D'Incognito and Urs Schenker

16:25 - **Mediterranean countries' food supply and food sourcing profiles: an Ecological Footprint viewpoint**
Alessandro Galli *(Global Footprint Network)*

16:40 - **Energy Use in the EU Food Sector: State of Play and Opportunities for Improvement**
Fabio Monforti Ferrario *(European Commission, Joint Research Center, IET)*

16:55 - **Energy Flows and Greenhouses Gases of EU national breads using LCA approach**
Bruno Notarnicola *(University of Bari)*

17:10 - **Life Cycle Assessment for Enhancing Environmental Sustainability of Sugarcane Biorefinery in Thailand**
Thapat Silalertruksa *(Joint Graduate School of Energy and Environment, King Mongkut's University of Technology Thonburi)*

17:25 - **Coupling LCA with forest and geographical information system models for bioenergy: a Norwegian case study**
Clara Valente *(Ostfold Research AS)*

17:40 - **Discussion**

18:00 - **Meeting Association Italian LCA Network**

20:30 - **Social Dinner**

7th OCTOBER 2015

Stresa, Grand Hotel Bristol

08:15 - Registration

Session 2.1. LCA and footprints to assess food production chains

Chairs: Adrian Leip and Peter Fantke

08:40 - **Environmental assessment of wheat and maize production in an Italian farmers cooperative**
Valentina Fantin *(Agenzia nazionale per le nuove tecnologie, l'energia e lo sviluppo economico sostenibile)*

08:55 - **Protein quality as functional unit – a methodological framework for inclusion in LCA**
Ulf Sonesson *(SP Technical Research Institute of Sweden)*

09:10 - **LCA as a decision support tool in policy making: a case study of Danish spring barley production in a changed climate**
Monia Niero *(Technical University of Denmark)*

09:25 - **Life Cycle Assessment of Biogas Production from Freshwater Macro-algal Feedstock: Substitution of Energy Crops with Algae**
Funda Cansu Ertem *(Technische Universität Berlin)*

09:40 - **Simplified modelling of environmental impacts of foods**
Hayo van der Werf *(Institut national de la recherche agronomique)*

09:55 - **Life Cycle Assessment of Organic Rice Farming in Thailand to Support Policy Decision on Sustainable Agriculture**
Rattanawan Mungkung *(Kasetsart University)*

10:10 - **Discussion**

10:30 - *Coffee break and Poster Session*

Session 2.2. Life Cycle Impact Assessment: needs and challenges for assessing food supply chains

Chairs: Serenella Sala and Assumpció Antón Vallejo

10:50 - **Pesticide Substitution: Combining Food Safety with Environmental Quality**
Peter Fantke *(Technical University of Denmark)*

11:05 - **Outcome of WULCA harmonization activities: recommended characterization factors for water footprinting**
Stephan Pfister *(Swiss Federal Institute of Technology Zurich)*

11:20 - **Building consensus for assessing land use impacts on biodiversity: contribution of UNEP/SETAC's Life Cycle Initiative**
Assumpció Antón Vallejo *(Research & Technology Food & Agricolture)*

11:35 - **Coupling land use information with remotely sensed spectral heterogeneity: a new challenge for life cycle impact assessment of species diversity**
Benedetto Rugani *(Luxembourg Institute of Science and Technology)*

11:50 - **Biodiversity impact: Case study beef production**
Ulrike Eberle *(Private Universität Witten/Herdecke)*

12:05 - **Pollinators in LCA: towards a framework for impact assessment**
Eleonora Crenna *(University of Milano - Bicocca)*

12:20 - **Discussion**

12:40 - *Lunch and Poster Session*

Session 2.3. Eco-innovation and industrial symbiosis in the food sector

Chairs: Maurizio Cellura and Chris Foster

14:00 - **Lost water and nitrogen resources due to EU consumer food waste**
Adrian Leip *(European Commission, Joint Research Center, IES)*

14:15 - **Sustainability assessment of ultra-high pressure homogenisation for milk and fresh cheese production: from pilot to industrial scale**
Lucia Valsasina *(Aalborg University and German Institute of Food)*

14:30 - **Strategies for reducing food-waste: Life Cycle Assessment of a pilot plant of insect-based feed products**
Roberta Salomone *(University of Messina)*

14:45 - **Environmental Impact Assessment of caproic acid production from food waste: A case study of a novel pilot-scale biorefinery in the Netherlands**
Wei-Shan Chen *(Wageningen University)*

15:00 - **Recovery of waste streams from agroindustry through industrial symbiosis in Sicilia**
Grazia Barberio *(Agenzia nazionale per le nuove tecnologie, l'energia e lo sviluppo economico sostenibile)*

15:15 - **Environmental impact of using specialty feed ingredients in pig and broiler production: A life cycle assessment**
Alexander Liedke *(Thinkstep AG)*

15:30 - **Discussion**

15:50 - *Coffee break and Poster Session*

Session 2.4. Sustainability assessment of food supply chain: socio-economic drivers and impacts

Chairs: Sarah McLaren and Ulrike Eberle

16:10 - **In food supply chain: social LCA, what to do?**
Catherine Macombe *(Institut national de recherche en sciences et technologies pour l'environnement et l'agriculture)*

16:40 - **Food redistribution in Helsinki Metropolitan and Turku Area**
Kirsi Silvennoinen *(Natural Resource Institute Finalnd)*

16:55 - **An integrated LCA study to evaluate feasibility, viability and desirability of bioethanol from giant reed crop for transport in Campania Region, Italy**
Angelo Fierro *(University Federico II of Napoli)*

17:10 - **Combining frontier analysis and Exergetic Life Cycle Assessment towards identification of economic-environmental win-win situations on dairy farms**
Sophie Huysveld *(Ghent University - Institute for Agricultural ans Fisheries Research)*

17:25 - **Life cycle sustainability assessment of consumption and production of ready-made meals**
Adisa Azapagic *(University of Manchester)*

17:40 - **LCC, S-LCA and LCSA in food and energy sectors: lessons from scientific literature**
Andrea Fedele *(University of Padova)*

8th OCTOBER 2015

Expo 2015 Site, EU Pavilion, Rho

10:45 - Registration

Roundtable "LCA for feeding the planet, energy for life"

Chairs: Paolo Masoni and Serenella Sala

11:00 - **Roundtable Discussion:**

Giovanni Brunelli *(Italian representative Ministry of Environment)*

David Wilkinson *(Director of Institute for Environment and Sustainability, European Commission, JRC)*

Tassos Haniotis *(European Commission-DG AGRI)*

Michele Galatola *(European Commission-DG ENV)*

Ybele Hoogeveen *(European Environment Agency)*

Llorenç Milà i Canals *(United Nations Environment Programme)*

Camillo De Camillis *(Food and Agriculture Organization of the United Nations)*

12:20 - **Open Discussion**

Life Cycle Impact Assessment: needs and challenges for assessing food supply chains

Coupling land use information with remotely sensed spectral heterogeneity: a new challenge for life cycle impact assessment of plant species diversity

Benedetto Rugani [1], Duccio Rocchini [2]

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[2] Fondazione Edmund Mach, Research and Innovation Centre, Dept. Biodiversity and Molecular Ecology, GIS and Remote Sensing Unit / Via Mach 1, 38010 San Michele all'Adige (TN), Italy
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1. Abstract

Remotely sensed spectral heterogeneity (SH) is a viable proxy measure for species diversity detection, and is introduced here as a complementary approach to current Life Cycle Impact Assessment−LCIA practice to expand its scope for evaluation of impacts from human-driven land use change on biodiversity. This rationale is based on the 'spectral variation hypothesis': the higher the spectral variability, the higher the ecological heterogeneity and species community diversity, occupying different niches. Focusing on the local scale of food crops cultivation in Southern Alps (area of Trentino Region, IT), we observe the relationships between land cover maps and habitat heterogeneity at different time and spatial resolutions, allowing us to argue about the robustness and potentials of SH to be a surrogate measure of cross-taxon, within-taxon or environmental nuances for species variability detection in LCIA.

2. Introduction

One of the major challenges in the field of Life Cycle Impact Assessment (LCIA) is to develop consensual and operational methods to assess the human pressure on biodiversity [1, 2]. In this regard, Souza et al. [3] observe that there is a general lack of consistent landscape oriented approaches to evaluate biodiversity in LCIA, and thus recommend developing impact characterization factors (CF) for application at multiple spatial scales (local, regional, global), e.g. by replacing land cover maps with continuous environmental information, and including landscape aspects such as habitat fragmentation or connectivity of ecosystems. Hence, we seek responding to 'this' call, by acquainting on a novel approach that could potentially place a step forward the appraisal of spatial variability of vascular plant species in LCIA. This approach is presented here with a focus on local scale agri-food croplands taken as a case study. It is based on the use of remotely sensed imagery, which is to predict plant species spatial distribution at broad scale, in a timely manner and with a certain degree of confidence [4], through e.g. the identification of unique reflectance or absorption features [5]. As an example, the variability of the spectral signal over space, i.e. Spectral Heterogeneity−SH, is considered a viable proxy for species diversity detection [6]. While the effectiveness of geospatial tools for the extrapolation of information on biodiversity is known in LCIA [7], no concrete examples exist of incorporating remote sensing information in the LCIA of plant biodiversity. Nevertheless, SH offers a plethora of solutions to analyse the relationship between plant species communities or taxonomic groups and local biophysical components, allowing to assess the anthropogenic alterations on ecosystems. Assuming the latter are described by land uses (LU) and LU Changes (LUC) in LCIA, and that human activities are the main cause for changes in habitat heterogeneity, it is ideally possible to refine/establish biodiversity potential

damage indicator(s) building on the observation and processing of remotely sensed imagery. An attempt of coupling SH with the typical LU information adopted in LCIA is illustrated in this paper.

3. Materials & Methods

3.1 Study area

A study area in the Trentino Region, Italy, was selected for demonstration purposes, and because of raster data availability. The analysed area (centre: 48°11'08" N, 11°07'22" E, datum WGS84) is dominated by cropland, the majority of it made of viticulture land (> 90%). LUCs related to cropland were analysed to argue on the human induced effects on the local biodiversity due to agri-food supply-chain products over time. These LUCs were considered within a time frame of 30 years (from 1984 to 2014) using local data sources, observing a slight increase over time in viticulture land (as from Eurostat data source). However, the total cropland (the remaining cultivations be mostly apple orchards) did not remarkably change over time.

3.2 Methodological steps

Land cover data were superimposed to habitat heterogeneity maps at different time periods and spatial resolutions (or grains). In general, this can help finding statistically significant relationships between LU and LUC effects on plant species diversity, thus considering SH as a surrogate of cross-taxon, within-taxon or environmental surrogates. To this end, a Principal Component Analysis (PCA) was performed on two satellite images (a 1984 Landsat TM and a 2014 Landsat8 image) acquired in the same seasonal period (end of the autumn period). First PCA components (rescaled from 0 to 255) explained respectively 83% and 71% in the 1984 and 2014 images. Hence, they were used to calculate heterogeneity by 3×3 moving windows. Reprocesssed pixels of the first component were scaled into the range 0-255 to standardize the magnitude of the input values by making the two images comparable on the 30 years. The whole processing was done in GRASS GIS 7. 0 [8] and the code is available upon request. Final output of this approach was to obtain variation coefficients for the average SH over the 30 years of LUC in the local analysed area, considering different grains: total (SH calculated on the full cropland area), and disaggregated (SH for vineyards and the rest of croplands). This helped to infer on the statistical discrepancies between the mean heterogeneity in 1984 and in 2014, and thus to determine the influence of crop-LUC to biodiversity patterns at a very local scale.

4. Results & Discussion

SH tends to decrease in all cases by 11% on average (increase in mean variability between SH variation coefficients in 1984 and in 2014) (Fig.1a, bottom). This is mainly due to shadows in the 2014 image. This discrepancy is considered too low to argue on the actual impact on plant biodiversity. In fact, Fig.1b shows that, while the mean SH decreases, the overall variability (standard deviation range) increases over time. However, the diversity between the three paired cases (total crop area, vineyards and other crops) is not statistically significant per $p>0.05$ and $p>0.01$. Because of this, and even if occurring in terms of SH change according to the 'spectral variation hypothesis' [6], we can argue that changes in biodiversity patterns, at this very local scale are caused by factors other than LUC patterns (i.e. presence of shadows).

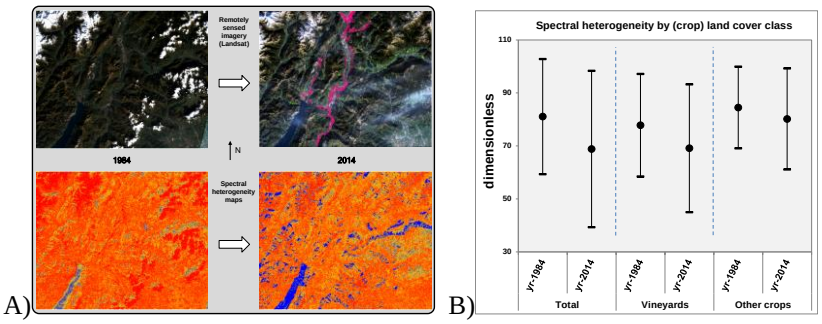

Figure 1: A) Elaboration by GRASS GIS of SH maps (bottom) from Landsat remotely sensed imagery (top; land use classes of vineyards (pink) and other cultures (green) are superimposed); B) variability (mean and standard deviation) in SH over considering different land cover hierarchical aggregations

The proposed SH-based approach can capture the changes associated with plant species diversity over time at multiple scales, by possibly linking lifecycle *land occupation* (~LU) and *transformation* (~LUC) flows with heterogeneity patterns. These could be translated in the LCIA jargon according to the hypothesis that variability in the remotely sensed signal relates to landscape diversity, which is considered a good proxy of diversity at species level [4, 6]. In this regard, for impact characterization at community and ecosystem scales, methods based on the SH rationale could complement existing CF calculations based on species-area relationship (SAR) [2, 9, 10], e.g. by improving the calculation of species richness factors in the SAR equation. It has been observed, for example, that spectral diversity is correlated with the area of each floras bounding box, because more habitats are expected to be present in larger areas, on average (which is analogous to the SAR rationale) [11]. Despite these opportunities, still some drawbacks and challenges must be overcome: 1) construction of a consistent mathematical framework to incorporate SH in LCIA; 2) quantitative comparison and/or combination with current LCIA methods; 3) the proposed SH approach can only address plant species diversity, without distinguishing among species abundance [7] or taxonomic groups.

5. Conclusion

This short paper illustrates a preliminary idea for potential development of SH-based CF for plant biodiversity in LCIA. An intensive research activity is still on-going to improve the analytical framework for routine assessment at multiple scales of land use and land use change. This could avoid using reference states or distance-to-target rationales, which are useful concepts to create archetypes but can also propagate large uncertainties in the calculation of CF for local scale assessments. Using times series SH maps (both annual and seasonal) can further reduce this subjectivity and uncertainty, while increasing the representativeness of biodiversity LCIA indicators (remotely sensed imagery provides 'real' state references).

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