The 11th International Conference on Life Cycle Assessment of Food 2018 (LCA Food 2018)

in conjunction with

The 6th LCA AgriFood Asia and The 7th International Conference on Green and Sustainable Innovation (ICGSI 2018)

Organized by

Centre of Excellence on enVironmental strategy for GREEN business (VGREEN), Faculty of Environment, Kasetsart University (KU)

The Joint Graduate school of Energy and Environment (JGSEE),

King Mongkut's University of Technology Thonburi (KMUTT)

and National Science and Technology Development Agency (NSTDA), Ministry of Science and Technology

Foreword

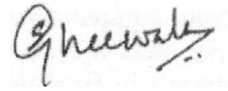
The Centre of Excellence on enVironmental strategy for GREEN business (VGREEN), Kasetsart University (KU) in collaboration with the Joint Graduate School of Energy and Environment (JGSEE) Center of Excellence on Energy Technology and Environment (CEE), King Mongkut's University of Technology Thonburi (KMUTT) and the National Science and Technology Development Agency (NSTDA) are jointly organizing the 11th International Conference on Life Cycle Assessment of Food 2018 (LCA Food). It is held in conjunction with the 6th LCA AgriFood Asia and 7th International Conference on Green and Sustainable Innovation (ICGSI). The events will be held during 16-20 October 2018 at The Sukosol Bangkok Hotel, Bangkok, Thailand.

The LCA FOOD conference is an international forum to exchange knowledge and practical experiences on LCA applications for agri-food products to enhance their sustainability. The LCA AgriFood ASIA conference serves as a regional forum to build up the capacity and exchange knowledge on LCA application for agri-food products to enhance collaborative projects at the regional level. ICGSI is a trans-disciplinary international forum focusing on green process engineering as a path towards sustainable development of societies and regions. This year's event is co-hosted by VGREEN-KU, JGSEE-CEE/KMUTT, NSTDA and FTI.

The primary purpose of LCA FOOD 2018 and concurrent events, LCA AgriFood Asia and ICGSI 2018, is to provide a global forum for the LCA community to share their perspectives on adopting LCA research and development progress and results, to exchange knowledge, views and experiences in the field of food production systems and policy, green and sustainable production and innovation. It is in this context that potential contributors from academic, research organizations, government agencies and international institutions, and private sector practitioners were invited to present their research work at the conference in the areas of science, technology and policy.
This program also contains abstracts of papers presented either orally or by way of poster during the 5-day event.

We hope the readers find this program & book of abstracts and the accompanying USB drive of proceeding, which contains all the papers presented at the conference, a useful sources of information and reference.

Asst. Prof. Dr. Rattanawan Mungkung
Co-Chairperson of the Organizing Committee



Prof. Dr. Shabbir H. Gheewala
Co-Chairperson of the Organizing Committee

Contents

Organising Committees

Rattanawan Mungkung	VGREEN, Kasetsart University
Shabbir H. Gheewala	JGSEE, King Mongkut's University of Technology Thonburi
Thumrongrut Mungcharoen	National Science and Technology Development Agency
Jitti Mungkalasiri	National Metal and Materials Technology Center, NSTDA
Sate Sampattagul	Chiang Mai University
Pomthong Malakul Na Ayuthaya	Chulalongkorn University
Surachai Sathitkunarat	National Science Technology and Innovation Policy office
Pongvipa Lohsomboon	Thailand Greenhouse Gas management Organization
Panrat Petchphakdee	The Federation of Thai Industry
Chaiyod Bunyagidj	United Analyst and Engineering Consultant Co., Ltd.

Scientific Committees: LCA Food

Assumpció Antón	IRTA, Spain
Bradley Ridoutt	CSIRO, Australia
Bruno Notarnicola	University of Bari Aldo, Italy
Bo P. Weidema	Aalborg University and 2.-0 LCA consultants, Denmark
Christel Cederberg	SIK, Sweden
Claudine Basset-Mens	CIRAD, France
Greg Thoma	University of Arkansas, USA
Hayo van der Werf	INRA, France
Imke de Boer	Wageningen University, the Netherlands
Jeroen Guinée	CML, Leiden University, the Netherlands
Kiyotada Hayashi	NARO, Japan
Llorençe Milà i Canals	UN Environment Programme
Nicholas M. Holden	University College Dublin, Ireland
Niels Jungbluth	ESU–services Ltd, Switzerland
Rattanawan Mungkung	Kasetsart University, Thailand
Shabbir H. Gheewala	JGSEE/ KMUTT, Thailand
Stewart Ledgard	AgResearch, New Zealand
Thomas Nemecek	Agroscope ART Research Institution, Switzerland
Ulrike Eberle	Corsus, Germany
Ulf Sonesson	RISE Research Institutes of Sweden, Sweden
Sarah McLaren	Massey University, New Zealand
Ian Vázquez Rowe	Pontifical Catholic University of Peru, Peru
Isabel Quispe	Pontifical Catholic University of Peru, Peru
Ramzy Kahhat	Pontifical Catholic University of Peru, Peru
Leda Coltro	The Food Technology Institute (ITAL), Brazil

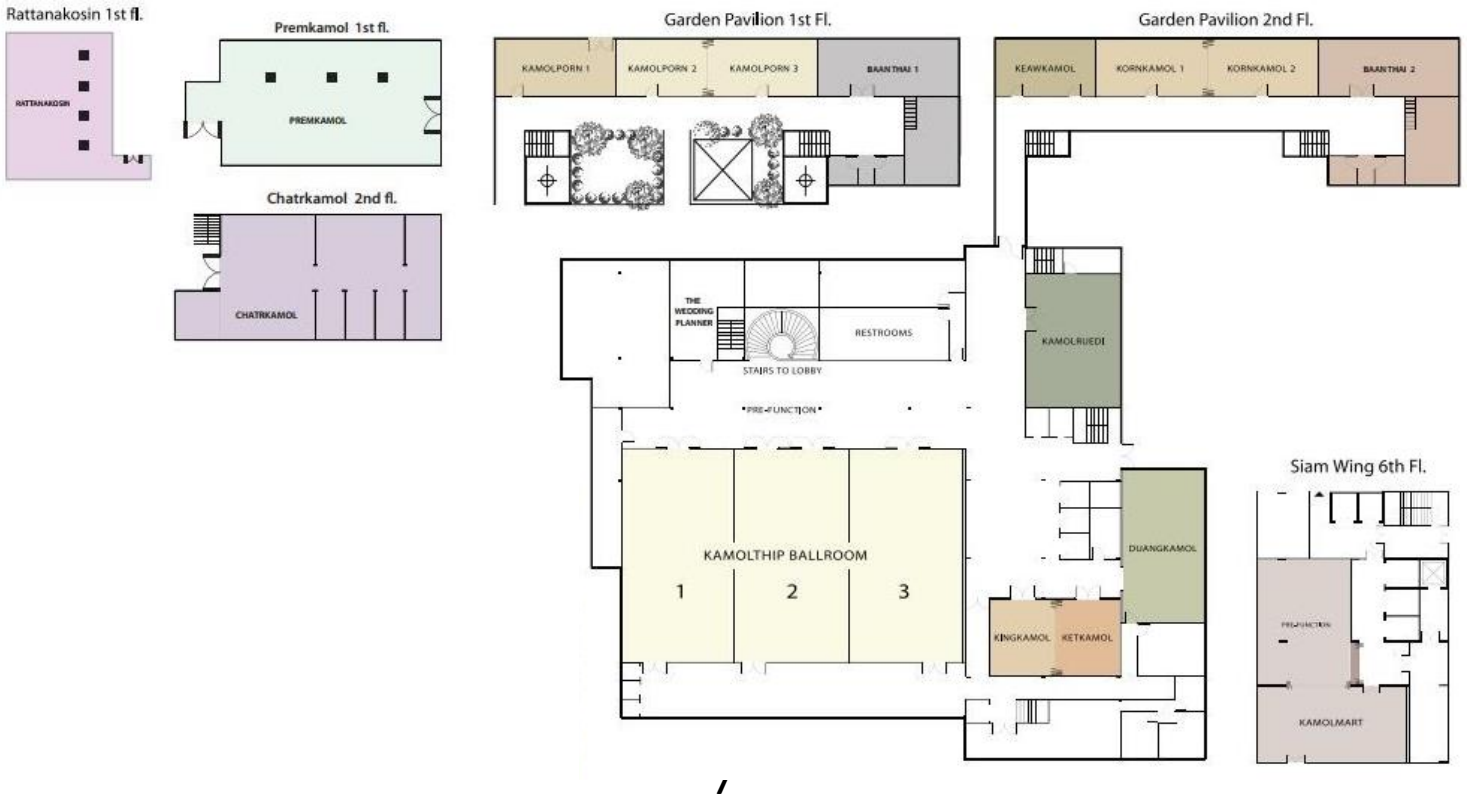
Scientific committees: LCA AgriFood ASIA

Udin Hasanudin	University of Lampung, Indonesia
Edi Iswanto Wiloso	Indonesian Institute of Sciences, Indonesia
Yandra Arkeman	Bogor University, Indonesia
Jessie C. Elauria	University of the Philippines, the Philippines
Kiyotada Hayashi	NARO, Japan
Marlia Mohd Hanafiah	National University of Malaysia, Malaysia
Sau Soon Chen	SIRIM Berhad, Malaysia
Thumrongrut Mungcharoen	NSTDA, Thailand
Shabbir H. Gheewala	JGSEE/ KMUTT, Thailand
Rattanawan Mungkung	Kasetsart University, Thailand

Scientific committees: ICGSI

Shabbir H. Gheewala	JGSEE, KMUTT
Thapat Silalertruksa	JGSEE, KMUTT
Rattanawan Mungkung	Kasetsart University
Chanikarn Yimprayoon	Kasetsart University
Cheema Soralump	Kasetsart University
Viganda Varabuntoonvit	Kasetsart University
Thumrongrut Mungcharoen	NSTDA
Jitti Mungkalasiri	MTEC, NSTDA
Seksan Papong	MTEC, NSTDA
Nongnuch Poolsawad	MTEC, NSTDA
Pornpimon Boonkum	MTEC, NSTDA
Pomthong Malakul Na Ayuthaya	Chulalongkorn University
Natworapol Rachsiriwatcharabul	Rajamangala University of Phra Nakhon
Sate Sampattagul	Chiang Mai University
Natanee Vorayos	Chiang Mai University
Napat Jakrawatana	Chiang Mai University
Trakarn Prapaspongsa	Mahidol University
Charongpun Musikavong	Prince of Songkla University
Jittima Prasara-A	Mahasarakham University

Floor Plan – The Sukosol Bangkok Hotel



KEYNOTE SPEAKERS PRESENTATIONS

Keynote Speakers

Associated Prof. Sarah McLaren

Massey University, New Zealand

Associated Prof. Sarah McLaren is the Director of New Zealand Life Cycle Management Centre (NZLCM Centre), and Associate Professor in Life Cycle Management at Massey University, New Zealand. She has worked with businesses and government to integrate life cycle thinking into management practices, product design, and policymaking for seventeen years. Currently Sarah is Chair of the Standards New Zealand International Review Group on LCA, New Zealand representative on the ISO 14046 " Water Footprint: Requirements and Guidelines" Working Group, Co-Chair of the Massey University Steering Group on Sustainability, and a Committee member of the Life Cycle Association of New Zealand. She previously worked as Research Leader at Landcare Research where she led two carbon footprinting projects for the horticultural sector, and managed the Life Cycle Management Project to integrate LCM into the operations, management and strategies of manufacturing companies. Prior to that Sarah was Director of the postgraduate Environmental Life Cycle Management Programme at the University of Surrey, UK, and Chair of the SETAC Europe LCA Steering Group.

Dr. John Ingram

Food Systems Programme Leader, Environmental Change Institute, The University of Oxford

Dr. John Ingram' s interests are in the conceptual framing of food systems; the interactions among the many actors involved and their varied activities, and the outcomes of their activities for food security, livelihoods and environment; and food system resilience. He has designed and led regional food system research projects in Europe, south Asia, southern Africa and the Caribbean and has conceived, developed and led a range of major international research initiatives. He has had substantial interaction with FAO, UNEP and CGIAR and many other international organisations, with national departments and agencies, with NGOs, and with businesses in the food sector helping to establish research on the links between food security and environment through the analysis of food systems. In addition to leading the food system research group within ECI, he also leads the multi-university post-graduate food systems training programme (IFSTAL) and coordinates the UK Global Food Security programme 'Resilience of the UK Food System'. He is an Associate Professor and Senior Research Fellow at Somerville College

Dr. Akkharawit Kanjana-opas

Deputy Secretary General, National Science Technology and Innovation Policy Office (STI) and Chief Executive Officer of Food Innopolis

Before joining STI, Dr. Akkharawit Kanjana-Opas had been responsible for the intellectual property management and technology transfer, business incubation as well as the collaborative research of the Prince of Songkhla University Science Park during 2004-2016. Currently, he is responsible for the New Economy Development based on Science, Technology and Innovation as well as the development of FoodInnopolis which the national initiative for food innovation ecosystem in Thailand. Dr. Kanjana-Opas received his Ph. D. in Marine Chemistry from Scripps Institution of Oceanography, University of California San Diego. Upon the completion of this graduate study, he has participated in several trainings in the field of Intellectual property and technology transfer in Japan, Germany, Italy, Sweden, Singapore, and Thailand. He is also certified as Thai professional patent agent by the Department of Intellectual Property, Thailand. He also teaches and conducts seminars related to intellectual property in various universities and institutions in Thailand and other ASEAN countries

Prof. Shabbir H. Gheewala

Joint Graduate School of Energy and Environment (JGSEE)

KMUTT, Thailand

Prof. Shabbir H. Gheewala is a full professor at the Joint Graduate School of Energy and Environment, Thailand where he teaches Life Cycle Assessment and heads the Life Cycle Sustainability Assessment Lab. He also holds an adjunct professorship at the University of North Carolina Chapel Hill, USA, and a Distinguished Adjunct Professor position at the Asian Institute of Technology, Thailand. He is on the editorial boards of the International Journal of Life Cycle Assessment (Springer) , Journal of Cleaner Production (Elsevier) , Energy for Sustainable Development (Elsevier) and the Journal of Sustainable Energy and Environment. His research focuses on sustainability assessment of energy systems; sustainability indicators; and certification issues in biofuels and agro-industry. Prof. Shabbir is a national expert on life cycle inventory as well as product carbon footprinting and water footprinting in Thailand. He has also worked on sustainability assessment of buildings, particularly low energy buildings. He mentors the research network on food, fuel and climate change in Thailand.

Dr. Arun Jacob

Environment Affairs Officer, Environment and Development at United Nations ESCAP

Dr. Arun Jacob works as Environment Affairs Officer at the Environment and Development Division of the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP). A development economist by training, Arun has extensively worked on themes related to sustainable development, natural resource management, international trade, technology and innovation policies and impact evaluation of policies. Prior to joining ESCAP, Arun worked at the United Nations Conference on Trade and Development (UNCTAD) and at the Centre for International Environment Studies, Geneva. Arun also worked as an Economist at the President's Office of Tanzania, where he was part of the core team that developed the national five-year and long-term development plans. Arun has published in peer-reviewed journals and is a regular contributor to flagship publications of the United Nations. Arun holds a PhD in Development Economics from the Graduate Institute of International and Development Studies, Geneva and an MPhil degree in Economics from Cambridge University (UK), where he was a Bill and Melinda Gates Scholar.

Dr. Anthony Bennett

Senior Food Systems Officer, FAO

Dr. Anthony Bennett is the Senior Food Systems officer (post production) of the Food and Agriculture Organization of the United Nations, based in the FAO regional Office for Asia Pacific (RAP) , Bangkok. Tony leads the RAP team working on food loss and waste as well as value addition and food systems. He holds a M. Sc. (Agriculture) in Engineering Technology, University College Dublin, Ireland and MA (Meritus) from Trinity College Dublin. With over 20 years of international experience in food and agro industry development, he leads the development and implementation of a portfolio of projects and programmes in Afghanistan, Pakistan, Sri Lanka and the region. Many of those programmes focus on value chains development. His areas of interest are sustainable food systems development, food value addition, food loss and waste reduction, food preservation and industry SME development.

Dr. Wijarn Simachaya

Permanent Secretary of the Ministry of Natural Resources and Environment, Thailand

Dr. Wijarn Simachaya is Permanent Secretary of the Ministry of Natural Resources and Environment, Thailand. His main responsibilities are natural resources and environmental plans and strategy development, international cooperation on natural resources and environment issues, representatives of the ministry of various UN, Sub-regional, and ASEAN forums. He has worked as a chairman of green growth strategy development and SDGs working groups for Thailand. Dr. Simachaya joined the Office of Environmental Policy and Planning Board in 1984 and Pollution Control Department in 1992. He used to serve as a director of the Environment Division of the Mekong River Commission Secretariat (International Organization) in Lao PDR in 1997-1998. He has served several high ranking positions in the ministry including Inspector General of the Ministry of Natural Resources and Environment, Director-General of the Pollution Control Department, Secretary General of the Office of Natural Resources and Environmental Policy and Planning and Deputy-Permanent Secretary of the Ministry of Natural Resources and Environment.

Associated Prof. Thumrongrut Mungcharoen

Chairperson of the Energy and Environment Cluster, National Science and Technology Development Agency (NSTDA), Ministry of Science and Technology, Thailand

Associated Prof. Thumrongrut Mungcharoen obtained BEng (Hons) from Chulalongkorn University and PhD from the University of Texas at Austin. During the past 25 years, he has been involved extensively as a expert in several projects on cleaner production, life cycle assessment, and eco-design for several local and international organizations (such as TEI, FTI, ERIA, APO, APEC, UNIDO and UNEP). He is one of the key persons who initiated the "Thai National Life Cycle Inventory Database", "National Scheme of Thai Carbon Footprint Label", and "Science Technology and Innovation for SDGs initiatives in Thailand". Representative awards he received are Fellow Award from Petroleum Institute of Thailand, Outstanding Academic Award from Kasetsart University, and Excellent Research Award on Alternative Energy from Ministry of Energy. He is currently the Board of Trustees of the Asia Pacific Roundtable for Sustainable Consumption and Production (APRSCP). He has more than 220 technical publications.

Mr. Numpol Limprasert

Sustainable Development Director, The Siam Cement Public Company Limited (SCG), Thailand

Mr. Numpol Limprasert has joined Siam Cement Group (SCG) since 1996 and has extensive experience in various fields i. e., production, engineering, operation, logistics, energy and management. He has embarked on a sustainable development field since 2009. With the current role as the Sustainable Development Director, he collaborates and works closely with the three business units of SCG to implement, monitor and ensure that all operations along the value chain are responsibly wellmanaged in accordance with SCG sustainable development policy, direction and strategies. Being the Secretary to SCG Sustainable Development Committee, Mr. Numpol plays a crucial role to shape sustainability pathway of SCG. He provides trends and insights on sustainable development issues together with SCG's gap analysis for the Committee's decision making on sustainability policy and transformative roadmap towards sustainable future of SCG. In 2017, he initiated the restructuring of sustainable development management structure into economic, environmental and social dimension in order to strengthen the corporate sustainability implementatio

PROGRAM

OVERVIEW PROGRAM

LCA FOOD 2018

In conjunction with LCA AgriFood ASIA and ICGSI

16-20 OCTOBER, SUKOSOL HOTEL, BANGKOK, THAILAND

October 16, 2018: Pre-conference workshops

Time	Program
08.30 - 09.00	Registration
09.00 - 17.00	2 Parallel workshops: (1) Food Loss and Waste (Coordinator: Rattanawan Mungkung, VGREEN/KU) (2) Product Environmental Footprint (Coordinator: Thapat Silalertruksa, JGSEE-CEE/KMUTT)

October 17, 2018: Conference Day 1

Time	Program
08.00 - 09.00	Registration / Uploading the presentation files
09.00 - 09.30	**Opening ceremony (including the photo session)** **Dr. Chongrak Wachrinrat**, Acting President of Kasetsart University **Dr. Pornapit Darasawang**, Vice President for Internationalization, King Mongkut's University of Technology Thonburi **Dr. Prasit Palittapongarnpim**, Acting Executive, Vice President of National Science and Technology Development Agency
09.30 - 10.00	**Keynote presentation (1)** **Topic:** Single-use plastic bags, impossible foods, farmers' markets, and the rise of the flexitarian. Where next for LCA Food?" **Speaker:** Associated Prof. Sarah McLaren, Massey University
10.00 - 10.30	**Coffee break**
10.30 - 11.00	**Keynote speaker (2)** **Topic:** Global food challenges towards sustainable consumption and production **Speaker:** Dr. John Ingram, Leader, ECI Food Programme, University of Oxford
11.00 - 11.30	**Keynote presentation (3)** **Topic:** Thailand as a Global Food Innovation Hub for ASEAN **Speaker:** Dr. Akkharawit Kanchana-Opas, Chief Executive Officer of Food Innopolis, Ministry of Science and Technology
11.30 - 12.00	**Keynote speaker (4)** **Topic:** LCA education, research and applications in Thailand **Speaker:** Prof. Shabbir H. Gheewala, JGSEE, KMUTT, Thailand
12.00 - 13.30	**Lunch break / Uploading the presentation files**

October 17, 2018: Conference Day 1 Parallel sessions

Time		Program
13.30 - 15.00	Room	Parallel sessions
	Kamolthip 2	Session: 1-A (LCA METHODS) Session chair: Jeroen Guinée Session chair: Bradley Ridoutt
	Kamolthip 3	Session: 1-B (FROM FARM TO TABLE) Session chair: Nicholas M. Holden Session chair: Edi Iswanto Wiloso
	Kamolruedi	Session: 1-C (FOOD SECURITY) Session chair: Thomas Nemecek Session chair: Greg Thoma
	Duangkamol	Session: 1-D (WAYS TOWARDS SDGs) Session chair: Thumrongrut Mungcharoen Session chair: Ulrike Eberle
	Kaewkamol	Special session: Carbon Footprint of Food Products: Moving Towards a Low Carbon Society
	Kornkamol 1-2	Poster presentation
15.00 - 15.30		Coffee break
15.30 - 17.00	Room	Parallel sessions
	Kamolthip 2	Session: 1-A (LCA METHODS) Session chair: Hayo van der Werf Session chair: Ulf Sonesson
	Kamolthip 3	Session: 1-B (FROM FARM TO TABLE) Session chair: Bruno Notarnicola Session chair: Sergiy Smetana
	Kamolruedi	Session: 1-C (FOOD SECURITY) Session chair: Sarah McLaren Session chair:Pongvipa Lohsomboon
	Duangkamol	Session: 1-D (WAYS TOWARDS SDGs) Session chair: Chaiyod Bunyagidj Session chair: Anne-Marie Boulay
	Kaewkamol	Special session: Using MEANS-InOut software to guide LCA of agricultural products
	Kornkamol 1-2	Poster presentations
18.00 - 20.00		Welcome dinner

October 18, 2018: Conference Day 2

Time	Program
08.00 - 09.00	Registration / Uploading the presentation files
09.00 - 09.30	**Keynote presentation (1)** **Topic:** The Benefits of Environmental Action to Support SDG Implementation in Asia-Pacific **Speaker:** Dr. Arun Jacob, Environmental Affairs Officer, Environment and Development at United Nations ESCAP
09.30 - 10.00	**Keynote presentation (2)** **Topic:** SDG 12.3 Towards food loss and waste reduction **Speaker:** Mr. Anthony Bennett, Senior Food Systems Officer, FAO
10.00 - 10.30	**Coffee break**
10.30 - 11.00	**Keynote presentation (3)** **Topic**: SDGs' National Policy and Implementation in Thailand **Speaker**: Dr. Wijarn Simachaya, Permanent Secretary of the Ministry of Natural Resources and Environment, Thailand
11.00 - 11.30	**Keynote presentation (4)** **Topic:** LCA and STI for SDGs in Thailand **Speaker:** Associated Prof. Thumrongrut Mungcharoen, Chairperson of the Energy and Environment Cluster, National Science and Technology Development Agency (NSTDA), Ministry of Science and Technology, Thailand
11.30 - 12.00	**Keynote presentation (5)** **Topic:** SDGs Practices in Private Sector **Speaker**: Mr. Numpol Limprasert, Sustainable Development Director, The Siam Cement Public Company Limited (SCG), Thailand
12.00 - 13.30	**Lunch break / Uploading the presentation files**

October 18, 2018: Conference Day 2 Paralled sessions

Time		Program
13.30 - 15.00	Room	Parallel sessions
	Kamolruedi	Session: 1-D (WAYS TOWARDS SDGs) Session chair: Shabbir H. Gheewala Session chair: Corina van Middelaar
	Kamolthip 3	Session: 1-A (LCA METHODS) Session chair: Bo P. Weidema Session chair: Claudine Basset-Mens
	Kamolthip 2	Session: 1-B (FROM FARM TO TABLE) Session chair: Stewart Ledgard Session chair: Piyanon Kaenchan
	Baanthai 1	Session: 2-B (SUSTAINABLE MATERIAL AND CHEMICAL USE) Session chair: Jitti Mungkalasiri Session chair: Marlia Mohd Hanafiah
	Kamolporn	Session: 1-D (FOOD LOSS AND WASTE) Session chair: Anthony Bennett Session chair: Rattanawan Mungkung
	Kornkamol 1-2	Poster presentation
15.00 - 15.30		Coffee break
15.30 - 17.00	Room	Parallel sessions
	Kamolruedi	Session: 1-A (LCA METHODS) Session chair: Bradley Ridoutt Session chair: Trakarn Prapaspongsa
	Kamolthip 3	Session: 1-A (LCA METHODS) Session chair: Kiyotada Hayashi Session chair: Ian Vázquez-Rowe
	Kamolthip 2	Session: 1-B (FROM FARM TO TABLE) Session chair: Greg Thoma Session chair: Napat Jakrawatana
	Baanthai 1	Session: 2-A (SUSTAINABLE RESOURCE USE) Session chair: Viganda Varabuntoonvit Session chair: Yuki Kudoh
	Kamolporn	Special session: IJLCA editors' meeting
	Kornkamol 1-2	Poster presentations
18.00 - 20.00	Social events (1) Young researcher networking activities (*recommended for young researchers and students) (2) Scientific committees' dinner meeting (by invitation)	

October 19, 2018: Conference Day 3

Time	Program	
08.00 - 09.00	Registration / Uploading the presentation files	
9.30 - 10.30	Room	Parallel sessions
	Kamolthip 2	Session: 1-B (FROM FARM TO TABLE) Session chair: Ulf Sonesson Session chair: Stewart Ledgard
	Kamolruedi	Session: 1-D (WAYS TOWARDS SDGs) Session chair: Rattanawan Mungkung Session chair: Kiyotada Hayashi
	Kamolthip 3	Session: 1-A (LCA METHODS) Session chair: Ulrike Eberle Session chair: Thapat Silalertruksa
	Kaewkamol	Session: 2-D (SUSTAINABLE ENERGY AND MOBILITY) Session chair: Sate Sampattagul Session chair: Pariyapat Nilsalab
	Baanthai 2	Special session: Biodiversity impact assessment
	Kornkamol 1-2	Poster presentations
10.30 - 11.00	Coffee break	
11.00 - 12.30	Parallel sessions	
	Kamolthip 2	Session: 1-B (FROM FARM TO TABLE) Session chair: Ian Vázquez-Rowe Session chair: Sarah McLaren
	Kamolruedi	Session: 1-D (WAYS TOWARDS SDGs) Session chair: Edi Iswanto Wiloso Session chair: Jittima Prasara-A
	Kamolthip 3	Session: 1-A (LCA METHODS) Session chair: Hayo van der Werf Session chair: Shabbir H. Gheewala
	Kaewkamol	Session: 2-D (SUSTAINABLE ENERGY AND MOBILITY) Session chair: Charongpun Musikavong Session chair: Thapat Silalertruksa
	Baanthai 2	Special session: Thinkstep
	Kornkamol 1-2	Poster presentation
12.30 - 13.30	Lunch break / Uploading the presentation files	

October 19, 2018: Conference Day 3

Time		Program
13.30 - 15.00	Room	Parallel sessions
	Kamolruedi	Session: 1-A (LCA METHODS) Session chair: Claudine Basset-Mens Session chair: Charongpun Musikavong
	Kaewkamol	Session: 1-A (LCA METHODS) Session chair: Thomas Nemecek Session chair: Bruno Notarnicola
	Baanthai 2	Special session: Soil quality
	Kornkamol 1-2	Poster presentation
15.00 - 15.30		Coffee break
15.30 - 17.00	Closing ceremony - Announcements of best oral and poster presentation awards - Next hosts of LCA Food 2020 - Next host of ICGSI 2021 - Summary of the conference - Closing remarks	

October 20, 2018 Day-out trip (Organic Tourism)

Time	Program
08.30	Meeting at the Sukosol hotel lobby
08.30 - 09.30	Travelling by bus
09.30	Arrives at Sampran Garden, Nakorn Pathom province
09.30 - 10.00	Soft drink and coffee (organic herb / organic coffee)
10.00 - 11.00	Presentation: About Sampran Garden
11.00 - 12.00	Field visit: Sampran organic farms
12.00 - 13.00	Lunch: Organic foods and drinks
13.00 - 14.00	Field visit: SUKJAI Market – an organic product community market
14.00 - 15.30	Field visit: Sampran organic farms
15.30 - 16.00	Soft drink and coffee (organic herb / organic coffee)
16.00 - 17.00	Travelling back to the Sukosol hotel

Detailed Program

TECHNICAL SESSIONS - ORAL PRESENTATIONS

Date: October 17, 2018 **Time:** 13.30 - 15.00

Location: Kaewkamol
Special session: Carbon Footprint of Food Products: Moving Towards a Low Carbon Society

Location: Kamolthip 2
Session: 1 - A (LCA METHOD)

Session chair: Jeroen Guinée
Session chair: Bradley Ridoutt

TIME/CODE	TITLE OF PRESENTATION/ PRESENTER
13.30 - 13.45 LCAF-2018-07-00019	LCA: everything is relative and nothing is certain *Jeroen Guinée (Invited speaker)*
13.45 - 14.00 LCAF-2018-05-00046	Incorporating spatially-explicit impact assessment in environmentally extended input-output analysis *Bradley Ridoutt*
14.00 - 14.15 LCAF-2018-07-00233	AGRIBALYSE®: strengths and challenges of a national LCI database initiative *Vincent Colomb*
14.15 - 14.30 LCAF-2018-07-00151	ELDAM, a new Quality Management System for LCI datasets exchange and review *Gustave Coste*
14.30 - 14.45 LCAF-2018-07-00354	A Survey of Life Cycle Inventory Database Implementations and Architectures *Matthew Fritter*
14.45 - 15.00 ICGSI-2018-08-00002	Development of adapted inventory database based on IDEA *Kiyotaka Tahara*

Date: October 17, 2018
Location: Kamolthip 3
Session: 1 - B (FROM FARM TO TABLE)
Session chair: Nicholas M. Holden
Session chair: Edi Iswanto Wiloso

TIME/CODE	TITLE OF PRESENTATION/ PRESENTER
13.30 - 13.45 LCAF-2018-09-00017	System Modelling and Life Cycle Assessment of Dairy production on heavy wet soils in Ireland *Nicholas M. Holden (Invited speaker)*
13.45 - 14.00 LCAF-2018-07-00187	Hotspot analysis on the life cycle assessment of Indonesian tempeh *Edi Iswanto Wiloso*
14.00 - 14.15 LCAF-2018-07-00250	LCA of certified palm oil *Jannick Schmidt*
14.15 - 14.30 LCAF-2018-07-00311	Effects of transport distance and the quality requirement level on LC-CO_2e of the produces susceptible to physical damage *Takeo Shiina*
14.30 - 14.45 LCAF-2018-07-00307	Addressing organic viticulture environmental burdens by better understanding causes of inter-annual impacts variations *Christel Renaud-Gentié*
14.45 - 15.00 LCAF-2018-07-00218	Implications for agricultural product carbon footprints of including changes in soil carbon *Maartje Sevenster*

Date: October 17, 2018
Location: Kamolruedi
Session: 1 - C (FOOD SECURITY)
Session chair: Thomas Nemecek
Session chair: Greg Thoma

TIME/CODE	TITLE OF PRESENTATION/PRESENTER
13.30 - 13.45 LCAF-2018-07-00245	How to supply food for the Swiss population in an environmentally optimal way by using domestic production resources best? *Thomas Nemecek (Invited speaker)*
13.45 - 14.00 LCAF-2018-07-00006	MEANS-InOut: user-friendly software to generate LCIs of farming systems *Julie Auberger*
14.00 - 14.15 LCAF-2018-06-00043	Novel feeds for future chicken lines to enhance sustainability *Craig W. Tallentire*
14.15 - 14.30 LCAF-2018-08-00107	Social implications of competitive crops: A case study of sugarcane and cassava in north-eastern Thailand *Jittima Prasara-A*
14.30 - 14.45 LCAF-2018-08-00108	Social performances of conventional and area based sugarcane product: A case study in north-eastern Thailand *Thiwaporn Phuayjan*
14.45 - 15.00 LCAF-2018-07-00126	Environmental, social and economic analysis of Burkina-Faso's mango value chain *Yannick Biard*

Date: October 17, 2018
Location: Duangkamon
Session: 1 - D (WAYS TOWARDS SDGs)
Session chair: Thumrongrut Mungcharoen
Session chair: Ulrike Eberle

TIME/CODE	TITLE OF PRESENTATION/ PRESENTER
13.30 - 13.45 LCAF-2018-08-00033	Comparing environmental topics of Sustainable Development Goals, Planetary Boundaries and Product Environmental Footprint *Ulrike Eberle (Invited speaker)*
13.45 - 14.00 ICGSI-2018-08-00006	Towards Sustainable Development Goal #12 – Sustainable Consumption and Production patterns through the implementation of 10-Year Framework in Thailand *Rattanawan Mungkung*
14.00 - 14.15 LCAF-2018-07-00336	SDG 12.3‑ Ecological effects of halving food losses and waste, the case of the German food sector *Thomas Schmidt*
14.15 - 14.30 LCAF-2018-07-00297	Environmental Analyses to Inform Transitions to Sustainable Diets in Developing Countries: A Component of the EATS Project *Martin C. Heller*
14.30 - 14.45 LCAF-2018-07-00259	Sustainable industrialization target of SDG goal 9: A case study of CO_2 emission per unit of value added in Thailand *Viganda Varabuntoonvit*
14.45 - 15.00 LCAF-2018-07-00143	Socioeconomic and environmental sustainability assessment of local food products *Saioa Ramos*

Date: October 17, 2018 Time: 15.30 - 17.00

Location: Kaewkamol

Special session: Using MEANS-InOut software to guide LCA of agricultural products

Location: Kamolthip 2
Session: 1 - A (LCA METHODS)
Session chair: Hayo van der Werf
Session chair: Ulf Sonesson

TIME/CODE	TITLE OF PRESENTATION/ PRESENTER
15.30 - 15.45 LCAF-2018-07-00060	Nutrition – function or impact? *Bo P. Weidema (Invited speaker)*
15.45 - 16.00 LCAF-2018-07-00150	Dietary Dependent Nutrient Quality Indexes as a Complementary Functional Unit in LCA – a feasible option? *Ulf Sonesson*
16.00 - 16.15 LCAF-2018-07-00030	A Life Cycle Assessment of different food protein sources incorporating the Protein Quality Index in the functional unit *Lisa-Marie Bischer*
16.15 - 16.30 LCAF-2018-07-00222	Human Health Impacts of Nutrition as a New Impact Category for Food LCAs *Katerina S. Stylianou*
16.30 - 16.45 LCAF-2018-07-00026	Life-LCA: A new approach for assessing the environment impacts of a human being - experiences from a case study with focus on human diet *Marcel Goermer*
16.45 - 17.00 LCAF-2018-07-00087	Linking linear programing and Life Cycle Assessment to measure the Nutritional Cost Footprint *Ian Vázquez-Rowe*

Location: Kamolthip 3
Session: 1 - B (FROM FARM TO TABLE)
Session chair: Bruno Notarnicola
Session chair: Sergiy Smetana

TIME/CODE	TITLE OF PRESENTATION/ PRESENTER
15.30 - 15.45 LCAF-2018-07-00355	Optimization of Swedish organic bilberry processing by life cycle assessment *Erik Svanes (Invited Speaker)*
15.45 - 16.00 LCAF-2018-07-00275	Defining nutritionally and environmentally healthy dietary choices of omega-3 fatty acids *Maria B. Salazar*
16.00 - 16.15 LCA-2018-08-00001	A Baseline Life Cycle Assessment of California Processed Tomato Products *Kiara Winans*
16.15 - 16.30 LCAF-2018-07-00165	Putting sustainable diets into practice *Jasper Scholten*
16.30 - 16.45 LCAF-2018-07-00271	Diet matters: the case of Spain *Laura Batlle Bayer*
16.45 - 17.00 LCAF-2018-09-00018	Alternative food production systems: from insects and microalgae to emerging processing technologies and smart LCA systems *Sergiy Smetana*

Location: Kamolruedi
Session: **1 - C (FOOD SECURITY)**
Session chair: Sarah McLaren
Session chair: Pongvipa Lohsomboon

TIME/CODE	TITLE OF PRESENTATION/ PRESENTER
15.30 - 15.45 LCAF-2018-07-00240	New Zealand Agri-Food Sector and Absolute Climate Impacts: An Application of Multi-Regional Input-Output Analysis *Sarah McLaren (Invited speaker)*
15.45 - 16.00 LCAF-2018-07-00045	Assessment of sustainability indicators on Swiss farms under usual farm conditions *Andreas Roesch*
16.00 - 16.15 LCAF-2018-08-00062	Environmental LCA of fruits and vegetable supply chains of the U.S: a case of synchronizing with the climate change adaptation and mitigation measures *Greg Thoma*
16.15 - 16.30 LCAF-2018-08-00015	How to identify sustainable food and beverage packaging solutions: a pragmatic approach supporting complex decision making *Anita Hallmann*
16.30 - 16.45 LCAF-2018-07-00360	LCA4CSA: Using Life Cycle Assessment to support co-designing climate-smart smallholder farming systems *Ivonne Acosta-Alba*

Location: Duangkamol
Session: 1 - D (WAYS TOWARDS SDGs)
Session chair: Chaiyod Bunyagidj
Session chair: Anne-Marie Boulay

TIME/CODE	TITLE OF PRESENTATION/ PRESENTER
15.30 - 15.45 LCAF-2018-07-00007	FAO LEAP Guidelines for water use assessment of livestock production systems and supply chains *Anne-Marie Boulay (Invited speaker)*
15.45 - 16.00 LCAF-2018-08-00132	Eco-efficiency for the manufacturers and for the society: what's the difference? A case study on Greek yogurt *Anne-Marie Boulay*
16.00 - 16.15 LCAF-2018-08-00072	Water Scarcity Footprint of Rice Cultivation in Thailand *Roihatai Kaewmai*
16.15 - 16.30 LCAF-2018-08-00065	Water Footprint Database of Thai Rice Farming for Area-based Water Management and Water Scarcity Footprint Label *Sarocha Dangsiri*
16.30 - 16.45 LCAF-2018-07-00132	Spatio-temporal resolution matters in water scarcity footprinting: Case study of New Zealand milk *Sandra Payen*
16.45 - 17.00 ICGSI-2018-08-00007	Implications of different approaches for explicitly incorporating environmental water requirement in the water stress index *Pariyapat Nilsalab*

Date: October 18, 2018 Time: 13.30 - 15.00

Location: Kamolruedi
Session: 1 - D (WAYS TOWARDS SDGs)
Session chair: Shabbir H Gheewala
Session chair: Corina van Middelaar

TIME/CODE	TITLE OF PRESENTATION/ PRESENTER
13.30 - 13.45 LCAF-2018-07-00349	Databases for renewable materials and food and feed as a requirement for a shift to a sustainable bioeconomy *Ulrike Bos (Invited speaker)*
13.45 - 14.00 LCAF-2018-07-00142	If we are to eat more seafood- what seafood should we eat? Combining nutrition and greenhouse gas emission of seafood products *Kristina Bergman*
14.00 - 14.15 LCAF-2018-07-00160	The impact of diseases in dairy cows on greenhouse gas emissions of milk production *Corina E. van Middelaar*
14.15 - 14.30 ICGSI-2018-08-00003	Greenhouse Gas Management of Kasetsart University towards Low-Carbon Lifestyle and Sustainable University *Sarocha Dangsiri*
14.30 - 14.45 ICGSI-2018-08-00012	Carbon-Emission Hot Spot Analysis of Service Industry for Climate Actions *Tananon Nudchanate*
14.45 - 15.00 LCAF-2018-05-00022	Environmental impact of bio-treatment: comparative life cycle assessment of potato peels treatment with insects, pigs and anaerobic fermentation *Shashank Goyal*

Location: Kamolthip 3
Session: 1 - A (LCA METHODS)
Session chair: Bo P. Weidema
Session chair: Claudine Basset-Mens

TIME/CODE	TITLE OF PRESENTATION/ PRESENTER
13.30 - 13.45 LCAF-2018-07-00254	Life Cycle Assessment, common sense and organic agriculture *Hayo van der Werf (Invited speaker)*
13.45 - 14.00 LCAF-2018-07-00167	Integration of US crops from LCA commons into Agri-footprint *Bart Durlinger*
14.00 - 14.15 LCAF-2018-07-00330	Input-output inventories for viticulture in the VitLCA tool *Christel Renaud-Gentie*
14.15 - 14.30 LCAF-2018-07-00273	Using Experimental design for Life cycle inventory – Application to the case study of a wheat bran and straw extrusion process *Claire VIALLE*
14.30 - 14.45 LCAF-2018-07-00058	An LCA of French beans from Kenya with a critical analysis of impacts due to pesticide applications *Claudine Basset-Mens*
14.45 - 15.00 LCAF-2018-09-00080	Cleaner Production Potentials in the South African Soft Citrus Value Chain *Valentina Russo*

Location: Kamolthip 2
Session: **1 - B (FROM FARM TO TABLE)**
Session chair: Stewart Ledgard
Session chair: Piyanon Kaenchan

TIME/CODE	TITLE OF PRESENTATION/ PRESENTER
13.30 - 13.45 LCAF-2018-07-00322	Nitrogen footprint and related impact categories for milk produced from contrasting farm systems in China and New Zealand *Stewart Ledgard (Invited speaker)*
13.45 - 14.00 LCAF-2018-08-00014	Environmental impact of organic and conventional milk in Europe – case studies from UK, Austria and Denmark *Marie Trydeman Knudsen*
14.00 - 14.15 LCAF-2018-07-00112	Valuing leftover streams through livestock; the impact of livestock system and productivity level *Ollie van Hal*
14.15 - 14.30 LCAF-2018-07-00149	Effects of measures to reduce nutrient losses on the overall environmental impact of the Swiss farming sector *Maria Bystricky*
14.30 - 14.45 LCAF-2018-03-00022	On-farm level acting in order to mitigate climate change using a point-based system *Gérard Gaillard*

Location: Baanthai 1
Session: 2 - B (SUSTAINABLE MATERIAL AND CHEMICAL USE)
Session chair: Jitti Mungkalasiri
Session chair: Marlia Mohd Hanafiah

TIME/CODE	TITLE OF PRESENTATION/ PRESENTER
13.30 - 13.45 ICGSI-2018-07-00082	Domestic Material Consumption (DMC) of Biomass in Thailand *Jitti Mungkalasiri*
13.45 - 14.00 ICGSI-2018-07-00010	Factors influencing sugarcane cultivation: A case study in Kanchanaburi province, Thailand *Patcharaporn Pongpat*
14.00 - 14.15 ICGSI-2018-07-00068	Functional fillers as a part of green chemistry: LCA review *Didem Civancik-Uslu*
14.15 - 14.30 LCAF-2018-07-00309	The production of organic fertilizer pellets from fruit and vegetable wastes *Patrick Brassard*
14.30 - 14.45 LCAF-2018-07-00230	Circular Brew: life cycle assessment of waste bread-based beer *Joana Almeida*
14.45 - 15.00 LCAF-2018-07-00284	An environmental prospective study of Thai bioplastic policy *Ruethai Onbhuddha*

Location: Kamolporn
Session: **1 - D (FOOD LOSS AND WASTE)**
Session chair: Anthony Bennett
Session chair: Rattanawan Mungkung

TIME/CODE	TITLE OF PRESENTATION/ PRESENTER
13.30 - 13.45 LCAF-2018-07-00373	Nutrition in the bin: Nutritional and environmental assessment of food wasted at home in the UK *Namy Espinoza-Orias (Invited speaker)*
13.45 - 14.00 LCAF-2018-08-00048	Socio-demographic predictors of food waste behavior in Denmark and Spain *Alessandra C. Grasso*
14.00 - 14.15 LCAF-2018-08-00034	Life cycle environmental and economic impacts of food waste recycling: A case study of organic vegetable farming in Japan *Naoki Yoshikawa*
14.15 - 14.30 LCAF-2018-07-00376	Resources wastage related to food loss and waste in rice supply chain in Thailand *Wannika Imcharoen*
14.30 - 14.45 LCAF-2018-07-00341	Life Cycle Assessment of Seafood Beyond the Sea: Understanding How Seafood Losses and Consumption Patterns within Post-Production Stages Impact the Life Cycle Impacts of Seafood Products *Kathleen Mifflin*

Date: October 18, 2018 Time: 15.30 - 17.00

Location: Kamolporn

Special session: IJLCA editors' meeting (by invitation)

Location: Kamolruedi
Session: 1 - A (LCA METHODS)
Session chair: Bradley Ridoutt
Session chair: Trakarn Prapaspongsa

TIME/CODE	TITLE OF PRESENTATION/ PRESENTER
15.30 - 15.45 LCAF-2018-05-00047	A critical review of metrics used in sustainable diet studies *Bradley Ridoutt (Invited speaker)*
15.45 - 16.00 LCAF-2018-07-00207	Challenges when using Life Cycle Assessment for novel bioeconomy production systems *Hannele Pulkkinen*
16.00 - 16.15 LCAF-2018-08-00050	Globalised or localised life cycle impact assessment methods? Implications from method comparison for sustainable food production in Thailand *Trakarn Prapaspongsa*
16.15 - 16.30 LCAF-2018-07-00046	Describing effects of grazing on soil quality in LCA *Andreas Roesch*
16.30 - 16.45 LCAF-2018-07-00043	A methodological approach to carry out consequential life cycle assessment of greenhouse gas removal by agricultural soils *Pietro Goglio*
16.45 - 17.00 LCAF-2018-08-00131	First Proposition to include an integrated indicator of soil quality within the Life Cycle Assessment framework *Alexis Thoumazeau*

Location: Kamonthip 3
Session: **1 - A (LCA METHOD)**
Session chair: Kiyotada Hayashi
Session chair: Ian Vázquez-Rowe

TIME/CODE	TITLE OF PRESENTATION/ PRESENTER
15.30 - 15.45 Invited speaker	The biodiversity, health and well-being in the context of global and local environmental changes *Montira Pongsiri (Invited speaker)*
15.45 - 16.00 LCAF-2018-07-00101	Correlations between regional- and field-scale biodiversity indicators within life cycle assessment: The case of rice production systems in Japan *Kiyotada Hayashi*
16.00 - 16.15 LCAF-2018-07-00364	A consistent variable-scale biodiversity impact assessment structure *Jan Paul Lindner*
16.15 - 16.30 LCAF-2018-07-00164	Pesticide emission and toxicity models in LCA need to be adapted for tropical regions *Céline Gentil*
16.30 – 16.45 LCAF-2018-06-00050	Spatially differentiated eco-toxicity characterization factors for copper soil emissions in Atlantic vineyards in Portugal and Galicia (NW Spain) *Ian Vázquez-Rowe*

Location: Kamolthip 2
Session: **1 - B (FROM FARM TO TABLE)**
Session chair: Greg Thoma
Session chair: Napat Jakrawatana

TIME/CODE	TITLE OF PRESENTATION/ PRESENTER
15.30 - 15.45 LCAF-2018-08-00063	A Stepwise Retrospective Life Cycle Assessment of US Pork: 1960 – 2015 *Greg Thoma (Invited speaker)*
15.45 - 16.00 LCAF-2018-02-00466	Life cycle assessment of cellular agriculture combined with agroecological symbiosis *Hanna Tuomisto*
16.00 - 16.15 LCAF-2018-07-00302	Life cycle assessment of cultured meat combined with assessment of opportunity costs of land use *Hanna Tuomisto*
16.15 - 16.30 LCAF-2018-07-00328	Mitigating environmental impacts of beef production - scenario comparison *Sanna Hietala*
16.30 - 16.45 LCAF-2018-07-00295	Life Cycle Assessment of a plant-based burger and comparison with a typical beef burger *Martin C. Heller*
16.45 - 17.00 LCAF-2018-09-00023	Evaluation of the Environmental Impacts Associated with Variation in U.S. Cattle Production Systems *Ben Putman*

Location: Baanthai 1
Session: **2 - A (SUSTAINABLE RESOURCE USE)**
Session chair: Viganda Varabuntoonvit
Session chair: Yuki Kudoh

TIME/CODE	TITLE OF PRESENTATION/ PRESENTER
15.30 - 15.45 ICGSI-2018-07-00012	Life cycle assessment of guayule as an alternative source of natural rubber *Kullapa Soratana (Invited speaker)*
15.45 - 16.00 ICGSI-2018-08-00004	Innovative Carbon-Neutral Upcycled Products for Climate Change Mitigation and Circular Economy *Supachok Tanapanon*
16.00 - 16.15 ICGSI-2018-07-00078	Evaluation of Permanent Magnet Recycling Based on the Future Waste Forecast and Location Routing Problem *Hiroshi Kuroki*
16.15 - 16.30 ICGSI-2018-07-00059	A Framework for Examining Stakeholder Technology Challenges in Transitioning to Zero Waste Manufacturing *Piya Kerdlap*
16.30 - 16.45 ICGSI-2018-07-00081	Mitigation of struvite formation in palm oil mill effluent (POME) treatment facilities *Muzzammil Ngatiman*
16.45 – 17.00 ICGSI-2018-07-00024	Carbon Footprint of Zeolite A and Zeolite Y Derived from Bagasse Ash for CO_2 Adsorption *Nareerat Na Chat*

Date: October 19, 2018 Time: 09.00 - 10.30

Location: Baanthai 2
Special session: ~~Special (~~Thinkstep~~)~~

Location: Kamilthip 2
Session: 1 - B (FROM FARM TO TABLE)
Session chair: Ulf Sonesson
Session chair: Stewart Ledgard

TIME/CODE	TITLE OF PRESENTATION/ PRESENTER
09.00-09.15 LCAF-2018-07-00379	AGRIBALYSE: From Database to Ecodesign. Learnings from France to promote Ecodesign in the food sector *Vincent Colomb (Invited speaker)*
09.15-09.30 LCAF-2018-07-00306	Using LCA for participatory eco-design in agriculture: the case of Technical Management Routes (TMR) design with winegrowers and extension officers *Anthony Rouault*
09.30-09.45 LCAF-2018-07-00107	Impact of biodegradable food packaging on climate change *Ana Morão*
09.45-10.00 LCAF-2018-07-00243	Learnings from applying LCA in the food packaging space in Australia *Joana Almeida*
10.00-10.15 LCAF-2018-07-00183	Improving the airplane catering service food and packaging analysis *Gonzalo Blanca Alcubilla*
10.15-10.30 LCAF-2018-07-00146	LC-CO_2 of the vegetables considering food quality maintenance effect of packaging *Akihiro Izumi*

Location: Kamolruedi
Session: **1 - D (WAYS TOWARDS SDGs)**
Session chair: Rattanawan Mungkung
Session chair: Kiyotada Hayashi

TIME/CODE	TITLE OF PRESENTATION/ PRESENTER
09.00-09.15 ICGSI-2018-08-00005	Organizational Life Cycle Assessment towards Sustainability: A Case Study of Thai Vegetable Oil Company *Rattanawan Mungkung (Invited speaker)*
09.15-09.30 LCAF-2018-08-00093	Ecological footprint assessment towards sustainable rice cultivation in Thailand *Konkanok Jaibumrung*
09.30-09.45 LCAF-2018-07-00372	Joining Environmental Impacts and Health Impacts of an Individual's Dietary Choices *Christie Walker*
09.45-10.00 LCAF-2018-07-00235	Making More Sustainable Food Choices: A Comparison of Environmental and Nutritional Impacts and Benefits of Pizzas on Health *Katerina S. Stylianou*
10.00-10.15 LCAF-2018-07-00203	Sustainability Assessment of Highland Maize Cultivation in Northern Thailand *Sarunnoud Phuphisith*
10.15-10.30 LCAF-2018-07-00115	Food-Environment-Poverty nexus *Laura Scherer*

Location: Kamolthip 3
Session: 1 - A (LCA METHODS)
Session chair: Ulrike Eberle
Session chair: Thapat Silalertruksa

TIME/CODE	TITLE OF PRESENTATION/ PRESENTER
09.00-09.15 LCAF-2018-07-00075	Land use impacts: comparing Irish and German milk production *Ulrike Eberle (Invited speaker)*
09.15-09.30 LCAF-2018-08-00007	Accounting for land use contribution to climate change in agricultural LCA: Which methods? Which impacts? *Cécile Bessou*
09.30-09.45 LCAF-2018-07-00365	Quantification of land use impacts on biodiversity with local ecosystem indicators: A case study in southwestern Germany *Jan Paul Lindner*
09.45-10.00 LCAF-2018-07-00351	GIS based Regionalized Land Use Characterization Factors for Life Cycle Impact Assessment using LANCA® *Ulrike Bos*
10.00-10.15 LCAF-2018-07-00374	Environmental assessment of global confectionery brand *Namy Espinoza-Orias* **CHANGED** One planet programme: Biodiversity core initiative *Anne Asselin*
10.15-10.30 LCAF-2018-08-00042	Human toxicity assessment of oil palm cultivation in Thailand: the variability from using different life cycle impact assessment methods *Pattaramart Makmoon*

Location: Duangkamol
Session: 2 - D (SUSTAINABLE ENERGY AND MOBILITY)
Session chair: Sate Sampattagul
Session chair: Pariyapat Nilsalab

TIME/CODE	TITLE OF PRESENTATION/ PRESENTER
09.00-09.15 Invited Speaker	Sustaiability of palm – based biorefinery to support bioeconomy *Shabbir H. Gheewala (Invited speaker)*
09.15-09.30 ICGSI-2018-07-00055	Are electric vehicles the key to improve environment in transport sector? – From a Well-to-Wheel perspective – *Yuki Kudoh*
09.30-09.45 ICGSI-2018-08-00022	Life Cycle Assessment of Automated Container Port Logistics Systems *Orawan Mokkhavas*
09.45-10.00 ICGSI-2018-07-00071	Dynamic carbon accounting applied to energy policy scenarios: accounting for full lifetime carbon *Ariane ALBERS*
10.00-10.15 ICGSI-2018-08-00008	Cost-benefit analysis of bioethanol development in Thailand *Piyanon Kaenchan*

Date: October 19, 2018 Time: 11.00 - 12.30

Location: Baanthai 2
Special session: ~~(Thinkstep)~~

Location: Kamolthip 2
Session: 1 - B (FROM FARM TO TABLE)
Session chair: Ian Vázquez-Rowe
Session chair: Sarah McLaren

TIME/CODE	TITLE OF PRESENTATION/ PRESENTER
11.00-11.15 LCAF-2018-07-00117	Life Cycle Inventory of French fisheries: AGRIBALYSE for sea products *Joël Aubin (Invited speaker)*
11.15-11.30 LCAF-2018-06-00025	The Zambian aquaculture supply chain: cages or ponds for sustainable growth? *Angel Avadi*
11.30-11.45 LCAF-2018-07-00228	Priority Pathways for Sustainable Intensification of Egg Production *Nathan Pelletier*
11.45-12.00 LCAF-2018-07-00276	Economic and environmental sustainability of rice farming systems in Thailand: adoption of site-specific fertilization practice *Jeerasak Chobtang*

Location: Kamolruedi
Session: **1 - D (WAYS TOWARDS SDGs)**
Session chair: Edi Iswanto Wiloso
Session chair: Jittima Prasara-A

TIME/CODE	TITLE OF PRESENTATION/ PRESENTER
11.00-11.15 LCAF-2018-07-00368	Opportunities for increased ecosystem services from incorporation of spatial and temporal diversity in crop rotations *Paul R. Adler (Invited speaker)*
11.15-11.30 LCAF-2018-07-00352	Measuring the impact on employment and paid wages as a consequence from mechanization of the sugarcane harvesting in Thailand *Wanchat Sawaengsak*
11.30-11.45 LCAF-2018-07-00139	Feed eco-design: how to make a good decision? Part 1- Uncertainty analysis of feed formulation *Sandrine ESPAGNOL*
11.45-12.00 LCAF-2018-07-00140	Feed eco-design: how to make a good decision? Part 2- rebound effects of eco-feed production *Sandrine ESPAGNOL*
12.00-12.15 LCAF-2018-07-00346	Environment and Social Sustainability Assessment of Maize-based Broiler Feed *Pornpimon Boonkum*
12.15-12.30 LCA-2018-07-00058	Assessing SAFA Economic Resilience of Maize Supply Chain in Thailand *Yuwanan Santitaweeroek*

Location: Kamolthip 3
Session: **1 - A (LCA METHODS)**
Session chair: Hayo van der Werf
Session chair: Shabbir H. Gheewala

TIME/CODE	TITLE OF PRESENTATION/ PRESENTER
11.00-11.15 LCAF-2018-07-00253	AGRIBALYSE goes organic: life cycle assessment of French organic agriculture *Hayo MG van der Werf (Invited speaker)*
11.15-11.30 LCAF-2018-07-00130	Animal Welfare – a New Indicator and Trade-offs with the Carbon Footprint *Laura Scherer*
11.30-11.45 LCAF-2018-07-00294	Comparison of different approaches to cope with multifunctionality of livestock in LCA – a Peruvian case study *Karin Bartl*
11.45-12.00 LCAF-2018-07-00383	Farm-level GHG calculations of the entire Dutch Dairy sector *Anne Gaasbeek*
12.00-12.15 LCAF-2018-07-00178	Sustainable Performance of Meat Cell Factory *Hanne Møller*
12.15-12.30 LCAF-2018-07-00147	Comparative environmental impact of alcoholic beverages consumption *Saioa Ramos*

Location: Duangkamol
Session: **2 - D (FOOTPRINT ASSESSMENT)**
Session chair: Charongpun Musikavong
Session chair: Thapat Silalertruksa

TIME/CODE	TITLE OF PRESENTATION/ PRESENTER
11.00-11.15 ICGSI-2018-08-00051	Competitive use of sugarcane for food, biofuel and biochemical through the environmental and economic benefits *Thapat Silalertruksa (Invited speaker)*
11.15-11.30 LCAF-2018-07-00333	Spatial variability in Greenhouse Gas Footprints of Palm Oil Production in Indonesia Wan Yee Lam
11.30-11.45 ICGSI-2018-08-00034	Ecological footprint of bioethanol from sugarcane sap and molasses in Thailand *Charongpun Musikavong*
11.45-12.00 LCAF-2018-08-00037	Carbon Footprint Reduction of PET-Bottled Water in Thailand *Supachok Tapananon*
12.00-12.15 LCAF-2018-07-00141	Database of food carbon footprints helps Public Sector in Sweden set and reach climate goals *Katarina Nilsson*
12.15-12.30 LCAF-2018-07-00152	Updated carbon footprint values for mineral fertilizers from different world regions *Frank Brentrup*

Date: October 19, 2018 Time: 13.30 - 15.00

Location: Baanthai 2
Special session: Special (Soil quality)

Location: Kamolruedi
Session: 1 - A (LCA METHODS)
Session chair: Claudine Basset-Mens
Session chair: Charongpun Musikavong

TIME/CODE	TITLE OF PRESENTATION/ PRESENTER
13.30 - 13.45 LCAF-2018-07-00057	Towards specific guidelines for applying LCA in South contexts *Claudine Basset-Mens (Invited speaker)*
13.45 - 14.00 LCAF-2018-07-00206	Valuing potential ecosystem services with a life-cycle oriented methodology *Pierre-Alexandre Willot*
14.00 - 14.15 LCAF-2018-07-00154	Nitrogen and phosphorus modelled in freshwater eutrophication: The director's cut *Sandra Payen*
14.15 - 14.30 LCAF-2018-07-00329	Making agricultural Life Cycle Assessment tools effective *Marguerite Renouf*
14.30 - 14.45 LCAF-2018-07-00156	Challenges for Knowledge Engineering in Life Cycle Inventory *Caroline SABLAYROLLES*
14.45 - 15.00 LCAF-2018-07-00027	Life Cycle Assessment of Premium Salted Potato Chips Manufactured by ITC - A Case Study *Ankush Jain*

Location: Duangkamol
Session: **1 - A (LCA METHODS)**
Session chair: Thomas Nemecek
Session chair: Bruno Notarnicola

TIME/CODE	TITLE OF PRESENTATION/ PRESENTER
13.30 - 13.45 **LCAF-2018-07-00169**	Assessing environmental impacts and risks of pesticide application in Swiss crops by combining LCA and risk analysis *Thomas Nemecek (Invited speaker)*
13.45 - 14.00 **LCAF-2018-08-00031**	Characterization factors for global fisheries *Arnaud Hélias*
14.00 - 14.15 **LCAF-2018-06-00053**	Methodological choices of LCA applied to aquaculture systems: Critical review & recommendations *Florence A. Bohnes*
14.15 - 14.30 **LCAF-2018-07-00231**	Life Cycle Assessment (LCA) of salmonid aquaculture systems: status and perspectives *Gaspard Philis*
14.30 - 14.45 **LCAF-2018-06-00026**	LCIs of Latin American seafood production systems in ecoinvent® *Angel Avadí*
14.45 - 15.00 **LCAF-2018-07-00029**	Life Cycle Assessment of applying Algal Oil in salmon aquaculture; challenges for methodological development *Lisa-Marie Bischer*

Instructions: oral presenters

Oral presentations will be arranged during 17-19 October 2018. The presenters can find their own presentation date, time, and room from the conference' s website and the abstract book provided upon registration.

Set up your presentation/Give your presentation

1. Each presenter is required to prepare the presentation file(s) in pdf or ppt format.
2. The presentation file should be uploaded on the conference's computer(s) at the computer room before the session of that presentation starts (8.00 am - 9.00 am and 12.00 pm -13.30 pm). Please contact the conference staff at the computer room for help.
3. The presentation file will be viewed on a screen for you to make sure all is correct.
4. The presentation files of all oral presenters will be transferred to the laptop in the presentation rooms by the conference staff.
5. Presenters should arrive their presentation room before the sessions start.
6. Basic materials for giving presentation, i.e. microphone, laptop (Windows environment), projector, and projection screen are provided in the presentation rooms. A laser pointer is also available.
7. It is not possible for a speaker to use a private notebook for presentations.
8. Regular oral contributions are 15 minutes in total which includes 3 minutes for Q&A.
9. Each room will have session chairs to manage the session and evaluate the presentation. Names of session chair for each room are presented in the abstract book.
10. During giving presentation, session chairs will help remind presenters of the time.
11. The best presentations will be awarded in closing ceremony on 19 October 2018.

Instructions: Poster Presenters

Poster sessions will be located in Kornkamol 1-2 room. To locate your assigned poster stand, please look for the stand marked with your paper reference number, such as LCAF-2018-01-00001, LCA-2018-01-00001, ICGSI-2018-01-00001, and so on.

Set up your poster/Give your presentation

1. Each presenter will be provided with poster stand and materials necessary for setting up poster on the stand.
2. The size of the poster is set at 90 cm (wide) × 120 cm (high) or A0.
3. Poster should be set up on Wednesday 17 October 2018, before 12.00 pm.
4. The poster will be evaluated by the scientific committee members of the conference on 18 October 2018, 13.30-17.00 pm. So, please be with your poster during that time to give information to the committee and audiences.
5. The best poster will be selected and awarded in closing ceremony on 19 October 2018.
6. Posters can be presented in Kornkamol 1-2 room until 19 October 2018, 17.00 pm. However, if the presenters want to remove the posters earlier, please remove the posters after 17.00 pm of 18 October 2018.

ABSTRACTS

LCA FOOD 2018 / LCA AgriFood ASIA

ORAL PRESENTATION

SESSION 1 – A
LCA METHODS

Code: LCAF-2018-07-00019

LCA: everything is relative and nothing is certain

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Abstract

Environmental Life Cycle Assessment (LCA) relies on data, models and knowledge from almost all environmental scientific disciplines, including related uncertainties. In addition, LCA involves making methodological choices. Over the past five years, we have published several approaches to deal with data and methodological choice uncertainties. One often heard critique is that these proposals do not account yet for 'correlations'. However, correlation has been addressed as yet in recent work.

Distinguishing between two meanings of the term 'correlations - correlated sampling and correlated data points - we present an overall framework integrating the different approaches comprehensively dealing with uncertainties in LCA studies. Practical application of this framework in the daily practice of LCA practitioners needs further work, including implementation in LCA software programs and particularly data.

Keywords: *life cycle assessment, uncertainty, relative uncertainties, correlations.*

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Code: LCAF-2018-05-00046

Incorporating spatially-explicit impact assessment in environmentally extended input - output analysis

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Abstract

Environmentally extended input-output analysis (EEIOA) is an important tool in food system and sustainable diet research. Whereas process-based life cycle assessment (LCA) is well suited to the environmental performance evaluation of specific food products and production systems, EEIOA has advantages when modelling at regional, national and global scales where interest relates more to food categories than specific food products, and full sectoral coverage is required. EEIOA has been most widely used in greenhouse gas (GHG) emissions accounting, serving as a basis for mitigation policy, and studies relating to dietary GHG emissions are now many. However, a major limitation arises when EEIOA is used to investigate resource use and emissions that require spatially-explicit impact assessment for meaningful interpretation (e.g. water use, ISO14046:2014). This is because conventional input-output tables are produced at the scale of political units which are not usually well aligned with environmentally relevant spatial units. This presentation summarizes results from a recent assessment (Ridoutt et al., 2018 ES&T, DOI: 10.1021/acs.est.8b00416) where a high spatial resolution water use account and spatially-explicit water scarcity characterization factors were used to develop water footprint extensions for 26 agricultural and 75 industrial sectors in Australia. These extensions were subsequently coupled with a multi-regional (Australia and rest of world) input-output model. The results link demand for agricultural commodities to the problem of water scarcity in Australia and globally, which is a significant advancement from previous EEIOA studies that report water use without impact assessment. The example shown in this study, whereby LCA impact category indicator results are used to augment the input-output model (rather than satellite data sets based on inventory-level accounting of natural resource use or emissions), is viewed as a feasible general approach for incorporating spatially-explicit impact assessment in EEIOA, thereby bringing EEIOA more into line with best practice impact assessment in LCA and extending the application of EEIOA to environmental concerns where regionalized impact assessment is necessary.

Keywords: *EEIOA; life cycle impact assessment; water footprint; water scarcity; sustainable consumption and production policy; sustainable resource use*

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Code: LCAF-2018-07-00233

AGRIBALYSE®: strengths and challenges of a national LCI database initiative

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Abstract

Agriculture and food LCI databases have developed rapidly in recent years. In this context, this article provides an update on the French AGRIBALYSE database and program, which has been running for almost 10 years. The authors have been the key contributors in this original initiative and share their learnings and views on the challenges ahead, both on the development of datasets but also on the promotion of Life Cycle Thinking in the French food sector. These highlights should be useful for all database developers, for users interested in good quality and harmonized data, and more broadly for promoters of eco-design and a more sustainable food sector.

Keywords: *LCI database, ecodesign, national project, France, partnership, participative approach*

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ELDAM, a new Quality Management System for LCI datasets exchange and review

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Abstract

When exchanging LCI data between LCA dedicated software, LCA practitioners often face technical restrictions of the software as well as potential lack of metadata on the datasets quality, limiting their reuse, update and improvement. To address these issues and facilitate LCI dataset exchanges within a community of scientists working on separate LCA software and LCI database, a set of data quality guidelines have been set up along with a tailor-made import-export and review tool for improving these rules applicability in an operational context.

***Keywords**: dataset quality, inventory review, data exchange, quality management system*

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Code: LCAF-2018-07-00354

A Survey of Life Cycle Inventory Database Implementations and Architectures

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Abstract

Without established standards and shared practice, interoperability poses a serious challenge in the domain of LCI database development. Through study of the existing LCI data ecosystem and new trends in LCI database technology, a set of generalized recommendations are made to improve interoperability for newly developed LCI databases, maximize their utility to LCA practitioners, and ensure that common practice in the web and database development domain is followed.

Keywords: *Life Cycle Inventory; Database; Interoperability; Canadian Agri-Food Life Cycle Data Center*

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Code: ICGSI-2018-08-00002

Development of adapted inventory database based on IDEA

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Abstract

Some developed countries, emerging economies, etc., have created inventory databases, but many of them have not yet grown into a comprehensive database. Also, not many databases update their inventory data on a regular basis, and it is predicted to take more time until homemade local databases maintain their data sufficiently. In practical LCA, it is common to use datasets out of the box from some established databases such as IDEA or European databases to evaluate the environmental impacts occurring in countries that do not have a comprehensive database. Therefore, we developed a simplified method to estimate country-specific inventory data based on Japanese data. The aim is to improve and reflect the local circumstances more compared to merely using datasets as they are. In this study, we propose a method that estimates overseas inventory data based on IDEA Ver. 2. that reflect the situation of the target country as much as possible. We developed an estimated inventory database of China and Thailand by applying a method to divide sector categories and fuel categories utilizing statistics that are available for both countries and statistics that are unique to each country.

Keywords: *Inventory Database, Adaptation, Asian database, IDEA*

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Code: LCAF-2018-07-00060

Nutrition – function or impact?

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Abstract

This work provides a conceptual framework to distinguish between two different roles of nutrition in Life Cycle Assessment of foods, namely on the one hand in the functional unit that forms the basis of comparisons of foods, and on the other hand in the calculations of health impacts from ingestion of food products. Satiety is proposed as a central attribute for comparisons of food products, while weighted measures nutrient content are suggested to be largely misplaced as part of the functional unit. In contrast, nutritional measures have a large role to play in assessing the human health impacts of the marginal ingestion of specific food products for the more than half of the global population that lives on an unbalanced diet.

Keywords: *Nutritional quality; functional unit; satiety; dietary risk; health impact.*

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Code: LCAF-2018-07-00150

Dietary Dependent Nutrient Quality Indexes as a Complementary Functional Unit in LCA – a feasible option?

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Abstract

Food production is a main driver of environmental pressure and resource use globally. At the same time food delivers a critical function to humans; nutrition supply. Within LCA of foods the dominating functional unit used is mass, regardless of the ISO requirements that the functional unit (FU) should reflect the actual function. The main function of food, "supply of nutrients", is complex since the nutritional value of a single food item depends on the dietary context and the nutritional value is a combination of several nutrients. A single score for nutrient quality is needed to fit into LCA. A method creating a single score nutritional quality index (NQI) was developed based on a method from nutritional science, the Nutrient Rich Food, 9.3. Instead of using daily requirements as a baseline, we used the actual dietary context thus creating an index reflecting the nutrient quality in a given dietary context. This index was used to analyze how relations in GWP between single products differed when using mass as FU or an NQI-adjusted FU, in two dietary contexts (average Swedish and a model unhealthy). The products included were: bread, apple, tomato, milk, hard cheese, spread and chicken fillet. The results were calculated using bread as the reference point. The results showed that in both dietary contexts apples, tomatoes and hard cheese had lower NQI-adjusted GWP than GWP. Milk had small differences and chicken fillet was the same in the unhealthy diet and performed better in the average diet. Spread had relatively higher NQI-adjusted GWP in the unhealthy diet and a negative value in the average diet. The main conclusions were: 1) Including nutritional value in LCA of foods increases the understanding of how the environmental impacts and nutritional functions of food are related, and 2) The environmental performances of different products vary with dietary context

Keywords: *LCA; Food; Nutrition; Dietary context; Functional unit;, GWP.*

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A Life Cycle Assessment of different food protein sources incorporating the Protein Quality Index in the functional unit

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Abstract

Including nutritional aspects in the functional unit is crucial when the environmental impact of different protein sources using LCA is analyzed and compared. The first goal of this study was to apply the methodological framework developed by Sonesson et al. (2017) based on the incorporation of a Protein Quality Index in the functional unit, to compare the environmental impact of several protein sources: chicken and pork meat, salmon, tofu, insects and algae. The Protein Quality Index takes several nutritional aspects into account like the presence of all esssential amino acids, amino acids digestibility and diet profile. The second goal was to assess the environmental impact of amino acid supplementation in chicken and pig feed with this new approach. The Protein Quality Index was calculated for these different protein sources and an LCA was conducted. Results were quantified for three different functional units: mass based, protein based and nutritional based. Results showed that including the Protein Quality Index in the functional unit allows a more detailed and accurate comparison of the environmental impact of protein sources, and that the choice of the functional unit is decisive when food systems are compared. A supplementation in amino acids leads to significant reductions of the environmental impact in most impact categories, for each of the regarded functional unit. The Protein Quality Index allows the inclusion of one of the major function of food systems i.e. the provision of protein in LCA but does not take other nutrients into account, which could also influence the comparison.

Keywords: *LCA; food; protein; amino acids; functional unit; protein quality.*

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Human Health Impacts of Nutrition as a New Impact Category for Food LCAs

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Abstract

Food life cycle assessments (LCAs) often neglect the direct beneficial and detrimental nutritional health effects that occur during the use stage of the food's life cycle. We developed the DALY Nutritional Index (DANI) that quantifies the marginal nutrition-related health burden of foods in disability adjusted life years (DALYs) per functional unit. To estimate DANI we determine inventory flows and develop nutritional characterization factors (CFs) for 16 dietary risks, building on the work of the Global Burden of Disease (GBD). Inventory flows for foods in the US diet are obtained from publically available databased while nutritional CFs are calculated using epidemiological evidence and US-specific burden rates from the GBD. We demonstrate this newly proposed nutritional LCA impact category for human health with a detailed example of a meat burrito.

Keywords: *LCIA; nutrition; human health; DALYs*

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Code: LCAF-2018-07-00026

Life-LCA: A new approach for assessing the environmental impacts of a human being – experiences from a case study with focus on a human diet

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Abstract

According to the UN sustainable development goal 12, besides production, also consumption shall become more sustainable. To reach this, potential environmental impacts caused by human con- sumption (e.g. human diets) need to be quantified. However, current methods to do so are mainly based on top-down approaches, sometimes lack of consistency and are probably too generic to trig- ger a substantial re-thinking of individuals regarding their own consumer habits. The goal of this work is to outline Life-LCA as a new bottom-up quantification method to assess the environmental impacts caused by human beings. Besides identifying Life-LCA specific challenges, a two- dimensional concept was developed. Dimension 1 focusses on the new " human life cycle", i.e. the consumption behaviors of human beings on a product level. Dimension 2 reflects the product life cycles of the specific consumed products. Based on this concept, a case study was conducted with focus on the diet of a German middle-aged man. Calculated dietary impacts of the assessed human being are high compared to results presented in other studies, probably due to individual character- istics that cannot be reflected by higher-level top-down studies. To overcome the key challenges of Life-LCA, which are the analysis of complex human consumption behaviors and social interactions, further method development is required.

***Keywords**: sustainable consumption; life cycle assessment (LCA); environmental awareness; personal environmental footprint; sustainable diets*

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Code: LCAF-2018-07-00087

Linking linear programing and Life Cycle Assessment to measure Nutritional Cost Footprint

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Abstract

Food loss and waste (FLW) threats food security and nutrition in a three-dimensional way. Firstly, it leads to a reduction of food availability. Secondly, FLW presents a negative impact on food access for producers who suffer FLW-related economic losses and for consumers owing to the contribution of FLW to tightening the food market and increasing food prices. Finally, FLW poses a threat to food security given the current unsustainable pattern of natural resources exploitation. FLW has been traditionally referred to as the decrease in mass, in all stages of the food chain, from harvest to consumption of edible food that was originally intended for human consumption. According to this, FLW policies are currently focused on a mass-based reduction approach. However, food waste management requires taking all 'reasonable' measures to apply the waste hierarchy principle, taking into account technical feasibility and economic viability, as well as ethical concerns. It is necessary that future strategies to reduce FLW consider not only their quantification in terms of mass, but also the nutritional quantities attributed to food waste, as well as the economic loss in all stages of the supply chain. Accordingly, this study assesses the nutritional losses and waste along the supply chain of the Spanish food system in terms of nutritional and economical cost. Moreover, an indicator that combines nutritional and economic variables is proposed to define FLW management strategies.

Keywords: *food waste; Life cycle assessment; linear programming; Nutritional cost footprint.*

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Code: LCAF-2018-07-00254

Life Cycle Assessment, common sense and organic agriculture

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Abstract

The general public sees organic agriculture as a solution to the environmental problems caused by conventional agriculture. Life cycle assessment (LCA) results show that environmental impacts of organic food are not less than those of food from conventional agriculture. This paper analyses this contrast and proposes ways to strengthen the potential of LCA to adequately compare environmental impacts of contrasting farming systems.

Keywords: *organic agriculture; common sense; reference unit; consequential LCA; biodiversity*

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Code: LCAF-2018-07-00167

Integration of US crops from LCA commons into Agri-footprint

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Abstract

The United States Department of Agriculture (USDA) hosts a Life Cycle Assessment (LCA) data repository called the LCA commons (https://www.lcacommons.gov/), providing LCA datasets related to Agriculture. The data is organized in unit processes with a high level of disaggregation. Generally, over 300 processes are used to model the cradle to gate inventory of a crop product. The datasets do not always align well to popular life cycle impact assessment methods (LCIA methods), as not all elementary flows are tracked to their emission compartments, non-standard substance names are used, and some data is missing due to the use of cut-offs. Agri-footprint is a Life Cycle Inventory (LCI) database for the agriculture and food sector, developed by Blonk Consultants. It covers data on agricultural products: feed, food and biomass. The aim was to include the US crop datasets in Agri-footprint, and thus making the LCI information available to a wider audience. To do this, inventories were condensed to a higher level of aggregation, data was connected to relevant background datasets, additional elementary flows were calculated and added to the inventories and data was restructured to better align to the Agri-footprint structure.

Keywords: *Agri-footprint, Crop cultivation, United States, LCA Commons, LCI database.*

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Code: LCAF-2018-07-00330

Input-output inventories for viticulture in the VitLCA tool

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Abstract

For life cycle assessment (LCA) to inform eco-design in agriculture requires input-output inventories for a diverse range of practice and system alternatives. For viticulture, this can be time-consuming because it is a relatively complex system. This work sought to streamline inventory generation by compiling parameterised methods for predicting viticulture inputs and emissions. The viticulture practices that can change as a result of viticulture eco-design were first reviewed to identify key practice variables. Then suitable inventory estimation methods that can be parameterised for these variables were compiled. The novelty is in the systematic approach used to parameterise input-output inventory development to support eco-design in agriculture.

Keywords: *grape; vine; wine; fruit; LCI; parameterisation*

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Code: LCAF-2018-07-00273

Using Experimental design for Life cycle inventory – Application to the case study of a wheat bran and straw extrusion process

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Abstract

The experimental design methodology can be used to determine representative models of a process running in function of the operating conditions and functioning parameters. These models allows the mass and energy balances prediction related to the studied process. Mass and energy balances can be used to find a technological optimum by maximizing the production yields, but also an environmental optimum thanks to Life Cycle Assessment. In addition, it ensures a better understanding of the direct effects of inventory flows of a process on the environment. This methodology was applied to an extrusion process, used to extract hemicelluloses from wheat bran and straw. Two different optimal configurations are proposed. The technological optimum leads to a maximization of the hemicelluloses production flowrates (to 2.52 kg/h). The environmental performance is optimized by minimizing three environmental impacts scores: Human health ($5.26x10^{-5}$ DALY), Ecosystems (2.20x10-7 species.year) and Resources (0.808 $).

Keywords: *Life Cycle Assessment; experimental design; process modeling; biorefinery*

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Code: LCAF-2018-07-00058

An LCA of French beans from Kenya with a critical analysis of impacts due to pesticide applications

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Abstract

This paper presents and critically analyzes a cradle-to-market-gate LCA study performed with Endpoint indicators for a public decision-maker for the fresh French bean *(*FB*)* value chain of Kenya. Five main stages were included*:* agricultural production, transport by road before pack-house, pack-house, transport by road after pack-house and intercontinental transport by air-freight. The functional unit was 1 kg of raw French bean processed. Supported by local experts, primary data were collected for all inputs and outputs for 33 farms over 5 counties and 2 pack-houses. At market-gate, air-freight was identified as main hot-spot pleading for the design of stabilized FB products that could be sea-freighted. At farm-gate, large differences were observed between farm types and fertilizer, water and land use were the key drivers of their eco-efficiency. Impacts due to pesticides applications were small at Endpoint level but were incomplete. To help practitioners perform more complete assessments of value chains in South contexts, operational and reliable tools are needed on estimating field pesticides′ emissions and uncertainty.

Keywords: *LCA; decision-makers; pesticides; French bean; Kenya*.

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Code: LCAF-2018-09-00080

Cleaner Production Potentials in South African Soft Citrus Value Chain

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Abstract

In response to growing environmental concerns, foreign fruit markets are opting for products which are produced with the least amount of environment impact associated with them. This, in turn, puts pressure on South African fruit suppliers to find alternative ways of producing fruit products, so as to mitigate the environmental impact associated with their production. The citrus industry in South Africa is one of the most valuable industries in the country's agriculture sector contributing to roughly one fifth of the total gross value of the horticulture during the same period. An LCA of the soft citrus supply chain has been conducted and four mitigation strategies have been compared against a base case scenario: Organic Fertilizer, Variable Speed Drive for irrigation, Photovoltaic Cells and Alternative Packaging Materials. The impact categories accounted for are: Climate Change, Acidification, Freshwater and Marine Eutrophication. The farm stage had the largest contribution across all the impact categories investigated ranging from 45% to 71%, with fertilizer and irrigation processes being the main environmental hotspots; Electricity resulted as the major environmental hotspot in both the packaging and cold storage stage. Photovoltaic Cells resulted in the greatest environmental impact reduction, Alternative Packaging Materials scored second, Variable Speed Drive for irrigation scored fourth, whereas electrostatic spraying was determined to be the least effective clean-tech investment in reducing the environmental impact associated with the soft citrus supply chain.

Keywords: LCA, Soft Citrus, Photovoltaic, Organic Fertilisers, Variable Speed Drive, Electrostatic Spray System, Packaging Material

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Code: LCAF-2018-06-00047

A critical review of metrics used in sustainable diet studies

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Abstract

National food-based dietary guidelines have traditionally sought to promote health and well-being and to reduce the incidence of diet-related disease. However, these guidelines are increasingly being viewed as a mechanism to reduce environmental impacts from the food system and a variety of studies applying environmental metrics to diets have emerged. Based on a recent critical review (Ridoutt et al., 2017 Adv Nutr 8: 933-946), this presentation evaluates the sustainable diets literature in terms of the completeness of coverage of environmental concerns and the reliability of metrics used to report environmental performance. The step-wise research method involved an original literature search that located 93 journal articles. The located literature was then mapped to the 14 discrete environmental concerns identified in the 169 targets underpinning the UN Sustainable Development Goals (SDGs). For environmental areas of concern for which a substantial body of literature existed, the metrics used were categorized and evaluated in terms of ability to quantify the relative level of environmental impact when applied in a life cycle context. Where reliable metrics were used, the dietary evidence was then assessed to identify any generalizable findings with respect to lower environmental impact dietary strategies. Overall, there was found to be a weak alignment between the areas of concern covered by the literature and those identified in the SDGs. Climate change was the most commonly addressed area of concern (74% of studies). Land use, which relates to the concerns of "deforestation", "land degradation and desertification", and "biodiversity loss" was addressed by 41% of studies. The area of concern " water scarcity" , related to water use, was addressed by 27% of studies. In the case of water use, most studies reported inventory-level metrics (e.g. blue water use, green water use, virtual water footprint). This is of concern due to the often poor correlation between inventory-level results for water use and results obtained after impact assessment modelling. A similar situation was found in the case of land use with most studies reporting inventory-level metrics (e.g. total land use, total arable land use). Such metrics inevitably identify foods produced on the most productive land by the most intensive agricultural practices as being preferable as these foods have the least total land use. In summary, the sustainable diets literature provides an incomplete coverage of relevant environmental concerns identified in the SDGs. The tendency to equate sustainable diets with lower greenhouse gas (GHG) -emission diets is problematic since it is well known that GHG emissions are not a proxy for the full range of environmental impacts associated with food production. At this time there are few generalizations that can be made about dietary habits that have lower overall environmental impact, apart from reducing food waste and avoiding overconsumption.

Keywords: *climate change; dietary guidelines; land use; life cycle impact assessment; United Nations Sustainable Development Goals; water use*

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Challenges when using Life Cycle Assessment for novel bioeconomy production systems

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Abstract

To increase the availability of sustainable plant proteins and to find those suitable for different food applications, novel protein sources should be explored and existing ones should be valorised more efficiently. Still, environmental impacts of such circular economy and bioeconomy solutions may be complex to assess. The production of oat protein concentrate from a side stream from the oat beta glucan production system was used as a case study for identification of challenges related to the application of LCA to novel circular bioeconomy products with the aim to estimate whether the production of side-stream based oat protein concentrate in this kind of system is environmentally preferable compared to other plant proteins and animal based proteins. Two major challenges were identified in the application of LCA in the case study, namely system boundary and functional unit setting, and time perspective for allocation. To reduce environmental impacts of food consumption it is important to strive for better valorisation of side streams by extracting valuable ingredients for food products and by developing attractive food products from all type of bioeconomy side-stream fractions that can even substitute animal protein. Nevertheless, the impacts of additional processing also need to be assessed and underlying assumptions carefully scrutinized.

Keywords: *LCA, novel food production system, co-products, bioeconomy, circular economy*

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Code: LCAF-2018-08-00050

Globalised or localised life cycle impact assessment methods? Implications from method comparison for sustainable food production in Thailand

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Abstract

The main aims of this research were to assess the implications of the various LCIA methods application, and to determine the impacts of direct (foreground) and indirect (background) emissions of food production in Thailand. Oil palm was chosen as the illustrative case. Five LCIA methods considered in this work were ReCiPe2016, IMPACT2002+, CML-IA, ILCD2011 midpoint+ and TRACI 2. 1. Impact categories investigated were human toxicity, freshwater ecotoxicity, terrestrial acidification, eutrophication, fine particulate matter formation, and ozone formation. Process contributions using the different methods were compared to determine the impacts of foreground emissions from the use phase in Thailand and background emissions from the production phase. The similarities and differences in the process contributions and contributing substances when applying various LCIA methods for some impact categories could be observed for some impact categories. The differences in the process contributions and the contributing substances were derived from the different rankings in characterisation factors of the relevant substances. The contributions from direct emissions from the use of fertilisers, pesticides, herbicides and fuels addressed the importance of spatial differentiation in LCIA for supporting sustainable food production. Future studies need to consider the variations from different systems and food products as well as to analyse the modelling approaches of each method.

Keywords: *LCIA; Spatial Differentiation; Site-Generic Characterisation; Site-Dependent Characterisation; Oil Palm.*

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Describing effects of grazing on soil quality in LCA

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Abstract

Describing the impact of farming on soil quality is challenging because the model should consider changes in the physical, chemical and biological status of the soil. Physical damage of the soil through heavy traffic has already been analysed in several LCA studies. However, compaction through grazing animals has widely been ignored, and physically based model approaches are very rare. With this paper, we introduce a new approach, which is closely related to stress propagation methods generally applied for analyzing compaction caused by heavy machinery. The new method was checked for plausibility by using a comprehensive multi-year dataset that contained detailed information on pasture management of several hundred Swiss dairy farms. First results show that the new method provides plausible results for the two physical soil indicators macropore volume and aggregate stability.

Keywords: *Soil quality, soil compaction, grazing, modeling*

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Code: LCAF-2018-07-00043

A methodological approach to carry out consequential life cycle assessment of greenhouse gas removal by agricultural soils

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Abstract

There is an urgent need for greenhouse removal technologies to compensate greenhouse gas emissions and restrict increases in global temperatures to no more than 2°C. Several consequential life cycle assessment (LCA) have been proposed to assess land based GGRT (e.g. cropland and forest management, biochar application, agroforestry) . However, a new methodological framework is necessary to reduce uncertainties and enable objective comparisons of GGRTs. We present i) an approach to assess soil based GGRTs with a consequential LCA at a global scale, ii) a discussion of the strengths and weaknesses of the methodology. The methodology is based on the IMAGE model to simulate land use distribution and market responses to implementation of GGRT and on models for C & N cycle simulation. It is comprehensive and integrates non-economic drivers but has large data requirements. Future research should focus on building a LCA network for LCA and agriculture, where common knowledge of crop management is shared and transparently communicated to improve LCA quality.

Keywords: *Life cycle assessment; Greenhouse gas removal technologies; Negative emission technologies; Greenhouse gases, consequential life cycle assessment; methodology*

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Code: LCAF-2018-08-00131

First proposition to include an integrated indicator of soil quality within the Life Cycle Assessment framework

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Abstract

Integrating a soil quality indicator within the Life Cycle Assessment (LCA) is necessary to assess the impact of land use on ecosystem services and related area of protections. Despite recent developments in the area, it remains difficult to find a consensus to integrate such an indicator due to the complex definition and assessment of soil quality. We propose a new way to integrate soil quality within LCA based on an integrative conception of soil quality that aims to assess directly the results of soil functions. First, we adapted a land management factor from the IPCC factors to quantitatively define the impact of various management practices on soil quality. Second, using this factor we calibrated a predictive model based on in-field soil quality integrative assessment from the Biofunctool® index. Over five experimental sites in a regional context of South East Asia, we proved that it is possible to predict the impact of land management on soil functional quality, with a restricted set of input parameters. Further studies on larger data set, in other contexts, may strengthen the approach and will make it possible to apply the model at a global scale to meet the LCA application requirements.

Keywords: *Soil Quality, Life Cycle Assessment, Land Management Factor, Soil Quality Index, Biofunctool®*

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The biodiversity, health and well – being in the context of global and local environmental changes

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Abstract

The Rockefeller Foundation – Lancet Commission on Planetary Health assessed the scale of the threats to human health and development posed by the multiple environmental changes such as climate change, land use change, and biodiversity loss occurring in the Anthropocene era. The Commission's July 2015 report (http: / / www. thelancet. com/ commissions/ planetary-health) makes the case for the need to consider health and well-being in a way which integrates knowledge of how underpinning Earth systems influence the broader determinants of health; and, puts forward research recommendations along with evidence-based, integrated policy solutions that address environmental sustainability together with human health and development. Planetary Health provides a coherent framework for addressing the Sustainable Development Goals through multisectoral policy action.

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Code: LCAF-2018-07-00101

Correlations between regional- and field-scale biodiversity indicators within life cycle assessment: The case of rice production systems in Japan

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Abstract

Regional-scale biodiversity indicators (potential species losses) , which were developed as characterization factors for assessing land use and land use change within the framework of life cycle assessment (LCA) , were compared with field-scale species richness based on paddy field surveys in Japan. Results indicate inconsistencies between regional- and field-scale biodiversity indicators (macro-micro inconsistencies) and show that it is difficult to employ regional-scale characterization factors based on the species-area relationship when assessing biodiversity impacts of rice production systems on a field scale. It is considered that conducting further studies on the biodiversity impacts of management practices would improve the applicability of biodiversity impact assessment within LCA.

Keywords: *Macro-micro inconsistency; correlation coefficient; potential species loss; species richness; paddy field*

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Code: LCAF-2018-07-00364

A consistent variable-scale biodiversity impact assessment structure

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Abstract

Impacts of land use on biodiversity are a current and relevant topic in the LCA community. Most existing methods for assessing biodiversity in LCA are either class-based or parameter-based. The class-based approach uses defined land use classes. For each class, an average value for biodiversity is derived from statistics. The parameter-based approach defines biodiversity as the result of a multivariate equation. Our work brings both approaches together in a hybrid approach, using predefined hemeroby intervals for different land use classes. Within the interval given by the hemeroby classes, a fuzzy system allows finer distinction. Our method allows both coarse and fine assessments of land use impacts on biodiversity. Even within the same LCA study, both coarse and fine assessments are possible. It allows different conservation priorities to be reflected in the assessment, but has a plausible and non-controversial default priority ready if the complex goal "high biodiversity" is not suitably defined for any given ecoregion.

Keywords: *biodiversity, fuzzy thinking, hemeroby, land use.*

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Pesticide emission and toxicity models in LCA need to be adapted for tropical regions

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Abstract

Currently available Life Cycle Inventory (LCI) pesticide emission models and Life Cycle Impact Assessment (LCIA) human toxicity and (eco)-toxicity characterization models were typically designed and parameterized based on temperate conditions. Taking pesticide emissions and their toxicity impacts on environment and human health into account in Life Cycle Assessment (LCA) studies is important in tropical regions, because large quantities of pesticides are used to increase crop yields and ensure food security. The objective of our study was to identify the characteristics that determine pesticide emissions and their impacts in tropical conditions, and to assess to what extent current LCI and LCIA models need to be adapted to better account for these conditions. We investigated existing models and conducted a systematic review of the characteristics that drive pesticide emission patterns and related toxicological impacts in the tropics. Our results indicate that high temperatures, high rainfall, soil characteristics (low organic carbon content, and often low pH) and cropping systems (e.g. mulching, application techniques) are important drivers of pesticide- related emissions in tropical conditions; and should be accounted for in existing LCI and LCIA models. However, as these processes are not as well understood as in temperate regions, and fewer measurements are available, further research is urgently required.

***Keywords**: Life cycle assessment; pesticides; emission models; toxicity characterization models; tropical regions*

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Code: LCAF-2018-06-00050

Spatially differentiated eco-toxicity characterization factors for copper soil emissions in Atlantic vineyards in Portugal and Galicia (NW Spain)

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Abstract

The main objective of the study was to improve the eco-toxicity characterization factors (CFs) for copper soil emissions based on chemical characteristics of soil in vineyards located in Portugal and Galicia (NW Spain) . A multiple linear regression model was applied to calculate the comparative toxic potential. Thereafter, the CFs for copper were computed on the basis of spatial differentiation considering the variable properties of soil within each wine appellation. The selected area comprised a total of 12 appellations. CFs obtained for the area evaluated ranged from 885 to 8,736 CTUe/ kg of Cu emitted to soil for cambisols and arenosols, respectively. Results obtained illustrate the high dependence of CF values on the chemistry features of each type of soil. Therefore, Cu soil mobility has shown to be strongly correlated to organic carbon content, influencing metal mobility, and pH values, which influence bioavailability (Arias et al., 2004). Consequently, soils with low organic carbon content reached the highest CFs.

***Keywords**: comparative toxic potential; grape production; Life Cycle Assessment; metal mobility; terrestrial eco- toxicity; wine*

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Code: LCAF-2018-07-00075

Land use impacts: comparing Irish and German milk production

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Abstract

Land use impacts on soil quality and biodiversity are rarely assessed in LCA so far. Thus, the aim of this study is to assess these impacts in a case study of German and Irish milk production.
Results show that despite lower milk yields Irish dairy production causes much lower biodiversity impacts and also much lower impacts on soil in three out of five soil parameters assessed compared to German milk production.
This shows clearly that it is important to include the assessment of land use impacts on biodiversity and soil in LCA in order to get a more complete picture of environmental impacts of agri-food products.

***Keywords**: land use impacts, biodiversity impacts, soil quality impacts, milk production*

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Code: LCAF-2018-08-00007

Accounting for land use contribution to climate change in agricultural LCA: Which methods? Which impacts?

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Abstract

Soil organic carbon (SOC) plays a key role in soil functioning, i.e. soil quality. Land use affects SOC and soil quality. However, despite various methodological developments, there is still no scientific consensus on the best method to assess the holistic impact of land use and land use change within LCA. The SOCLE project aimed to review how SOC is accounted for in LCA and to test the feasibility and sensitivity of best methodological options. In total, five crop products (annual/perennial, temperate/tropical) and two livestock products were investigated through 32 scenarios of land use changes (LUC) and agricultural land management changes (LMC). Three methodologies were applied, IPCC Tier 1-2 (2006), Müller-Wenk & Brandaõ (2010) and Levasseur et al. (2012). The accounting of LUC and LMC influences greatly the results on the climate change impact category. Based on the project results, we recommend accounting systematically for the impact of LULUC on climate change by applying, *a minima*, the comprehensive IPCC Tier 1 approach (2006). When available, site-specific data should be used (e.g. Tier 2) for SOC stocks but also C:N ratio and in order to model the digressive impact over 90% of the time period needed to reach equilibrium.

Keywords: *Soil carbon, Climate change, Land use, Agricultural practices.*

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Code: LCAF-2018-07-00365

Quantification of land use impacts on biodiversity with local ecosystem indicators: A case study in southwestern Germany

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Abstract

Impacts of land use on biodiversity have been a topic of ongoing development in the LCA community for about two decades. Here we present a method based on the potential field methodology by Lindner (2016) , developed further for application specifically in the state of Baden-Wuerttemberg, Germany. For any given plot, conditions parameters are used as input for a calculation framework that yields a scalar result as the biodiversity potential of the plot. This result is considered a relevant proxy for biodiversity. The input parameters are defined to embrace, among other policies, the eco-accounting scheme of the state of Baden-Wuerttemberg. Furthermore, experts from government agencies, NGOs and academia have been interviewed and their views have been integrated. The method functions mainly as an accounting tool. Limited use as a guiding tool for land management is also possible. The method is demonstrated in a case study. The study covers four different agriculture and forestry management regimes for the production of renewable raw materials in Baden-Wuerttemberg. Each of the management regimes is assessed with the proposed method.

Keywords: *biodiversity, potential field, Germany, land use.*

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Code: LCAF-2018-07-00351

GIS based Regionalized Land Use Characterization Factors for Life Cycle Impact Assessment using LANCA®

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Abstract

Land is used and modified in its natural functions for the cultivation of food and energy crops as well as for infrastructure and other production purposes. Despite their global significance, land use impacts are currently only rarely addressed, although methods for integrating land use aspects into LCA have been developed recently. The present work describes the development and calculation of regionalized characterization factors based on the LANCA® method in a geo information system (GIS) as well as the critical evaluation of the results. As result, maps showing the different land use impact characterization factors for various land use types are presented.

Keywords: *land use impact assessment, LANCA®, ecosystem services, GIS, maps*

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Code: LCAF-2018-07-00374

Environmental assessment of global confectionery brand

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Abstract

The environmental performance of the annual production of a global confectionery brand manufactured by Nestlé was assessed with the purpose of identifying hotspots and opportunities for improvement throughout its value chain. The study aggregated the production of 13 factories worldwide and had a full life cycle scope. It was shown that implementing guidelines for the responsible sourcing of cocoa (via the Nestlé Cocoa Plan) and palm oil without deforestation in its value chain, and an active switch to the use of renewable electricity at factory level could significantly reduce the environmental impacts associated with the brand.

Keywords: *Life cycle assessment, confectionery, chocolate, environmental sustainability, responsible sourcing.*

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Code: LCAF-2018-08-00042

Human toxicity assessment of oil palm cultivation in Thailand: the variability from using different life cycle impact assessment methods

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Abstract

This research aimed to understand the similarities and differences when using different life cycle impact assessment methods for human toxicity assessment, to assess the human toxicity impacts of oil palm cultivation and to recommend a suitable method to be adapted for life cycle impact assessment in the Thai context. USEtox, ReCiPe 2016 and IMPACT 2002+ were used to assess human carcinogenic and non-carcinogenic toxicity impacts of oil palm production processes in Thailand. The similarities when using the three methods are the hotspot process with the highest contribution in both human carcinogenic and non-carcinogenic toxicity impacts - potassium fertiliser production; and the least important process with the lowest contribution in both human toxicity impacts – direct emissions from fertilizer and pesticide applications in Thailand. The differences found are the main substances contributing to human toxicity impacts because the characterisation factors of the contributing substances for each method are ranked differently in each method. The USEtox method was primarily recommended for human toxicity assessment of oil palm cultivation due to its compliance in all essential aspects being considered.

Keywords: *Major agricultural crops; agricultural chemicals; Life Cycle Assessment; Human Toxicity Assessment.*

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Code: LCAF-2018-07-00253

AGRIBALYSE goes organic: life cycle assessment of French organic agriculture

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Abstract

Organic agriculture has shown vigorous growth in recent years. Life cycle inventory (LCI) data of products of organic agriculture are rare. The ACV-Bio project creates LCI data for arable crops, grassland, forages, grapes, cattle, sheep, pigs and poultry in France. The web-based MEANS-InOut software is used to facilitate and streamline the generation of LCIs and their external review by independent experts. MEANS InOut is adapted to the specificities of organic agriculture, according to methodological developments defined by the project partners: it allows the assessment of intercrops, cropping systems and the use of forages to feed pigs.

Keywords: *organic agriculture; AGRIBALYSE LCI database; intercrops; cropping system; biodiversity indicators; agronomic diversity*

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Code: LCAF-2018-07-00130

Animal Welfare – A New Indicator and Trade-offs with the Carbon Footprint

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Abstract

This study introduces an indicator framework to quantify the impacts on the welfare of farm animals. Consumers are increasingly concerned about animal welfare, and the framework can guide them in their decisions. We apply it to compare diets and six specific animal products, from conventional meat to insects as a novel protein source. To reduce burden shifting, we also analyze the synergies and trade-offs with the carbon footprint, and make the impact categories comparable by standardization to z-scores. Diets richer in animal products have both a higher carbon footprint and a higher animal welfare loss. Although beef causes less animal welfare loss than most other animal products, its high carbon footprint still leads to an overall high impact. In contrast, insects have a low carbon footprint, but cause a very high animal welfare loss. This shows that there are clear trade-offs between environmental and ethical aspects of our food choices.

Keywords: *animal products; environment; ethics; impact assessment; sustainability*

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Comparison of different approaches to cope with multifunctionality of livestock in LCA – a Peruvian case study

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Abstract

Multifunctionality of livestock is a typical feature of smallholder dairy systems. The objective of this study was to assess and compare different methods for the inclusion of multifuncionality of livestock in a LCA. A cradle to gate LCA of energy corrected milk (ECM) from typical smallholder dairy systems in the Southern Peruvian Andes was calculated using four different allocation approaches and system expansion (substitution): NA, no allocation; EM, economic allocation to market products; ET, economic allocation to products and other livestock functions; FP, allocation according to farmer´s perception and SE, system expansion. The results varied considerably depending on the allocation method. 1 kg of ECM contributed to global warming with 1. 65, 1. 39, 1. 25, 0. 55 and 0. 89 kg CO_2-equ. using mehods NA, EM, ET, FP and SE, respectively. The results of the study showed that the inclusion of non-commercial livestock functions reduces the environmental burden allocated to milk, that the farmers´ perception of livestock functions does not necessarily reflect their economic value and that the application of system expansion/ substitution to livestock systems is limited due to lacking equivalency of functions and products from main and alternative production systems. Especially when defining impact mitigation strategies multifuncionality issues should be considered in order to avoid moving impacts from the dairy system to other systems beyond the dairy unit.

Keywords: *Live Cycle Assessment; milk; livestock; multifunctionality; system expansion; Peru.*

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Farm-level GHG calculations of the entire Dutch Dairy sector

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Abstract

A significant amount of greenhouse gases is emitted as waste product of animal farming. The dairy sector in the Netherlands is an important player in the global dairy market, and increasingly, both the dairy farmers and their customers are interested in knowing just how well their farms perform when it comes to reducing GHG emissions. Reliable monitoring of emission data would enable farmers to implement the necessary changes to increase sustainability. A climate add-on to the mandatory Annual Nutrient Cycle Assessment (Dutch: KringloopWijzer), was created. The add-on integrates GHG calculations, based on a state-of-the art LCA standard into the online KringloopWijzer tool. The integration makes environmental impact data and benchmarks available on sector and farmer level and thus stimulates more sustainable practices and reduction of the GHG emissions. The tool has the capacity to calculate GHG emissions for the entire Dutch dairy sector, allowing over 17,000 dairy farmers to independently calculate their GHG emissions.

Keywords: *Dairy sector, GHG emissions, tool development, sector assessments, benchmark*

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Sustainable Performance of Meat Cell Factory

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Abstract

The objective of this article is to describe methodological issues in Life Cycle Sustainability Assessment (LCSA) when comparing a traditional slaughter line of pork with a cell-based concept, MFC (Meat Factory Cell). MFC is a new concept in an industrial context, and therefore there is little current knowledge about the sustainability of this process. An LCSA study includes the environmental (E-LCA), social (S-LCA) and economic (Ec-LCA) dimensions. Data availability and acceptable data quality were found to be critical issues when performing an LCSA study. It was necessary to use scenarios in combination with actual data, and the result is a semi-quantitative assessment. In the E-LCA study, economic allocation is used. It is assumed that a higher price of the by-products can be obtained in the MFC. By using economic allocation, the increased value of the by-products gives a lower impact on the meat product. In the S-LCA study, selected focus areas are health and safety, discrimination and local employment.

Keywords: *social LCA; economic LCA; meat; slaughter line; allocation; by-products*

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Comparative environmental impact of alcoholic beverages consumption

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Abstract

Environmental consequences resulting from the intensive food production are widely known. Up to know, authors have been focused on identifying better food production systems or alternatives for "greener" basic food products (animal protein vs. plant protein etc.). However, discretionary foods (such us chocolates or alcohol production and consumption) can have great environmental impact. In this study, Spanish red wine and bottled or drought beer have been compared to identify the most suitable alternative for the alcohol consumption.

Results of this comparison suggest that draught beer is the option with the least global warming, acidification and eutrophication followed by the red wine and bottled beer respectively. The differences in the final impact values are mostly due to the packaging material and weight. Thus, efforts should be focused on developing new packaging materials with less impact or lighter beverage containers.

Keywords: *wine, beer, packaging, discretionary foods, PEF*

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Towards specific guidelines for applying LCA in South contexts

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Abstract

The demand for LCA studies on agri-food value chains from South contexts is growing, but the application of LCA in these contexts is challenging. An initiative has been launched to formalize best practices based on the field experience from LCA experts for South contexts. Specificities of the application of LCA in these conditions relate to the diversity and complexity of production conditions and systems, the limited awareness and capacities in LCA as environmental assessment tool by stakeholders, the lack of specific background data, the scarcity and often low-quality of statistic data on studied systems, and the limits imposed to LCA commissioned from abroad. The guidelines in preparation will mainly focus on practical aspects of goal and scope definition, data collection and partnership, inventory and interpretation for key stakeholders.

Keywords: *Life Cycle Assessment; developing countries; agriculture; decision-support; guidelines*

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Valuating potential ecosystem services with a life-cycle oriented methodology

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Abstract

Numerous methods exist to valuate ecosystem services, notably are contingents. An objectivised life-cycle oriented method based on LCA and Emergy Accounting (EA) could be able to asses a bundle of ecosystem services. This method is based on the 4 steps of LCA and is applied to an aquaculture pond. Diverted LCA indicators and EA indicator are used to assess each ecosystem services. The both metrics show us different images of ecosystem services, a biophysical value (LCA indicator) and the environmental work required to supply it (emergy indicator) The results are relevant with our knowledge about aquaculture pond. Further researches are needed to improve the method, like characterisation factors specific to ecosystem services, a better inclusion of cultural ecosystem services and a better link between LCA and EA boundaries

Keywords: *ecosystem services; emergy accounting; life cycle assessment; sustainable production*

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Nitrogen and phosphorus modelled in freshwater eutrophication: The director's cut

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Abstract

Existing spatially-explicit freshwater eutrophication indicators focus on phosphorus as the sole contributor to the impacts, although nitrogen may be a limiting factor too. We developed Fate Factors (FFs) for both dissolved inorganic nitrogen (DIN) and dissolved inorganic phosphorus (DIP), distinguishing emissions from soil and emissions to freshwater. The fate processes modelled include nutrient attenuation from land to stream, in the river network, in reservoirs and lakes, and associated with water consumption. FFs were calculated at a river basin resolution with a global coverage. Preliminary emission-weighted global average FFs are (in days) FF_soil_DIN = 117; FF_river_DIN = 251; FF_soil_DIP = 21; FF_river_DIP = 241. The present fate model is consistent with recent advances in marine eutrophication impacts assessment and complements such an approach.

Keywords: *Freshwater eutrophication; Nutrient; LCIA; Global; Spatially-explicit.*

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Making agricultural Life Cycle Assessment tools effective

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Abstract

Customized life cycle assessment (LCA) tools are potentially valuable for facilitating eco-design in agriculture, but if not effective are prone to being under-utilised. We drew on the experiences of tool developers to identify the key challenges and opportunities for making tools effective (based on effectiveness criteria defined in earlier research), and to propose practical recommendations to inform future tool development. Priority recommendation are online hosting, uncertainty analysis, data input from farm data systems, results categorised by practices, consensus best-practice methods, accounting for diverse practices, regionalized analysis, and capitalizing on agriculturist knowledge.

Keywords: *sustainable agriculture; eco-efficiency; inventory development; simplified LCA; streamlined LCA.*

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Challenges for Knowledge Engineering in Life Cycle Inventory

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Abstract

Large amounts of data are required to obtain reliable results for life cycle assessment (LCA). Up to now, LCA experts generally use a free/ commercial database for the background system and experimental data for the foreground system to generate the life cycle inventory. In parallel, an increase in the number of articles describing process operations published on the Internet has been observed. These articles could provide a valuable source of data for the foreground system. However, the huge mass of data they contain is typically unstructured, requiring time-consuming manual extraction. Knowledge engineering (KE) provides a way of overcoming this bottleneck, through methods for structuring experimental information and expressing it in a standardized vocabulary. An Ontological and Terminological Resource is proposed to facilitate the use of data from heterogeneous sources and the supplying of the annotation base. This base supplies the data for the foreground system. A combination of KE and LCA methods would, thus, constitute a viable solution, providing additional data for the foreground system. This article describes a data processing pipeline coupling KE and LCA methods. The proposed method was applied to a bio-refinery's case study, four different rice straw pretreatment processes.

Keywords: *Life Cycle Assessment, Knowledge Engineering, Big data, Bio-refinery*

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Code: LCAF-2018-07-00027

Life Cycle Assessment of Premium Salted Potato Chips Manufactured by ITC- A Case Study

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Abstract

The objective of this study is to use life cycle analysis to identify environmental hot-spots, quantify environmental impacts, and explore various opportunities to improve environmental footprint of the packaged premium salted potato chips manufactured by ITC under the brand Bingo!. The scope of this study is the cradle-to-grave assessment of the packaged premium salted potato chips. GaBi software version 6.115 has been used to develop the Life Cycle Assessment (LCA) model. In this study, analysis has been done on the environmental impact categories like Global Warming Potential (GWP), Primary Energy Demand (PED) and water consumption.

The scenarios under consideration of this LCA model comprise exploring different options such as changing the frying oil, reducing oil content in chips, improving solid content of the potatoes, reducing primary packaging content and different end-of-life treatment options. This study shows that a savings potential in GWP can be achieved in the range of 6.15%-11.8% as a result of the implementation of the identified scenarios.

The findings of the study provide insights into the key hotspots that have significant environmental impacts. The results will help to identify a potential range of sustainability opportunities, formulate environment related decisions and target focused efforts that will lead to the possible reduction in significant environmental impacts and overall, improvement in the sustainability of value chain.

Keywords: *Life cycle assessment; Premium Salted Potato Chips; printed laminate*

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Code: LCAF-2018-07-00169

Assessing environmental impacts and risks of pesticide application in Swiss crops by combining LCA and risk analysis

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Abstract

The impacts on the environment and the ecotoxicological risks were assessed for five crops in Switzerland and three crop protection scenarios with low, mean and high treatment frequency. LCA and risk assessment were applied in parallel. A considerable reduction potential existed between the scenarios, particularly for the high treatment frequency. Only one or a few active ingredients dominated ecotoxicity impacts and risks. Avoiding these dominating active ingredients seems to be promising for mitigating ecotoxicological impacts. Furthermore, the study showed that it is necessary to consider all relevant environmental compartments and not to focus on water bodies alone. For aquatic ecotoxicity potentials assessed by LCA (USEtox method), pesticides contributed less than half in all scenarios, while heavy metals and other toxic substances were dominating.

Keywords: *Crop protection; pesticide; ecotoxicity; LCA; risk assessment*

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Characterization factors for global fisheries

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Abstract

Natural resources are probably the most un-consensual area of concern in Life Cycle Impact Assessment. Very few works deal with biotic resource. Current Life Cycle Assessment framework is only at the onset for estimating impacts of fish removal. This study shows outlines of a recent work (Hélias *et al.* (2018), Fish Fish, in press) proposing a new model and operational values for characterization factors (CFs) to quantify impacts on biotic resources using. CFs are calculated with partial derivatives on a model linking the inventory (the mass of fish caught) and the impact (the depleted stock fraction). This is done with to the Schaefer model, representing the dynamics of the stocks. They combine catches, current biomass and maximum intrinsic growth rates. CFs for all fish stocks of global FAO areas are obtained. CF values among stocks generally tend to decrease when fish catches increase because high catches are generally associated with abundant stocks. This allows taking into account in Life Cycle Assessment the use of sea resources.

Keywords: *characterization factor; biotic resource; fish; marginal approach; FAO stocks.*

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Code: LCAF-2018-06-00053

Methodological choices of LCA applied to aquaculture systems: Critical review & recommendations

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Abstract

Aquaculture has been the fastest growing food production sector for several decades. Despite its reputation of being a sustainable protein source, this industry has been associated with several environmental impacts, such as climate change or aquatic eutrophication. It is therefore important to ensure that its fast development occurs with as low environmental impacts as possible. Life cycle assessment (LCA) is the most common tool to assess environmental sustainability of systems and processes, and has been extensively applied on aquaculture systems. In this work, we reviewed 65 LCA studies applied on aquaculture and aquafeed systems, and analyzed the methodological practice of LCA by the practitioners. We selected four important issues that highly influence the final scores of the LCA studies: the functional unit, the handling of multifunctionality, the system boundary and the impact coverage. For each of them, a thorough analysis was conducted, leading to a set of recommendations that we believe will improve the quality, reproducibility and comprehensiveness of future LCA studies in the aquaculture field.

Keywords: *aquaculture; seafood; fish; LCA methodology; critical review.*

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Code: LCAF-2018-07-00231

Life Cycle Assessment (LCA) of salmonid aquaculture systems: status and perspectives

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Abstract

This study is the first step of a PhD project characterizing the environmental impacts generated by disease and parasite treatments in the Norwegian salmon industry. It reviews LCAs of salmonid aquaculture systems, systematically investigating the methods, inventories, impact assessments and conclusions of 24 original studies (*status*). Based on results obtained, and in the light of recent research developments, suggestions are made to improve standardization, the variable inventory data quality (representativity and completeness) , and the challenges to compare environmental impacts across studies. Among other things, this study discusses why systematic LCA data reporting is desirable and how the lack of datasets and models to measure the impacts of disease and disease treatments is problematic for aquaculture environmental assessments (*perspectives*).

Keywords: *Life Cycle Assessment, Environmental Impact, Salmon, Trout, Aquaculture, Food.*

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Code: LCAF-2018-06-00026

LCIs of Latin American seafood production systems in ecoinvent®

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Abstract

A 2017-2018 ecoinvent® project, in the context of the " Sustainable Recycling Industries programme" , provided new undefined Unit Process LCI datasets representing fisheries, aquaculture and fish processing in Latin America. South America is an important seafood producing area, representing 10% of the global wild captures from marine, brackish, and freshwater environments in 2015. In fact, certain countries are important global producers of specific seafood species, such as anchoveta (Peru) , tunas (Ecuador) , salmonids (Chile) and tilapia (Brazil) . The inclusion of a seafood-related dataset is novel to ecoinvent® and thus formalises a new area of LCI data collection for which a specific modelling strategy was proposed. Results (impact assessment based on the produced inventories) were tested and compared against literature and previous LCAs performed by the authors. The authors are confident the results of this project will encourage other data providers, in particular those based in developing countries underrepresented in inventory databases, to further enrich ecoinvent® with global seafood inventories.

Keywords: *aquaculture; fisheries; fishmeal; Latin America; LCI; seafood*

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Code: LCAF-2018-07-00029

Life Cycle Assessment of applying Algal Oil in salmon aquaculture; challenges for methodology and tool development

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Abstract

Evonik and DSM founded the joint venture Veramaris®, introducing a new Algal Oil based omega-3 fatty acid source for aquaculture. This intracellular oil is produced in a biotechnological manufacturing process using non-marine resources. The rationale for this development is that the capacity to generate omega-3 fatty acids through fish is not sufficient to fulfill the dietary requirements of a growing population, and that many fish species used as feed in aquaculture are either fully utilized or overfished, leaving little room for expansion. Algal Oil reduces the dependency of salmon aquaculture on marine fatty acid production and fish stocks, by replacing marine ingredients with algal oil and crop-based ingredients. To illustrate the environmental impacts and potential tradeoffs of this new product, a Life Cycle Assessment (LCA) was performed. Indicators developed for application of LCA to fisheries were used to assess the marine ecosystem impact of replacing fish oil by Algal Oil and fish meal by crop-based protein sources in salmon feed. The study demonstrated that the use of Algal Oil as a source of omega-3 fatty acids leads to a considerable reduction of impact on marine ecosystems of farmed salmon. This improvement is accompanied by an increase in impacts associated with agriculture. Current LCA methodologies do not allow weighting of these opposing effects. However, to make informed choices between the available options this would be required. Because the availability of natural marine resources is limited, the strong growth expected in salmon aquaculture requires innovative feed solutions decoupled from limited fish stocks to meet future requirements for omega-3 fatty acids. Veramaris® Algal Oil in combination with vegetable crops enables growth of salmon aquaculture that is independent of limited fish stocks.

Keywords: *LCA, aquaculture, overfishing, marine ecosystem impacts, algal oil, Omega-3 fatty acids*

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SESSION 1 – B
FROM FARM TO TABLE

Code: LCAF-2018-09-00017

System Modelling and Life Cycle Assessment of Dairy production on heavy wet soils in Ireland

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Abstract

The increasing global demand for milk, combined with both national and international policies, has driven dairy production expansion in Ireland. At the same time, agriculture in Ireland is responsible for a significant proportion of national environmental impacts, which are mainly due to dairy production. Around 30% of milk in Ireland is produced on poorly drained soil and available land resource for expanded production is also poorly drained. This land is considered marginal for grass based dairy production. System modelling and life cycle assessment were used to evaluate the climate change, acidification and eutrophication impacts of grass-based spring-calving milk production on poorly drained farms in Ireland. A dairy system simulation model, Dairy_sim, was used to find optimum management, which maximizes grass production and utilization with little or no excess silage, to derive the inventory of life cycle assessment modelling.

Keywords: *Dairy_sim, system model, LCA, land drainage*

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Hotspot analysis on the life cycle assessment of Indonesian tempeh

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Abstract

Tempeh is a fermented soybean product and an important non-meat protein source in the Indonesian diet which plays an essential role in the culture and economy. The raw material is however mostly imported from the USA. This paper evaluates the environmental performance of tempeh by comparing existing tempeh production alternatives in Indonesia, identifying impact hotspots, and analysing parameter sensitivity for possible improvement.

The life cycle assessment was conducted over a complete range of impact categories. Using a case study of tempeh production in West Java, the study differentiated two levels of technology, defined as conventional and hygienic tempeh production. The cradle-to-gate product system included soybean cultivation, transportation, and tempeh processing. Minor differences in environmental impact exist between the different production systems. The global warming impact of 1 kg of tempeh, either conventional or hygienic, is between 0.9 and 1.0 kg CO_2-eq. Road transport within Indonesia was found to dominantly contribute to the total transport impact and to be a highly sensitive parameter, showing great variability due to changes in assumed distance and assumed average load. Options to develop locally-grown soybean should consider possible trade-offs with local transportation.

Hotspots of Indonesian tempeh are related to the provision of soybean and their transport to the tempeh factory. This means that the processing of soybeans into tempeh at the factory only has a small contribution to total environmental impacts. Therefore, improvements aiming at environmental gains should focus mainly on the development of locally-grown soybeans or other beans, more efficient modes of local transport, and to a lesser extent on the installation of wastewater treatment, increased use of renewable energy, and increased energy efficiency.

Keywords: *Environmental performance; Soybean; Fermented food; Traditional food; Contribution analysis; Sensitivity analysis*

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Code: LCAF-2018-07-00250

LCA of certified palm oil

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Abstract

Palm oil is the most widely used vegetable oil globally. It is mainly grown in Indonesia and Malaysia, where it is often accused for its impacts on climate change an biodiversity caused by e.g. deforestation. The sustainable alternative to conventional palm oil is certified palm oil, which many palm oil using companies have committed to use. However, there is a lack of quantitative information on the performance of certified palm oil. This paper outlines how this can be approached and provides LCA results for certified and non-certified palm oil. The results clearly show that certified palm oil performs better than non-certified. However, the results are also associated with uncertainties, mainly due to issues related to reliability, completeness and consistency for the collected primary data for certified producers. Therefore, there is a need for further standardising LCA data for certified palm oil producers.

Keywords: *Palm oil; certified production, Round Table on Sustainable Palm Oil (RSPO).*

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Effects of transport distance and the quality requirement level on LC-CO_2e of the produces susceptible to physical damage

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Abstract

The objectives of this study are to illustrate the effects of packaging on the equivalent life cycle CO_2 emission (LC-CO_2e) of two kinds of fresh produces (strawberry and peach) and to prove the existence of the optimum packaging condition based on LC-CO_2e of these produces. We focused on the effects of transport distance and quality requirement level on the LC-CO_2e under different packaging conditions for strawberries (4 kinds) and peaches (6 kinds). The effects of packaging condition on the LC-CO_2e of strawberries and peaches were illustrated based on the transport distance by simulated transport test which reproduced the transport condition of trucks in Japan using 3D vibrator. Results indicated that the transport distance is the key factor on the LC-CO_2e of strawberries and peaches. The optimum packaging condition was different depending on the transport distance based on the LC-CO_2e of fresh produces tested. In the long distance transport, the cushioning performance is essential to prohibit the increase of LC-CO_2e of the product which are susceptible to physical damage.

Keywords: *packaging; food loss; transportation; cushioning; perishables*

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Addressing organic viticulture environmental burdens by better understanding causes of inter-annual impacts variations

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Abstract

Organic viticulture is developing rapidly due to consumers demand and state incentives in some EU countries. Nevertheless, it has shown higher inter-annual variability in its environmental impacts than conventional viticulture. Therefore, the organic winegrowers would benefit from a better understanding of this variability in order to better address their environmental impacts. A study was conducted in four contrasted pedoclimatic conditions and two contrasted years in terms of climate and of pest and disease pressure. LCAs of organic wine grape was calculated based on detailed inventories of data from the eight real vineyard situations. Main contributor to impacts was diesel combustion. The inter-annual variation was different between the plots. The impacts that varied the most were the freshwater and soil eco-toxicities, marine eutrophication, freshwater eutrophication and metal depletion. The main agricultural operations contributing to impact variations were disease management due to disease pressure related to climatic conditions variations.

Keywords: *sustainable agriculture; Cradle-to-farm gate LCA; variability; climate, diesel, copper.*

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Implications for agricultural product carbon footprints of including changes in soil carbon

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Abstract

Changes in soil organic carbon (SOC) are an important driver of greenhouse gas emissions and removals but they are not commonly covered in life-cycle inventory (LCI) data. Long-term changes in SOC have been modelled for Australian rain-fed cropping systems under current management practices. The resulting average annual soil organic carbon change has been included as an emission or removal of carbon dioxide in the LCI data for crops. The effect on the total farm-gate carbon footprint of those crops can be significant, depending on local soil and climate conditions. The variability means that the average ΔSOC values are associated with high uncertainty.

Keywords: *broad-acre cropping; life cycle assessment; global warming.*

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Optimization of Swedish Organic Bilberry Processing by Life Cycle Assessment

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Abstract

Fresh bilberries are a rich resource of bioactive compounds that are known for their health promoting effects. However, they are a seasonal product and perishable with short shelf-life. To increase the commercial value and reduce waste it is therefore rational to process berries into added value products. The aim of this study was to evaluate the environmental sustainability of I) two different drying technologies for bilberry processing, and II) different bilberry raw materials. As a sensitivity parameter, the impact of including bilberry pickers' travels was included. The method used was Life Cycle Assessment (LCA). The processing technologies evaluated were hot air-drying (HA) and microwave assisted hot air drying (MW-HA). Results showed that press cake had the lowest environmental impact. It was found that the rye flour used in the extrusion of the bilberry product had per se, a high environmental burden. The results also indicate that the HA drying technology is the more sustainable processing technology. Also, the inclusion of the bilberry pickers' travels would greatly increase the environmental footprint of the bilberry products if to be included.

Keywords: *Bilberry, Life cycle Assessment, Food processing, Drying technology, Environmental footprint*

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Defining nutritionally and environmentally healthy dietary choices of omega-3 fatty acids

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Abstract

Heart disease is the leading cause of death in the U.S., which can be attributed to unhealthy diets, hence increased intake of polyunsaturated fatty acids (FA) has been recommended. While oily fish is a good source of omega-3 (n-3) FA, enriched foods have been developed as vegetarian alternatives, such as n-3 enriched eggs, that are becoming more popular. In this study, life cycle assessment was conducted to compare the environmental characteristics of two common n-3 FA dietary sources, salmon and n-3 enriched eggs, and evaluate the potential effects of increasing the n-3 FA intake from current daily consumption to the recommended daily intake (RDI). The functional unit (FU) was defined as the amount of each food needed to fulfill the RDI of 300 mg of n-3 FA. The product systems included all the main stages from feed production to final disposal. Results showed that although salmon presented higher midpoint (acidification, eutrophication and global warming potentials) and endpoint (disability-adjusted life year) impacts on a mass basis, it was a more sustainable option than n-3 eggs when the n-3 FA concentration was considered. Furthermore, sensitivity analyses indicated that both the origin of salmon and supplement source for n-3 enriched eggs had significant effects on their environmental performance. This study can help make recommendations about healthy and sustainable choices of n-3 FA sources in the U.S. diet at reduced environmental costs, allowing the public to understand the associated impacts and act to improve their eating habits.

Keywords: *Omega-3 fatty acids; Salmon; Omega-3 eggs; Life cycle assessment; Sustainable diet*

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A Baseline Life Cycle Assessment of California Processed Tomato Products

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Abstract

The U.S. state of California is the leading producer of processing tomatoes globally, producing approximately one-third of the total global processing tomato production in 2016. The California tomato industry has made significant attempts in the last 10-20 years to address environmental and production challenges, such as drought and water limitations, as well as energy use and greenhouse gas emissions.This study uses a comprehensive life cycle assessment (LCA) approach to estimate the environmental burdens of producing diced and paste tomato products in California, USA and to document trends over time. The LCA accounts for greenhouse production of transplants, field cultivation of tomatoes, and facility processing into a diced and a paste product. It examines data from two different years, 2005 and 2015, to elucidate trends in cultivation and processing practices and the effects of these trends on the environmental and health impacts. It also incorporates results of biogeochemical modeling.

Changes in irrigation technology, increases in tomato yields, and reductions in fossil energy use by farmers and processors led to supply chain life cycle water use efficiency increases of 41% and 43% , for paste and diced product, respectively, and energy use efficiency increases of 14% and 28% , respectively. These efficiency increases also led to decreases in the 100-year global warming potential, ecotoxicity potential, and atmospheric pollution effects (ozone depletion, acidification potential, and photochemical ozone creation) . Production and combustion of natural gas and diesel contribute the most to environmental impacts, followed by irrigation water pumping, and gypsum and fertilizer production and use.

***Keywords**: Environmental Product Declarations; greenhouse; cultivation, processing facility; biogeochemical modeling*

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Putting sustainable diets into practice

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Abstract

The world's food system faces a great balancing act. By 2050 9.6 billion people need to be fed in a more sustainable way. Besides that, diets should be healthier and adapted to human nutritional needs, preventing both malnutrition and diet related illnesses. It is crucial that food companies develop a clear understanding of the strengths and weaknesses in their (current) product portfolio related to environmental impacts and nutrient intake. To get these insights the optimization tool Optimeal has been developed. It enables food and beverage producing companies to implement sustainability targets into product development and create future-proof products. As a case study we have used Optimeal to investigate the role of dairy in a healthy and sustainable diet in the Netherlands. In three steps the potential contribution of dairy to sustainable diets has been identified. The first step was the identification of hotspots, which products or ingredients have the biggest impact (environmental and nutritional). The second step was the assessment of the Sustainability Nutrition Balance. In step 3 the analysis is used to improve the product by creating a better Sustainability Nutrition Balance. The analysis showed that as a source of useful nutrients, dairy is just as environmentally efficient as the products used to replace them. With this method it is possible to take the first steps towards an integrated assessment of the performance of foods in sustainable diets and solve global issues facing the food and beverage industry.

Keywords: *Sustainable diets, optimization, innovations, product development, food products.*

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Code: LCAF-2018-07-00271

Diet matters: the case of Spain

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Abstract

Food consumption plays a significant role in the climate change scene due to the climate burdens carried by the production of the food items being consumed. In Spain, the population has shifted from a Mediterranean to a more Western type diet, which is related to health problems (FEN, 2013). Here, we investigate the GHG emissions of the food consumption pattern of an average Spanish citizen (MAPAMA, 2017), and compare it to an alternative diet based on the Spanish Dietary Guidelines (Tur-Marí et al., 2010). To be able to compare diets, the selected functional unit is an annual food basket with the representative food products consumed by a Spanish adult that covers the daily energy requirement of 2000 kcal. The system boundary scopes from cradle-to-consumer, and food losses are considered along the whole supply chain. A full inventory of 48 representative food products was built from available published literature. Our results show that current Spanish food consumption emits about 1.5 t CO_2-eq per capita annually, being the meat products the main contributors. Emissions can be reduced by 19.5% when nutritional guidelines are followed. Dietary decisions are key actions that consumers can carry out to mitigate CO_2 emissions, and National Dietary Guidelines can be a good policy tool to promote diets with climatic and nutritional co-benefits.

Keywords: Climate change; dietary patterns; national dietary guidelines; food consumption

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Alternative food production systems: from insects and microalgae to emerging processing technologies and smart LCA systems

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Abstract

Changing food production and consumption systems is acknowledged as potential solution to feed the world' s growing population within the planetary boundaries. Transfer of food production systems to novel sources, technologies or diets require holistic accounting of environmental impacts and nutritional properties of foods. Current research proposes a holistic method to account for direct nutritional impact on human health as a part of environmental impact in endpoint human health category.

Keywords: *alternative food sources, nutritionally corrected LCA, human health, direct nutritional impact.*

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Code: LCAF-2018-07-00322

Nitrogen footprint and related impact categories for milk produced from contrasting farm systems in China and New Zealand

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Abstract

Intensification of dairy production is occurring globally and an important driver of this is an increase in the quantity and quality of brought-in feeds used on farms. This study compared dairy farm systems in China (year-round housing) and New Zealand (NZ; year-round grazing of pasture) varying in intensity and brought-in feed inputs. Country-specific models and emission factors were used to calculate all farm-related emissions, while background emissions were determined using life cycle assessment (LCA) and ecoinvent or Chinese life cycle databases. The nitrogen (N) footprint (i.e. sum of reactive N emissions on a kg N basis) of Chinese milk was 1.5-2.5 times higher than that for NZ milk, mainly due to much higher ammonia emissions. In the grazed pasture systems of NZ, the N emissions from nitrate leaching were more dominant at 40-50% of total N footprint compared to 20-40% for the Chinese farms. The various forms of N emissions contribute differently to a range of environmental impacts and therefore the N footprint can be a useful generic environmental indicator. However, some N forms only contribute to some impact categories and their significance will vary depending on the system studied and site of impact. Hence, the relatively high ammonia emissions from Chinese farms can be important for particulate matter impacts, while relatively high nitrate emissions from NZ farms can be important for eutrophication impacts (and can be site-specific). On a per-kg milk basis, all impact category indicators, and the N footprint, decreased with increased dairy system intensity (from greater use of brought-in feeds and associated increases in milk production per cow) in China. In contrast, there was little change with dairy system intensification in NZ due to an increased contribution from off-farm feed production.

Keywords: *Nitrogen; milk; environmental impacts; feed crops.*

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Environmental impact of organic and conventional milk in Europe case studies from UK, Austria and Denmark

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Abstract

It has not been common practice in life cycle assessment studies of organic dairy products to consider soil carbon changes and include impacts of biodiversity and ecotoxicity, despite evidence that it is especially within those areas that organic and conventional production differs. The aim of the present work was to include those impacts based on newly published characterization factors in the assessment of organic and conventional milk in Europe. Three systems was selected for the analysis, which represent a range of approaches to dairy production in Europe; (i) low-land mixed crop-livestock systems (DK), (ii) lowland grassland based systems (UK), and (iii) mountainous systems (AT). The study showed that for the commonly included impact categories such as global warming potential, eutrophication and land use, organic milk had similar or slightly lower impact than conventional milk, except from land use, which was higher. Including soil carbon changes reduced the carbon footprint by 5-18% , especially in systems with a high share of grass in the feed rations. Interestingly for the rarely included impact categories of biodiversity, freshwater ecotoxicity and resource depletion, organic milk had only 33% of the impacts of conventional milk. Thus, the study highlights the importance of including those impact categories in life cycle assessments of organic and conventional products. Furthermore, the study showed that including more grass in the feed ration increased the carbon sequestration and decreased the negative impact on biodiversity.

Keywords: *organic; biodiversity; dairy; ecotoxicity; LCA; soil carbon*

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Valuing leftover streams through livestock; the impact of livestock system and productivity level

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Abstract

While the role of livestock in sustainable food systems is heavily debated, recent studies show that livestock can contribute to global nutrition security by converting leftover streams – products humans cannot or do not want to eat – into animal-source food (ASF). Where these studies clearly underpin livestock's role in global food security, the current study aims to identify which combination of livestock systems, differing in production level, can optimally convert leftover streams into protein. To this end, we developed an optimization model containing a variety of livestock systems (pigs, dairy cattle, beef cattle, laying hens and broilers), differing in production level (low, mid and high), to enable better utilization of the various (low quality) leftovers. Included leftover streams consist of waste and processing co- products related to current food consumption in the EU and currently available grazing resources in the EU. The optimal use of these leftover streams requires mainly low productive dairy cattle, and provides 30 g animal protein/ cap/ day. Although this protein supply fulfils half of our daily protein requirement, it requires a shift in consumption patterns and farming practices. This study illustrates that using leftover streams optimally, improves the role of livestock in nutrition security.

Keywords: *land use; feed-food competition; livestock; food-waste; marginal land*

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Effects of measures to reduce nutrient losses on the overall environmental impact of the Swiss farming sector

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Abstract

We analyzed the effect of different measures to control nitrogen and phosphorus pollution on the overall environmental impact of the Swiss agricultural sector, including imports and exports. Our results show that it is possible to reduce the environmental burden of the agricultural sector within Switzerland, but only at the expense of shifting environmental impacts abroad. In order to reduce the overall environmental impact of a country's agri-food sector, small-scale local factors such as site-adapted tillage practices have to be considered in combination with a global perspective.

Keywords: *environmental impact; agricultural sector analysis; water pollution control measures*

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On-farm level acting in order to mitigate climate change using a point-based system

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Abstract

The Swiss farmer organization IP-SUISSE has initiated a project aiming at reducing the greenhouse gas emissions (GHGe) by 10% on 10.000 farms in 2022 compared to 2016. IP-SUISSE intends to introduce a point-based system for climate mitigation measures like for example using phase feeding for pig fattening, covering the slurry pit, or applying a fertilization plan. Farmers participating in the IP-SUISSE label have to implement a sufficient number of measures in order to meet a minimum amount of points set for each farm.

Using the SALCA-Method (Swiss Agricultural Life Cycle Assessment) by Agroscope the Global Warming Potential (GWP) of 30 pilot farms of three types (animal-intensive, mountain agriculture, arable farming) is calculated for two years 2016 and 2018, respectively, meaning before and after implementing climate mitigation measures of the point-based system.

The amount of GHGe (in CO_2-equivalents; CO_2e) reduced in 2018 with the intended mitigation measures of the pilot farms is as follows: the largest reduction potential is achieved in animal-intensive farms (with 45 t CO_2e per farm on average) followed by the mountain dairy farms (30 t CO_2e per farm) and the arable farms (30 t CO_2e per farm).

First extrapolations yield to a GWP of all 10'000 IP-SUISSE label producers of about 1.5 Mio tCO_2e per year. Therefore, a reduction of 10% corresponds to around 150'000 t CO_2e, i.e. 15 t CO_2e per farm on average. With respect to the above-mentioned estimates, the GHG reduction goal seems feasible.

Keywords: *Farm-level measures, Global warming mitigation, Point-based system, SALCA, farm LCA, Greenhouse gas reduction.*

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Code: LCAF-2018-08-00063

A Stepwise Retrospective Life Cycle Assessment of US Pork: 1960 – 2015

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Abstract

The primary goal of this study is to assess the carbon, energy, water and land footprints per kg. (2.2 pounds) of live weight (LW) pork produced at five-year increments between 1960 and 2015. This assessment utilizes the Life Cycle Assessment (LCA) methodology, which is a technique to assess the potential environmental impacts associated with a product system by compiling an inventory of relevant energy and material flows, evaluating the associated burdens, and interpreting the results to assist in making more informed decisions and to provide an understanding of the drivers of change over the past 55 years. This LCA is "cradle-to-farm gate" e.g. covering the material and energy flows associated with the full supply chain beginning with extraction of raw materials through the production of live, market-weight swine, inclusive of culled sows, at the farm gate. On average, production-weighted metrics declined across all four categories over the assessment period. The largest decrease was seen in land use (75.9 percent), followed by water use (25.1 percent), then global warming potential (7.7 percent), and finally energy use (7.0 percent).

Keywords: *historical LCA; Pork production; time series; swine production simulation*

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Life cycle assessment of cellular agriculture combined with agroecological symbiosis

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Abstract

Food systems are facing the challenge of sustaining the production of nutritious food to the growing population. New agricultural and food production technologies that provide solutions both to adaptation to environmental changes and reduction of environmental impacts of agriculture are needed. The aim of this study is to estimate the environmental impacts of transforming current agriculture by agroecological symbiosis (AES) combined with cellular agriculture. AES utilises agroecological principles for plant production, where nutrients are recycled effectively, the use of plant protection products is reduced by preventative methods and soil quality is improved by cover crops and versatile crop rotations including clover-grass leys. Anaerobic digester that produces energy from plant residues and clover-grass leys from agriculture and biowaste from communities is an integral part of agro-ecological symbiosis as it helps to recycle the nutrients back to the fields and produces bioenergy that can be utilised by local businesses. The concept of cellular agriculture covers technologies that produce agricultural products by using tissue engineering and cell cultivation processes. The applications of cellular agriculture that are currently under development include products such as cultured meat (i.e. in vitro meat or lab-grown meat), milk and egg protein produced by microbes, animal-free gelatin and cultured plant cells. The preliminary results show that replacing livestock production with cellular agriculture combined with AES can provide multiple environmental benefits, such as reduce greenhouse gas emissions, eutrophication, land use and water use; and improve the soil properties, biodiversity and the resilience of food production to environmental changes.

Keywords: *agriculture, bioenergy, environmental impacts, land use, LCA, meat*

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Code: LCAF-2018-07-00302

Life cycle assessment of cultured meat combined with assessment of opportunity costs of land use

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Abstract

Cultured meat (i.e. in vitro meat, lab-grown meat or clean meat) is produced by cultivating animal muscle cells in a bioreactor. The previous studies estimating the environmental impacts of large-scale production of cultured meat indicate high industrial energy use requirement whereas greenhouse gas emissions, land use and water use could be reduced compared to conventionally produced meat. The objectives of this paper is to demonstrate the importance of considering opportunity costs of land use in a comparative assessment when comparing the impacts of cultured meat with conventionally produced meat. Life cycle assessment with land use opportunity cost analysis was used for estimating the energy and GHG emission balances and biodiversity impacts of replacing conventionally produced beef and poultry meat with cultured meat. As cultured meat production has been estimated to require less land than beef and poultry production, it was assumed that the land area released from meat production was used for Mischanthus energy grass production, which was used for generation of heat and electricity. The GHG emission savings were calculated by assuming that the energy from Miscanthus replace fossil fuels. The results showed that replacing conventional beef and poultry with cultured meat combined with Mischanthus energy grass production would lead to substantial GHG emission mitigation and the system would produce more industrial energy than is needed for the energy inputs of the production process.

Keywords: *LCA, meat, environmental impacts, land, bioenergy, agriculture*

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Code: LCAF-2018-07-00328

Mitigating environmental impacts of beef production - scenario comparison

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Abstract

Cattle based production is known to possess much mitigation potential in its environmental burden. Assessing the mitigation potential of a complex cattle production system requires detailed modelling of the processes as conditions vary according to management strategies and production environment. To avoid trade-offs in mitigation of environmental impacts, relevant impact categories should be assessed simultaneously. Here, a dynamic LCA model was constructed to detect effects of feasible emission mitigation strategies of Finnish dairy breed bull production. Three impact categories were included in the model; global warming, eutrophication and acidification. Scenarios included altered management strategies and feed compositions from 80% roughage to 40% roughage and replacing perennial roughage with annual whole crop feed. Global warming potential was seen to decrease in high concentrate based production (HC), while it stayed the same on high roughage based production (HG) and was increased with whole-crop based production (WC) . Eutrophication potential was decreased with all scenarios, most significantly with WC and HC scenarios. Acidification was seen to increase with higher share of roughage (HG) and was significantly decreased with WC and HC scenarios. Scenario comparison demonstrated how trade-offs can occur between impact categories when mitigation strategies are implemented. Thus, when designing mitigation strategies, well-adjusting all relevant impact categories should be included in the assessment.

Keywords: *Beef, cattle, greenhouse gas, scenario, mitigation*

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Life Cycle Assessment of a plant-based burger and comparison with a typical beef burger

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Abstract

Animal-based foods, and in particular, beef, carry a heavy environmental footprint, yet comprehensive assessments of plant-based mimics are limited. The Beyond Burger, composed primarily of pea protein and vegetable oils, is designed to look, cook, and taste like fresh ground beef. A cradle-to-distribution LCA of the Beyond Burger demonstrates that its production generates 90% less greenhouse gas emissions, and requires 46% less non-renewable energy use, >99% less (characterized) water use, and 93% less (characterized) land use than U.S. beef, represented by a 2017 LCA by Thoma *et al.* Sensitivity assessment demonstrates that these results are robust across modeling uncertainties. Top contributors to greenhouse gas emissions for the Beyond Burger are pea protein production (20%) and the primary packaging polypropylene tray (11%). Land use is dominated by ingredient production, whereas processing activities represent half of waster use.

Keywords: : *plant-based protein, meat substitute, GHGE, energy use, water use, land use*

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Evaluation of the Environmental Impacts Associated with Variation in U.S. Cattle Production Systems

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Abstract

This work is part of a larger research project to produce a cradle-to-grave national sustainability benchmark assessment of the U. S. Beef Industry. This cradle-to-farm gate portion of the assessment includes three of the seven cattle producing regions in the U.S.: The Southern Plains, Northern Plains, and Midwest. Data from a comprehensive survey of cattle producers was combined with information from other publicly available sources to set parameters in the Integrated Farm System Model (IFSM) for simulating representative cow-calf, stocker and finishing operations in the three regions. The IFSM simulations informed the construction of multiple lifecycle inventory models, which represent archetypal cattle operations from each of the three regions. In total, 50 archetypal ranches and 19 finishing operations were simulated. Impacts across categories were highly variable, with some farms producing 1kg LW with an order of magnitude difference in results. Results for nitrogen-related impact categories were surprisingly sensitive to clay content in pasture soils, but also varied with nitrogen content in feed rations. Other variations across impacts were driven by replacement rate, irrigation, and stocking density. These three regions provide an initial glimpse into the on-farm portion of the national benchmark for U.S. beef production. These results provide an opportunity to evaluate the sector' s diverse production characteristics and management practices, and also help to identify opportunities for enhancing the resiliency of U.S. beef production.

Keywords: *beef production; livestock farming; grazing management; regional LCA*

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AGRIBALYSE: From Database to Ecodesign. Learnings from France to promote Ecodesign in the food sector

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Abstract

French agricultural stakeholders promote LCA approach through AGRIBALYSE program, providing a national food LCI database and methodology. Through the years, the program has evolved deeply, priorities shifting from an "eco-labelling"/Environmental declaration program scheme to ecodesign. This raises new challenges. Indeed providing a national LCI Database is not enough to support the application of eco-design in the agrifood sector. Ecodesign approach raises different challenges depending on the project leader: farmer organization, food processing SME or multinational, retailers or catering firms. Ecodesign requires the ability to assess innovative agricultural practices: data is required as well as emission models accurate enough to capture fluxes variations associated to practice change. This leads to move away from mostly used IPCC Tier 1 models and to include more diverse soil occupation (crop rotation, mixed crop, agroforestry etc.) . Also LCA indicators are still not enough to encompass main sustainability challenges of food system and must be completed by complementary indicators such as biodiversity, and animal welfare, and possibly more social indicators in the future. Through about 30 food eco-design pilots projects supported in France from 2016-2020, we should be able to draw some common "success keys" from those experiences and support faster evolution of the food sector towards more sustainability.

Keywords: *Eco-design; environmental performance; LCA; food companies; farmer association*

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Using LCA for participatory eco-design in agriculture: the case of Technical Management Routes (TMR) design with winegrowers and extension officers

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Abstract

As agricultural systems must satisfy new expectations, especially with regards to environmental issues, the way new ones are designed has to change. With a focus on viticultural Technical Management Routes (TMRs) and based on the LCA framework proposed by Renaud-Gentié (2015) , we developed a participatory eco-design approach with winegrowers and extension officers in the Loire Valley area. As underlined by Renouf et al. (2017) , in agriculture, a key challenge when using LCA with agents of change is the balance between analysis capacity and ease of use. We identified three main challenges in order to reach this balance in a collective eco-design approach in agriculture: i) making LCA results understandable for non LCA experts, ii) enabling modularity of agricultural LCA results, iii) need for live LCA results during the collective design process. Considering these issues, we equipped the eco-design approach with a combination of 3 tools: a specific format to display LCA results, a serious game and a simplified LCA calculation tool. To our knowledge, our work is the first addressing how LCA could be used to eco-design with farmers and the first attempt to bridge the gap between eco-design and agricultural system design. Indeed, using LCA in a participatory approach brings many challenges linked to knowledge sharing and consensus building.

Keywords: *Cradle-to-farm gate LCA; eco-design; viticulture; Technical Management Routes; participatory workshops; single score.*

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Impact of Biodegradable Food Packaging on Climate Change

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Abstract

Plastic materials are widely used for packaging of food and as food service items. As a result of these applications disposed plastic is often contaminated with wet food waste. This study aims to investigate what is the best end-of-life option for plastic packaging contaminated with food residues. In the scope of this study, the waste treatment option considered both for biodegradable polylactic acid (PLA) and fossil based plastics is incineration with heat recovery. For PLA, because of its biodegradability, additional feasible waste treatment options are included: composting and anaerobic digestion. These different end-of-life options are compared on global warming potential (GWP) for five food waste systems, with different moisture content: coffee cup, consumed yogurt cup, used coffee capsule, used tea bag and cucumber wrap (1/4 cucumber thrown away).

The results show that incineration of the contaminated packaging is more favorable if the food residue has a low moisture content (<60%), which is the case for used coffee cups, yogurt cups, coffee capsules. Industrial composting is more favorable for packaging with food residues of high moisture content, such as a used tea bag and cucumber. Anaerobic digestion is the best option for all systems but it is still technically challenging. Treating high moisture waste by composting or digestion avoids using low calorific value streams in incineration facilities. Lastly, landfill, is the worse option, from a GWP perspective, because even though PLA will remain inert in landfills, food waste decomposes into methane.

Keywords: *food packaging, Polylactic acid (PLA), bioplastics, composting, incineration, GWP*

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Learnings from applying LCA in the food packaging space in Australia

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Abstract

This paper shares practitioner insights from a set of life cycle assessment (LCA) studies carried out in Australia on food and beverage packaging. Our overview shows how LCA is increasingly being used in the food industry to support packaging related decisions in areas such as procurement, policy making and product profiling. The main research questions asked by stakeholders during these studies pertained to the comparative life cycle impacts of different packaging material options and to the relative impact of successful resource recovery at end of life. The key challenges identified relate to impact assessment criteria and data models.

Keywords: *Sustainable procurement, waste, reference flow modelling, disposable packaging, litter*

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Improving the Airplane Catering Service

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Abstract
Annually about 7.7 billion passengers travel by plane (ACI, 2017). The food menus that are served during the flight, which are pretty common in most airline menus, are composed of the food, its packaging and the tableware. To create a more sustainable catering service on flight applying eco- design measures, an LCA has been performed. Results have shown that reusable and single use items impacts take place in different stages of their life cycle (flight phase 79% , and production 80% respectively) and a set of key variables have been identified. Further investigation is needed in order to better identify and address eco-design strategies both for single use and reusable items.

Keywords: *Sustainability, diet, package, carbon footprint, LCA, airlines.*

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LC-CO_2 of vegetables considering food quality maintenance effect of packaging

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Abstract:
In this study, we quantitatively evaluate the effect of various packaging conditions on the quality maintenance of fresh spinach during storage. The system boundary of the life cycle assessment (LCA) is from the raw material procurement, production, disposal and recycling of spinach and its packaging. For packaging, we use two types of modified atmosphere (MA) oriented polypropylene (OPP) films with micro holes, conventional OPP film with macro holes, and naked packaging (binding tape). The experimental results show that the quality of spinach is maintained best in the order of MA packaging, conventional packaging, and naked packaging. The results indicate that LC-CO_2 for MA packaging have the minimum impacts.

Keywords: *LC-CO_2; food packaging; vegetables; MA packaging; OPP film; food quality maintenance*

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Code: LCAF-2018-07-00117

Life Cycle Inventory of French fisheries: AGRIBALYSE for sea products

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Abstract

Life Cycle Inventories (LCIs) of the French fishery sector were developed in the framework of the AGRIBALYSE program. The "Fishery LCI" project has two major objectives: (1) improve knowledge about and methods for environmental impact assessment of fishery products via LCA, and (2) produce LCIs of representative products of French fisheries to include them in the AGRIBALYSE database. A sample of 16 "triplets" combining a target fish species, a fishing method (use of specific gear) and a fishing area was investigated. LCA was conducted according to ILCD and PEF recommendations, and an indicator for pressure on fish stocks was added. Results showed the huge influence of fuel use on most impacts and distinguished the studied fisheries from each other. Fuel use results from interactions of multiple factors: fishing yield, fishing method, distance from the landing port to fishing areas, and individual practices. The indicator of pressure on fish stocks also distinguishes the fisheries by the ecological status of the fish populations. Nevertheless, other biotic indicators are required to better characterize impacts of fisheries on marine ecosystems.

Keywords: *LCA; fisheries; seafood; pressure on fish stocks*

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The Zambian aquaculture supply chain: cages or ponds for sustainable growth?

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Abstract

A value chain analysis (including an environmental assessment component) of the Zambian aquaculture supply chain was performed to appraise the existing types of aquaculture systems, towards informing future development investments. The main types of culturing systems are land- based ponds and lake-based cages. The former type is represented by a vast majority of small-scale operations and a few large ones, while the latter is mainly represented by a handful of large scale operations, producing the bulk of aquaculture output. We performed a comparative LCA across system types and sizes, to determine their relative environmental impacts per unit of output (1 t of whole fish at farm gate) . It was found that large lake-based cage systems more environmentally efficient than large extensive systems and the under-managed small pond systems, but less than well-managed small pond ones. Nonetheless, due to the sheer volume of their output, large cage systems are the main contributors to the impacts of the average produced tonne, despite the larger impacts of extensive and under-managed systems. In respond to the Zambian government's goal of expanding aquaculture production, in an environmentally respectful way, it could be suggested to improve the management of semi-subsistence small-scale pond systems, to match that of the commercial pond systems. Moreover, large lake-based systems are quite efficient, but their proliferation is constrained by lakeshore space and higher input demand than land-based systems.

Keywords: *cages; growth; ponds; supply chain; tilapia; Zambia*

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Priority Pathways for Sustainable Intensification of Egg Production

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Abstract

Temporally-resolved life cycle modelling has demonstrated substantial resource efficiency gains and impact reductions in the Canadian egg industry over time. These changes are attributable to efficiency gains both at farm level, and along the supply chains that ultimately enable egg production. They point towards some important areas for continued sustainable intensification efforts as well as probable limitations with respect to others. Benchmark LCA studies have also elucidated key hotspots for technology and management interventions for contemporary production in this sector, which can similarly support identifying appropriate measures for further efficiency gains. Using these recently published life cycle models, priority strategies for sustainable intensification in the egg industry are identified and discussed.

Keywords: eggs; efficiency trends; temporally-resolved LCI modelling; sustainable intensification

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Economic and environmental sustainability of rice farming systems in Thailand: adoption of site-specific fertilization practice

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Abstract

In rice production systems, fertilizers are usually applied to improve plant productivity. However, improper use of fertilizers can contribute not only to elevated production costs but also increased adverse environmental effects. A site-specific fertilization (SSF) is a practice where fertilizers are managed by accounting for nutrient requirements of crops and existing nutrients in soils. We assessed economic performance and environmental impacts of rice farming employing SSF and compared it with a conventional system (Non-SSF). Four economic performance indicators were calculated: (1) total production cost, (2) total incomes, (3) net profit and (4) net farm labor income. In addition, eight environmental indicators were assessed: (1)Climate Change (CC), (2) Acidification Potential (AP), (3)Terrestrial Eutrophication Potential (TEP), (4)Freshwater Eutrophication Potential (FEP), (5) Marine Eutrophication Potential (MEP), (6) Human Health Toxicity (non-cancer) (HH-non-cancer), (7) Human Health Toxicity (cancer) (HH-cancer) and (8) Ecotoxicity for Aquatic Freshwater (Ecotox). Results showed that the SSF did not affect economic indicators. However, the SSF could improve the impacts of CC, AP, TEP and MEP but worsened the impact of HH (non-cancer).

Keywords: *economic sustainability, environmental sustainability, rice farming system, site-specific fertilization, precision agriculture*

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SESSION 1 – C
FOOD SECURITY

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How to supply food for the Swiss population in an environmentally optimal way by using domestic production resources best?

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Abstract

The environmental impacts of nutrition can be reduced at both the production and consumption stages. We investigated how a diet associated with the lowest possible environmental impacts might look like for the Swiss population. The DSS-ESSA model system, built to simulate the Swiss food supply including imports and exports, was extended by including detailed nutritional requirements and LCA indicators for environmental impacts. The environmental impacts of the diet could be reduced by over 50% in the optimized scenarios, mainly by reducing feed imports, food imports and animal production impacts. The composition of the average diet would change significantly: drop in the proportion of meat (-70%) and larger proportions of grains or potatoes (+35%) as well as legumes including peanuts (20% of protein supply), whilst milk consumption levels would remain constant.

Keywords: *Food supply, environmental impact, optimization model*

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MEANS-InOut: user-friendly software to generate LCIs of farming systems

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Abstract

INRA and CIRAD have launched the MEANS-InOut software, an operational and user-friendly tool to generate Life Cycle Inventories of the main crops and livestock systems. MEANS-InOut ensures that users do not forget any input, resource, waste, or pollutant flows and follow a consistent method to implement their inventories. MEANS-InOut remains under continual development to follow the evolution of sustainability assessment methods.

Keywords: *LCI tool, agri-food systems, multi-criteria assessment, methodology, AGRIBALYSE.*

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Novel feeds for future chicken lines to enhance sustainability

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Abstract

The environmental implications of incorporating novel ingredients into future chicken diet formulations to serve as European sourced alternatives to imported soybeans was investigated. The novel ingredients considered were: microalgae, macroalgae, duckweed, yeast protein concentrate, bacterial protein meal, leaf protein concentrate and insects. The nutritional requirements of two future meat-producing chicken lines were predicted: a fast-growing and a slow-growing line. Diets were formulated to include the novel ingredients, whilst meeting the nutritional requirements of these birds. Soybean products could be completely replaced by novel feed ingredients, whilst reducing the greenhouse gas emissions and arable land requirements for feed provision relative to conventional diets. Incorporating novel ingredients in diets offers a viable option for providing more sustainable and nutritionally balanced feed to meat chickens in the future; it was also shown to mitigate the increased environmental burdens associated with moving towards higher welfare livestock systems.

Keywords: *Alternative ingredients; Livestock; Feed formulation; Chicken diets; Environmental impact.*

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Social implications of competitive crops: A case study of sugarcane and cassava in north-eastern Thailand

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Abstract

This contribution compares the social performances of sugarcane and cassava products using Social Life Cycle Assessment. A case study in Nakhon Ratchasima province of Thailand has been demonstrated. The site selected is the largest producer of these products. Key stakeholders groups studied are workers, local community, and value chain actors (farm owners and machine contractors). The reference unit is planting area of 1 rai (a Thai area unit) in a year. The results suggest that at the time of study, cassava farm owners earn more net income than sugarcane farm owners. However, the sugarcane farm owners seem to be in a better place with regards to loan and technology development, and market security. Workers can gain more wage in cassava production because this crop is more labor intensive. On the other hand, machine contractors earn more net income in sugarcane cultivation as this crop is more mechanized. Employment generation is not so different between these two crops. However, the local community prefers cassava over sugarcane in relation to health and safety issue. In addition, it should be noted that the supporting information given by this paper should be taken into consideration along with the nation's demands for these agricultural products.

***Keywords**: Social life cycle assessment; social performance; sugarcane; cassava*

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Social performances of conventional and area based sugarcane product: A case study in north-eastern Thailand

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Abstract

This contribution compares social performances of conventional and area based sugarcane cultivation using a case study in Udon Thani, the province having the largest sugarcane planting area in northeastern Thailand. Social Life Cycle Assessment was used as a technique to assess social performances of various stages in the sugarcane supply chain. The reference unit is 1,000 tonnes of sugarcane. Key stakeholder groups examined are workers, local community, farm owners and machine contractors. The results suggest that the area based approach can help improve social performances in several aspects. For example, the farm owners earn more net income, have market security, as well as have access to loan and technology development, when compared with conventional practice. However, in area based practice, the machine contractors and workers earn little lesser incomes because cost of labor and machine hiring in area based practice is lower. This may have to be compromised as machine contractors and workers are also farm owners in the group. After all, members of this group will get profit allocation from selling sugarcane and providing services.

***Keywords**: Social life cycle assessment; social performance; sugarcane; area based agriculture*

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Environmental, social and economic analysis of Burkina-Faso's mango value chain

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Abstract

The purpose of this study is to complement a LCA with two other components of sustainable development, i.e., with an economic and social analysis. Such an approach provides the ground for an integrated analysis of a value chain, and helps to highlight tradeoffs between the environmental, economic and social impacts of a value chain. We illustrate this approach with the mango sub- sectors in Burkina Faso. Five major systems have been distinguished according to final product and destination market: fresh mango exported to the EU by boat or plane (partly certified organic), fresh mango exported to continental Africa by truck, dried mango for the EU market and fresh mango consumed locally in Burkina Faso. The certified export of mango (fresh and dried) is being displayed as a success story of a landlocked country that ranks the bottom 10 poorest countries in the world. Economic operators however face many challenges, most often to be solved through public action: difficulties in transport, multiple power and water cuts (and consequently equipment failures, deterioration of the processing and packaging quality of fruits, losses), difficulties in cross- border trade (slow administration, illegal costs, etc.), poor land zoning in urban areas where processing units are installed (proximity to houses, fire risk, etc.), and in rural areas where orchards are located.

Keywords: *mango; value chain; sustainability; environment; social; economics.*

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New Zealand Agri-Food Sector and Absolute Climate Impacts: An Application of Multi-Regional Input-Output Analysis

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Abstract

The challenge of achieving food security has led to the recognition of the importance of operating agri-food systems within absolute environmental boundaries, including the climate thresholds. There is an emerging interest in the development of absolute environmental sustainability assessment (AESA) methods, particularly for climate impacts. This study builds on previous research that proposed an AESA framework to benchmark the production-based climate impacts of agri-food systems. It adopts both consumption- and production-based accounting to benchmark the climate impacts of the New Zealand (NZ) agri-food sector against the share of the 2°C carbon budget. Firstly, a multi-regional input-output analysis was undertaken to quantify the climate impacts of the sector in 2012. Then a share of the 2°C carbon budget was assigned to the agri-food sector using two alternative methods (grandfathering and economic value). Finally, the calculated climate impacts were compared with the two alternative carbon budget shares. The results showed that the sector was a net carbon exporter in 2012. It was also found that both the consumption- and production-based climate impacts exceeded the 2°C carbon budget shares for both methods.

Keywords: *Absolute sustainability, absolute environmental sustainability assessment, climate change, carbon budget, multi-regional input-output analysis, benchmarking.*

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Assessment of sustainability indicators on Swiss farms under usual farm conditions

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Abstract

This study evaluates the results from an extensive sustainability assessment of 12 Swiss farms including all three dimensions (environmental, economic, social) of sustainability. The method is based on a newly developed method specially designed for use in Switzerland (Roesch *et al.* 2017). The aim of a currently ongoing project is a practical test of the method on 12 Swiss farms to verify the relevance, reliability and feasibility of the entire process, from data acquisition to the computation of the final sustainability indicators.

First results from the first test year 2016 showed that computation of the sustainability indicators is feasible but the process of data acquisition including plausibility control needs to be improved. The analysis revealed that the various sustainability indicators correlate only little, indicating the need to keep most of the indicators for achieving a good overall picture of the farms. Synergies between economic indicators and environmental impacts were barely found. Higher workloads generally did not lead to increased economic success. The two indicators for biodiversity and landscape quality must both be kept because they provide complementary information of the farm.

Keywords: *Sustainability of farms, indicator, data acquisition, sustainability assessment tool*

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Environmental LCA of fruits and vegetable supply chains: a case of synchronizing with the climate change adaptation and mitigation measures

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Abstract

The current study aimed at understanding the life cycle impact of the existing fruits and vegetables (F&V) production systems for evaluating the future production scenarios. The environmental evaluation of the existing system revealed that farm inputs (fertilizer, irrigation and fuel) significantly contribute to most of the impact categories; and directly corelated with the product yields. Meanwhile, potential risks of climate change and seasonal stresses are on the productivity and quality of F&V products, such as texture, color, maturity and nutrients. Likewise, other risks are potential failure of the current crop protection strategies due to pest infestations, and increased crop-water and nutrient stresses. Other studies argued that different agro-ecological parameters and farm characteristics (raw material inputs and farm types: organic vs inorganic farms, crop-(non)rotations, greenhouse etc.) can lead to varying environmental profiles of the products. Likewise, processing of different F&V products is important for food preservations but owe significant environmental costs, e.g. due to packaging, refrigerated store and transport facilities. These are indeed among the vital tools to be manipulated in the future production systems, especially to cope with the climatic stresses; hence sustainability assessment of such are of highly importance. These nexus among the climatic stresses, potential adaptation and mitigation options thus clearly emphasized to evaluate environmental footprints of future production systems.

Keywords: *horticultural crops, life cycle assessment, food security, climate change, material flow analysis*

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How to identify sustainable food and beverage packaging solutions: a pragmatic approach supporting complex decision making

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Abstract

The constant improvement of the packaging sector plays an important role in the food and beverage industry. Pragmatic approaches need to be designed to help project managers and their teams to make informed decisions.

The present work describes the development of an easy-to-use tool to support decision making with the help of a comprehensive quantitative environmental assessment for food and beverage packaging solutions. The Life Cycle Thinking approach is the basis for the tool. The complete life cycle of food and beverage packaging solutions (primary and secondary packaging) is taken into consideration. Numerous packaging materials are applied for the environmental assessment, sourced from the GaBi LCA database of thinkstep. A key component in the packaging material group is the possibility to evaluate bio-based materials and the associated impact in terms of biogenic carbon uptake and regionalized water consumption. Different packaging alternatives can be directly compared and benchmarked with a separate set of parameters defining e.g. the packaging materials, logistics, distribution and End-of-Life settings respectively. Besides the result indicators on Life Cycle Inventory level – like primary energy demand and use and consumption of blue water – a broad range of result indicators on environmental impact level are assessed, reflecting effects such as climate change, acidification, eutrophication and water scarcity. The tool includes the calculation of the Material Circularity Indicator according to the Ellen MacArthur Methodology and an equivalency calculator to support classifying the results.

Keywords: *food and beverage packaging; multi-criteria decision making; LCA; material circularity indicator; quantitative comprehensive environmental assessment*

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LCA4CSA: Using Life Cycle Assessment to support co-designing climate-smart smallholder farming systems

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Abstract

Climate Smart Agriculture (CSA) is an approach developed by the FAO and it is usually presented as a triple winning strategy to improve the capacity of agricultural systems to adapt to climate change, reduce their greenhouse gases emissions and ensuring local and global food security. This concept entails complex linkages between environmental components that need to be addressed at different scales. In order to strength CSA initiatives assessment the methodological framework LCA4CSA, based on Life Cycle Assessment (LCA) was developed to support collective co-design of climate smart farming systems. It considers the production processes at crop and farm scales. We present the LCA4CSA framework. It has been applied in a case study in the Cauca department of southern Colombia, where farmers produce coffee, sugarcane and some domestic animals. Results showed different trade-offs between indicators and pillars when considering the whole farm system in addition to crop system alone. LCA4CSA seeks to be a tool for thinking about the benefits that technical changes can bring to production systems while considering the complex dynamics of farming systems.

Keywords: Climate Smart Agriculture, Farm system, crop system, smallholder

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SESSION 1 – D
WAYS TOWARDS SDGS

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Comparing environmental topics of Sustainable Development Goals, Planetary Boundaries and Product Environmental Footprint

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Abstract

The Sustainable Development Goals (SDGs), adopted by the United Nations (UN) in 2015, are a set of global goals and targets. They are covering social, environmental and economic topics with the claim of a holistic sustainability framework. To put the SDGs into action politics, companies and societies are called to contribute. Therefore, amongst others, the SDGs needed to be integrated and reviewed against other frameworks with the goal of integration into sustainability assessment frameworks. For this study environmental sustainability is taken as a starting point and the environmental topics of the SDGs are compared to topics addressed in the planetary boundaries framework (Rockström et al., 2009; Steffen et al., 2015) and the environmental impact categories used in Life Cycle Assessment (LCA) as proposed by the European Commission in the Product Environmental Footprint (PEF) process (EC, 2012; EC, 2013). These three frameworks are based on different backgrounds (political, scientific) but all claim to cover the main environmental challenges. Out of these, two environmental challenges could be identified that are addressed by all three systems: climate change and the use of freshwater. Further challenges are addressed by two of the frameworks or solely by one. The results as well as challenges in the comparison show that a further analysis and specification of the environmental issues is necessary to integrate and develop sustainability assessment frameworks.

***Keywords**: Sustainable Development Goals; Planetary Boundaries; Product environmental footprint*

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Towards Sustainable Development Goal #12 – Sustainable Consumption and Production patterns through the implementation of 10-Year Framework in Thailand

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Abstract

The aim of this stud was to investigate the current status of Sustainable Development Goal 12 and 10-Year Framework implementation in Thailand as well as to identify the gaps and strategies. The information on Sustainable Consumption and Production (SCP) activities was gathered through literature review and the focused-group interviewing. The key national organizations and international bodies were also interviewed to capture the current situation and insights. The SCP activities implemented in Thailand were analyzed in terms of policies, supporting actions, integration among organizations and monitoring systems. The data were analyzed by using SWOT to identify strengths, weaknesses, opportunity and threat. After that, the TOWS analysis was performed to identify the relationships between strength and opportunity, strength and threat, weakness and opportunity, and weakness and threat. There are 3 types of ecolabels with thousands of labelled products in place; however, consumers do not yet understand about the messages from different ecolabels. The sustainable lifestyle is rooted in the sufficiency economy which is the basis of formulating the 20-year national strategy. The governmental sustainable procurement policies have been developed and implemented successfully; the green product procurement implementation is being expanded to cover local administrative organizations, universities, and private sectors. There are several standards on energy saving and performance of buildings but these standards have not yet been harmonized; the green building certification system called TREES (Thai's Rating of Energy and Environmental Sustainability) is in place. There is a national policy on sustainable tourism with consideration of carrying capacity, but there are no limit on the number of tourists allowed to visit at any places and no tourist fee is applied. There are national policies on sustainable agriculture as well as organic farming systems (with the focus on rice, fruit and vegetables). The existing certification and labelling systems are: GAP (Good Agricultural Practice), Organic Farming, Q (Quality) mark, and Carbon footprint labels. Current research and development activities are related to climate change mitigation and adaptation, life cycle sustainability assessment, food loss and waste. In terms of cross-cutting issues, the national SCP roadmap has been developed, but not yet transferred to local organizations. Based on the results of the SWOT and TOWS, 10 national flagship projects were identified. It is most critical that the SCP has to be put on the national agenda. SCP activities can be promoted through the national SCP roundtable to effectively coordinate among all organizations.

Keywords: *Sustainable Development Goals (SDGs), Sustainable Consumption and Production (SCP), 10-Year Framework (10YFP), Thailand*

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SDG 12.3 – Ecological effects of halving food losses and waste, the German food sector case

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Abstract

The food sector is diverse and is a complex value-added chain. How considerable are the impacts on the environment with regard to food consumption and food waste, and how comprehensive are the ecological effects of reaching the Sustainable Development Goal/ Target 12. 3 of the United Nations – to halve food waste? The overall goal of the sustainability assessment in the REFOWAS (REduce FOod WASte)-Project was to create a consistent and complete LCA model of the German food sector including previous processes and food waste to answer such questions.

Environmental impacts of the German food intake in 2010 are calculated at 38 million hectare agricultural land use in Germany and abroad. A total of 177 million tons CO_2-equivalents of greenhouse gas emissions are attributed to the eaten and spoiled food products and the cumulative energy demand is about 3,700 PJ. Therefore 19 % of the whole greenhouse gas emissions of Germany belong to consumed food, and 4 % to food waste. The total saving potential amounts to nearly -10 % for each impact category if avoidable food waste is halved according to SDG 12.3. This corresponds to two percent of all German greenhouse gas emissions.

Keywords: *SDG 12.3; food waste; Germany; hybrid LCA; ecological effects; sector analysis.*

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Environmental Analyses to Inform Transitions to Sustainable Diets in Developing Countries: a Component of the EATS Project

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Abstract

Sustainable diets are an environmental, economic and public health imperative, but identifying clear intervention points is challenging. The Entry points to Advance Transitions towards Sustainable diets (EATS) project seeks to re-package existing data, combined with an interview-informed awareness of current national and sub-national policy processes, to inform food system-level decision making. Here we view historic trends in food supply in Vietnam and Kenya as a proxy for national average diets, and consider them in terms of the greenhouse gas emissions and cumulative energy demand associated with producing that food. Economic prosperity in Vietnam in recent decades has led to increases in meat consumption and, in turn, amplified increases in diet level environmental impacts. Mild levels of beef consumption in Vietnam have now overcome the most popular meat, pork, as the dominant source of greenhouse gas emissions. Meanwhile, historically consistent levels of dairy and beef in Kenya dominate diet-level environmental impacts. This preliminary work will be integrated into later stages of the EATS project to promote systemic approaches to sustainable development.

Keywords: *decision making, Vietnam, Kenya, SDG, GHGE, diet*

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Sustainable industrialization target of SDG goal 9: A case study of CO_2 emission per unit of value added in Thailand

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Abstract

The aim of the present study is to evaluate a Sustainable Development Goals (SDG) indicator for target 9.4.1 by economic sectors in Thailand. SDG indicator for target 9.4.1 is CO_2 emission per unit of value added represents the amount of emissions from fuel combustion by an economic activity, per unit of economic output. This study analyses Thailand's CO_2 emission by 15 economic sectors using Economic Input-Output (EIO) with Leontief model to include the direct and indirect emissions. The Gross Domestic Product (GDP) in each sector using as value added to calculate SDG target 9.4.1. The total CO_2 emission amount calculated equal to 1,592 tonne CO_2/ million THB, which direct CO_2 emission responsible for 48% and 52% from indirect CO_2 emission. More than 80% of the total CO_2 emission comes from five economic sectors, i.e., public utilities, paper industries and printing, non-metallic products, mining and quarrying, transportation and communication.

Keywords: *Sustainable Development Goals (SDGs), CO_2 emissions, Economic Input-Output (EIO) method*

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Socioeconomic and environmental sustainability assessment of local food products

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Abstract

Local agri-food products are usually endangered due to the competition with big multinationals and their globalization policies. Indeed, lack of consensus regarding the socio-economic and environmental benefits of consumption of local product causes a large confusion among consumers. In this context, the solution begins with the creation of a set of socio-economic and environmental indicators to highlight strengths and to identify the weakness points of these products. The set have been developed considering the socio-economic and environmental vulnerabilities and strengths of main European agri-food sectors. The set considers different indicators which have been validated in a comparative case study of local and imported canned tuna. Overall, consumers and producers find useful to have quantitative values that allows them to identify sustainable products and add value to their products, respectively. However, the calculation of these indicators takes too much time and effort

Keywords: *origin; sustainability, carbon footprint, food miles.*

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FAO LEAP Guidelines for water use assessment of livestock production systems and supply chains

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Abstract

In 2016, a Technical Advisory Group (TAG) for water use assessment was launched within the Livestock Environmental Assessment and Performance (LEAP) Partnership (created by FAO in 2012), to address those sustainability issues related to water, in order to support the optimization of water resources use and identification of opportunities to decrease potential impacts from water use in livestock production. Following a 2-year consensus building process regrouping 30 international experts from around the world, the TAG provided recommendations on the different parts of a water use assessment: goal and scope, data quality and inventory, assessment of water scarcity and water productivity, interpretation and reporting. Two water methods are recommended for the assessment of environmental performance related to water scarcity (water scarcity footprint): BWSI and AWARE. The complementary water productivity metric assesses the output unit per m^3 on a specific process, unit or life cycle stage. While an overall water productivity metric of a production system incorporating indirect water use (e.g. from feed produced at a different location) may be performed, it shall be accompanied by the water scarcity footprint of the analyzed system. In the development and application of water use assessment guidelines, some flexibility in methodology was desirable to accommodate the range of possible goals and special conditions arising at different levels within the livestock sector, while still providing guidance that will support greater consistency in common areas and objectives. Despite some challenges in the consensus finding, these guidelines are the first document that allowed for methodologies from both communities of water use in LCA and water management to co-exist in a consistent framework, and we believe it represents an important step forward in terms of water use assessment and water footprint for the agricultural and livestock sector.

Keywords: *water footprint, water scarcity, LCA, water productivity*

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Eco-efficiency for the manufacturers and for the society: what's the difference? A case study on Greek yogurt

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Abstract

Greek-style yogurt (GY), a high protein content product, has disrupted the yogurt market over the last decade, entailing new environmental challenges to the dairy industry. Its conventional production process generates large volumes of acid whey, which is predominantly managed as a waste. Recent studies have been carried out on new production approaches to reduce and/or eliminate these large volumes of acid whey and on finding innovative solutions to optimize whey valorization. Our project aims to evaluate these solutions from a sustainable development perspective by developing an innovative eco-efficiency (EE) tool. This model adopts a systemic vision based on the life cycle approach by taking into account the interests of different actors in the value chain to answer the question: "What is the most eco-efficient way to produce GY from a societal perspective?". By combining life cycle environmental indicators with two different types of value performance indicators (manufacturer profit versus gross value added created along the value chain) we intend to provide new metrics, bringing to light win-win and trade-off solutions between value creation and environmental performance. Preliminary results from a Canadian case study, show that GY eco- efficiency performance is affected by technological process choices and supply chain procurement decisions. Results are also sensitive to the adopted value creation perspective, namely private profit for the manufacturer versus added-value to Canadian society. This suggests that developing EE tools based on a societal vision of value creation could broaden managers' perspective and potentially influence decisions towards a more sustainable pathway for the society. The ultimate goal is to develop holistic decision-support tools, based on life cycle thinking, for industrial dairy processors in order to optimize the use of milk's natural components.

***Keywords**: Eco-efficiency; LCA; Greek-style yogurt; Supply Chain Management, Co-Products treatment, Sustainable Production.*

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Water scarcity footprint of rice cultivation in Thailand

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Abstract

Thailand is an agricultural country which many areas have facing a water scarcity problem in some months of the year. This research aims to (1) prepare available water remaining characterization factors (AWARE CFs) for 25 Thai watersheds, and (2) assess water scarcity footprint (WSF) of major and second rice in Thailand. Monthly and yearly AWARE CFs of the working group water use in life cycle assessment were downscaled for representing AWARE CFs of 25 Thai watersheds. AWARE CFs and water stress index (WSI) CFs were applied to compare WSF of major and second rice. Based on results of AWARE CFs, 25 Thai watersheds do not appear to be experiencing water scarcity. However, results indicate the potential for water scarcity in many watersheds of Thailand. The differences in WSF assessment of major and second rice determined by AWARE CFs and WSI CFs were found. The utilization of WSF CFs must be seriously concerned for determination of WSF. WSF CFs should be based on local data of Thailand.

Keywords: *Watershed; water stress index; drought; available water remaining characterization factors*

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Water Footprint Database of Thai Rice Farming for Area-based Water Management and Water Scarcity Footprint Label

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Abstract

Rice is a major economic crop which has created local livelihood, careers and incomes in the agricultural sector. Thailand is one of the leading rice producers at global scale. Rice is a key commodity in the agriculture sector requiring the highest portion of water demand, around 40% out of the total sector demand of 65% . This study was aimed to develop the water footprint database of rice farming at the national level to support the information for area-based water management and water footprint label based on the methodology described in ISO14046. The water footprint inventory data associated with 8 main cultivated rice species were gathered in accordance with the ISO 14046 Water Footprint. The statistical data of rice cultivation area and production in 2016 were used as the basis for sampling to cover 62% of the national annual production with a 90% confidence interval. Eight rice species were sampled by simple random sampling method, covering 62% of the national annual production with a 90% confidence interval. The total number of samples was 817, covering 114 samples of Khao Dokmali105, 103 samples of Pathumthani1, 103 samples of Pitsanuloke2, 112 samples of RD41, 112 samples of Chainat1, 103 samples of RD6, 70 samples of San Pah Tawng1, 100 samples of riceberry. The study found that the rice cultivation in Thailand had the average 1,665 m^3/ ton of water footprint inventory and had 0. 18 m^3H_2Oeq/ kg paddy rice of water scarcity footprint. One hectare of rice cultivation normally required water around 6,340 m^3/ ha on the average. The results showed that Khao Dok Mali105 has the highest water scarcity (0.55 m^3H_2Oeq/kg paddy rice) due to Northeastern area has the highest water stress index, following by RD6, Chainat1, RD41, Pathumthani1, Riceberry, Pitsanuloke2. San Pah Tawng1species has the lowest water scarcity footprint (0.01 m^3H_2Oeq/ kg paddy rice). The water footprint inventory data and the water scarcity footprint values would be reviewed by a national expert board as well as a stakeholder consultation to finally approve the datasets as the water footprint national database. It is expected to use the water footprint national database for more effective water resource management for rice cultivation and to support the decisions on the national water policy especially which area should not grow rice twice a year due to a high risk of water footprint. The databases would also be useful for supporting the development of water scarcity footprint label at the time being by the Water Institution for Sustainability, the Federation of Thai Industries.

Keywords: *Rice farming, Thailand, Water footprint database, Water footprint inventory, Water stress index, Water scarcity footprint*

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Spatio-temporal resolution matters in water scarcity footprinting: Case study of New Zealand milk

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Abstract

We calculated the water scarcity footprint of New Zealand milk produced in two contrasting regions using the AWaRe method recommended by UNEP/ SETAC. Regional and monthly assessment was compared to country and annual assessment. Results clearly showed that aggregated characterisation factors (CFs) overestimated impacts. The water scarcity footprint calculated at the regional and monthly resolution was 22 L $_{world\ eq}$/ kg FPCM (Fat- and Protein-Corrected Milk) for milk from the Waikato "non-irrigated moderate rainfall region", and 1,118 L $_{world\ eq}$/ kg FPCM for milk from the Canterbury "irrigated low rainfall region". The contribution of background processes dominated for milk from non-irrigated pasture, but was negligible for milk from irrigated pasture, where irrigation dominated the impacts. This study highlighted the importance of using high-resolution CFs rather than aggregated CFs. Databases and software should evolve to facilitate their application.

Keywords: *Water consumption; Water footprint; AWaRe; Monthly vs. Annual; Country vs. Region.*

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Implications of different approaches for explicitly incorporating environmental water requirement in the water stress index

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Abstract

Human and environmental demands for water are both important; therefore, two approaches are proposed for assessing water scarcity using the water stress index. In one of them, the human demand for water explicitly includes environmental water as one of the components (WSI_{e1}), whereas in the other, environmental water is explicitly reserved by subtracting it from the water availability (WSI_{e2}). The results obtained from using the two approaches in the case of Bang Pakong watershed correspondingly contribute to the explanation of existing stress situation especially in the dry season. The stressful results were noticed during December to February for both approaches as results of less available water and higher environmental water. The assessment of environmental water requirement (EWR) in this study was quantified according to low and high flow periods. The two approaches perform well for assessing water scarcity in Bang Pakong watershed; however, the WSI_{e1} approach is recommended following the regulation of Royal Irrigation Department. In conclusion, priority of water allocation is the key consideration for selecting the approach. The WSI_{e1} approach is recommended for the case of human and environment are both important and their priorities can be rearranged. Hence the result interpretation using the WSI_{e1} approach is more serious than the WSI_{e2} approach in terms of water scarcity potential.

Keywords: *water stress index; environmental water requirement; freshwater use; impact assessment; water resource management.*

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Databases for renewable materials, food and feed as a requirement for shift to sustainable bioeconomy

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Abstract

This publication intends to consider a role and applicability of quantification approaches as the means of transformation to bioeconomy. The particular approach described is the use of databases of biogenic resources within a Life Cycle Assessment framework. Furthermore, the type, structure and applications of the datasets are discussed on the example of existing research projects and industrial studies. A brief overview of results intends to open a discussion on how assessing the use of biogenic resources contributes to bioeconomy.

Keywords: *bioeconomy, food and feed database, renewable materials database, consistent databases, transformation*

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If we are to eat more seafood- what seafood should we eat? Combining nutrition and greenhouse gas emissions of seafood products

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Abstract

Many countries advise their populations to eat more seafood, both for health and environmental reasons, but give little guidance as to what type of seafood should be increasingly consumed. Seafood sustainability assessments have shown that seafood products, originating in a myriad of production systems around the globe, involving capture fisheries and aquaculture that use a range of technologies, engender vastly different levels of environmental impacts. Quantitative ranking of the environmental impact and nutritional value of seafood products, preferably in combination, would allow health officials to provide more targeted dietary advice and to support sustainable seafood consumption patterns.

Here, we characterized seafood products consumed in Sweden by constructing and quantifying an aggregated nutrient density score for seafood and then combined it with species-, technology- and origin-specific greenhouse gas data for each product. The result is a combined score that shows which seafood products give the highest nutritional value at the lowest climate impact and hence should be promoted in dietary advice. Uncertainties, data gaps and further research needs are pointed out.

Keywords: *seafood, nutrition, greenhouse gas emissions, fisheries, aquaculture*

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The impact of diseases in dairy cows on greenhouse gas emissions of milk production

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Abstract

Combining life cycle assessment with a dynamic stochastic simulation model allows to simulate the dynamics and consequences of diseases in livestock, and to reduce the environmental impact of our food production systems. This study aims to estimate the impact of diseases in dairy cows on greenhouse gas (GHG) emissions of milk production, using the Dutch situation as a case study, and contributes to reaching the sustainability development goals by providing information about climate change mitigation. Three diseases with a high incidence in intensive milk production systems were included: foot lesions, clinical mastitis, and subclinical ketosis. First, a dynamic stochastic Monte Carlo simulation model was used to simulate the impact of diseases on dairy cow productivity. Cows received a parity (1-5+) , a potential milk production, and a risk of a disease. Based on type of disease, cows had a reduced daily milk yield, discarded milk if treated with antibiotics, a prolonged calving interval, and an increased risk of removal. Second, an LCA was performed to quantify the impact of diseases on GHG emissions from cradle-to-farm gate. Emissions of carbon dioxide, methane and nitrous oxide were estimated for processes along the dairy production chain that were affected by the consequences of diseases, including feed production, manure management and enteric fermentation. System expansion was applied to account for the production of meat from culled animals. Emissions of GHGs were estimated for a cow and herd with and without one of the diseases and were expressed as the sum of kg CO_2 equivalents (100 years' time horizon) per ton of fat-and-protein-corrected milk (kg CO_2e/ t FPCM). On average, GHG emissions increased by 1.5% per case of foot lesions, 6.2% per case of clinical mastitis, and 2.3% per case of subclinical ketosis. The increase in GHG emissions showed a high variation between parity and type of disease. Removal of cows was an important contributor for all diseases, and can increase GHG emissions by >50% . At the national level, the increase in GHG emissions resulting from these three diseases was estimated to be 0.4 Mton CO_2e per year in total, which equals 15% of the total emission reduction target for the agricultural sector that is set by the Dutch government. In conclusion, reducing diseases in dairy cows is an effective strategy to mitigate GHG emissions of milk production and can contribute to sustainable development of the dairy sector.

Keywords: *sustainable development; livestock production; climate change mitigation; diseases; the Netherlands.*

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Greenhouse Gas Management of Kasetsart University towards Low-Carbon Lifestyle and Sustainable University

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Abstract

Kasetsart University (KU) is the oldest agricultural university aiming to provide "Knowledge of the Land" to promote the well-being as well as sustainable development throughout the nation. Along with this goal, KU has also committed to become a model for society on low-carbon lifestyle and sustainable university. The objective of study was to identify the Green House Gas (GHG) emission sources, assess the quantity of GHG emission level, and identify the hot spots leading to the GHG management strategies to reduce the total GHG emissions. The assessment of GHG emissions associated with KU's activities were conducted in accordance to the national guideline on carbon footprint of organization. The scope of analysis in 2012 and 2013 covered 14 faculties as well as 4 central buildings, KU library, wastewater facilities and waste management system whereas that in 2014 covered one more faculty (Faculty of Environment, the most recent one, established in 2012) and the office of president. The GHG inventory data were identified and gathered from all individual organisations within the defined studied scope. The period of GHG emissions was linked with the fiscal budget year (1 October to 30 September). The data of emission factors associated with the GHG inventory data were taken from the national databases. In general, the main GHG sources in scope 1 were from the fuel used for personnel's cars (especially diesel, benzene and gasohol) while that in scope 2 were attached to the electricity use and that in scope 3 were linked with the use of tap water, the use of paper, and waste management. The main GHG emission was attached to the electricity use (68-92%). In 2012, the total GHG emissions was 22,984 tCO_2e/yr and the carbon intensity was 0.6386 tCO_2e/person. In 2013, the total GHG emissions was 25,150 tCO2e/ yr and the carbon intensity was 0.7079 tCO2e/ person. In 2014, the total GHG emissions was 23,940 tCO_2e/yr and the carbon intensity was 0.7157 tCO_2e/person. However, the carbon intensity was slightly increased due to more new buildings with the engineering equipment as well as more air conditioning systems. The GHG reduction measures were taken place. The temperature of AC systems was set at 25 ^oC and the scientific equipment must be off (not in a stand-by mode) when not using it; these could potentially reduce 938 tCO_2e/yr. The 3Rs project to minimize the wastes going to landfill was taken place and could potentially reduce 423 tCO_2e/ yr. The bio-diesel production for university buses was implemented and could potentially reduce 163 tCO_2e/yr. The KU library also took the lead in participating the carbon offset program in addition to their own GHG reduction strategies to become the first carbon-neutral library in Thailand and a model for other libraries in the Green Library Network. In conclusion, Carbon footprint was useful as a measurement and management tool to move towards low-carbon lifestyle and sustainable university.

Keywords: *Carbon footprint of organization, Carbon neutral, Greenhouse gas management, Kasetsart University, Low-carbon lifestyle, Sustainable university*

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Carbon-Emission Hot Spot Analysis of Service Industry for Climate Actions

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Abstract

The service sector is one of the key sectors contributing to GHG emission by economy activity. Carbon footprinting of organisation was then introduced as a GHG measurement and management tool to various service organisations in Thailand. This study was aimed to assess the carbon footprint of organisations associated with the life cycle service activities. The hot spots identified from the carbon footprinting could be useful to derive the GHG management strategies in the climate-conscious service industry. The carbon footprinting of service organisations was implemented according to the national guidelines on carbon footprint of organization. Pilot cases included shopping mall, retailers, distribution center, hotels, hospitals, bank, restaurants, and library. The GHG inventory data were collected based on the activity data in 2015-2017. Fuel consumption (for vehicle, and generator and fire pump), refrigerant use, fire distinguisher (CO2), LPG (for cooking and maintenance), and methane from wastewater treatment facilities and septic tank were typically identified as the sources of GHG emissions in scope 1. Electricity use was the key source of GHG emissions in scope 2. Use of tap water and paper were the common areas of interest to be included as the sources of GHG emissions in scope 3. The associated GHG emission factors considering 7 greenhouse gases were taken from the national GHG emission factor databases. The results of carbon footprint values of different organisations in the service industry indicated that the high GHG emissions were found in hospital (14,863 tCO_2e/yr) shopping mall (12,582 tCO_2e/yr) and bank (10,408 tCO_2e/yr), due mainly the high energy consumption for their service activities. The GHG emissions from hotel (5,006 tCO_2e/yr), distribution centre (4,735 tCO_2e/yr) retailers (1,807 tCO_2e/yr), and library (1,197 tCO_2e/yr) were moderately high. The GHG emissions from restaurant (83 tCO2e/yr) were rather low. The magnitudes of GHG emission were linked to the size of organisations and the number of people to be serviced. The key hot spot contributing largely to the carbon footprint or organisations was related to the electricity use in scope 2 for about 70-90%, followed by refrigerant (hotel), anesthetic substance, N_2O (hospital), and fuel consumption for vehicle (bank). It is worth emphasizing that the activities identified in scope 3 (optional) could be the key issues, such as fuel consumption for logistic activities (retailers), waste management (hospital), and electricity use by rented areas (shopping mall). The key hot spots of service industry for the office-based service organisations were linked with the energy usage for air condition and lighting systems. To reduce the GHG emissions, it was suggested to adopt the inventory technology for air condition system and light-emitting diode bulbs to shopping mall, retailers, distribution center, hotel, hospital, bank, restaurant and library and resulted in GHG reduction for about 200-1,500 tCO_2e/yr. However, the activities in scope 3 should not be overlooked as it could be significant GHG emission sources such as logistics in distribution center, raw material production and waste management in restaurants and hospitals.

Keywords: *Carbon footprint of organisation, Greenhouse gas management, Service sector, Thailand*

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Environmental impact of bio-treatment: comparative life cycle assessment of potato peels treatment with insects, pigs and anaerobic fermentation

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Abstract

One-third of global food is wasted or lost which leads to huge requirements for waste treatment. Waste treatment needs more resources which add on the environmental impacts. It is necessary to determine which waste treatment method has lower environmental impacts and higher economic benefits to make food consumption more sustainable. Currently, there is a research gap in comparative environmental impact assessment of different food waste treatment methods. This research examined if bio-treatment with insect technologies is less impacting than utilization with pigs and anaerobic fermentation. The results showed that pork production had highest environmental impacts (175.74 µPt) than insect biomass production (16.9 µPt) and biogas production (20.3 µPt). The functional unit of gross sale of product and protein obtained showed that insects are more sustainable in comparison to pork and biogas. Food waste treatment with insects could be recommended based on the findings of this study.

***Keywords**: bio-waste treatment; potato peels; life cycle assessment; insects; pigs, anaerobic fermentation.*

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Nutrition in the bin: Nutritional and environmental assessment of food wasted at home in the UK

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Abstract

Detailed UK data for household food waste was translated into average waste per capita per year for 424 separate food items. Each food item was matched with a proxy for nutritional composition taken from the UK composition of Foods (Finglas et al., 2015). The nutrients lost were normalized against the UK Reference Nutrient Intakes for adult women (19-50 years, taken as a proxy for the general population). As a result, the nutrition equivalent to 42 complete daily diets per capita per year was lost with wasted food. The environmental impacts of food wasted were calculated for 5 impact categories. Ingredients production is the largest contributor to all impacts. Edible food waste is associated with 3900 kg CO_2-eq/ ton. Different food groups contribute to nutrient losses and environmental impacts. This first combined nutritional and environmental assessment of food waste provides a different way of looking at this issue, identifying hot-spots for potential interventions.

Keywords: *food waste; sustainability; environmental impact; nutrient deficiencies; life cycle assessment*.

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Socio-demographic predictors of food waste behavior in Denmark and Spain

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Abstract

Food waste generated at the household level represents about half of the total food waste in high- income countries, making consumers a target for food waste reduction strategies. To successfully reduce consumer-related food waste, it is necessary to have an understanding of factors influencing food waste behaviors. The objective of this study was to study food waste from a food-related behavior perspective and to investigate socio-demographic predictors among consumers in two European countries Denmark and Spain. The present study, based on a survey involving 1,518 Danish and 1,511 Spanish consumers, examines the association of age, gender, education, marital status, employment status and household size with food waste behavior. By using structural equation modelling based on confirmatory factor analysis we created the variable 'food waste behavior' from self-reported food waste and two activities which have been correlated with the amount of food wasted, namely shopping routines and food preparation. Multivariable linear regression analyses were conducted with food waste behavior as the dependent variable and the socio-demographic characteristics as independent variables. Results show that being older or unemployed were associated with less food waste behavior in both countries. In Denmark being male was associated with lower food waste behavior. Results underscore the importance of socio- demographic inclusive strategies for food waste reduction in Denmark and Spain.

***Keywords**: Food waste; Consumer; Behavior; Socio-demographic; Predictors; SEM*

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Life cycle environmental and economic impact of food waste recycling : A case study of organic vegetable farming in Japan

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Abstract

Closed food recycling systems include not only the recycling process, but also the utilization of recycled materials. This study conducted a life cycle assessment of the impacts of food waste treatment and spinach farming systems on environmental loads and regional economies. Two recycling technologies, on-site composting (in-vessel) and centralized composting (aerated static pile), were compared to waste incineration. The results showed that on-site composting had a high environmental impact and lower cost, whereas centralized composting had a lower environmental impact, but also a lower economic benefit. These tradeoffs will need to be considered when deciding which food recycling system to introduce, based on the situation of the local area.

Keywords: *Food waste; composting; spinach farming; input-output analysis*

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Resources wastage related to food loss and waste in rice supply chain in Thailand

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Abstract

This study assessed food loss and waste in the rice supply chain in Thailand and quantified water and land wastage related to food loss in rice supply chain in Thailand. The results showed that in the year 2016/2017, Thailand produced 31 Mt of paddy rice. There was 1.784 Mt rice paddy rice loss during harvest, 0.213 Mt loss of milled rice during milling, 0.490 Mt loss of grist during rice processing, 0.122 Mt loss of rice during storage and cooking and finally a waste of 0.494 Mt of cooked rice during consumption. All the loss and waste converted back to the paddy rice was equivalent to 4.168 Mt. The irrigation water (for second rice) and indirect water use by fertilizer and diesel (for major and second rice process) used to produce this amount of rice was 734.22 million m^3. The land used to produce this amount of rice is 1,478,512 ha. This amount of water and land accounted for almost 13% of all resources used for rice production of the whole country. Therefore, this wastage of resources should be reduced urgently by reducing loss and waste by improving technology and management to obtain more sustainable production and consumption.

Keywords: *Food loss and waste, Sustainable production and consumption, Supply Chain*, *Material Flow*

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Life Cycle Assessment of Seafood Beyond the Sea: Understanding How Seafood Losses and Consumption Patterns within Post-Production Stages Impact the Life Cycle Impacts of Seafood Products

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Abstract

In the context of growing concern for the sustainability of global seafood systems, life cycle assessment (LCA) has emerged as an essential tool to evaluate and improve the eco-efficiency of global seafood provisioning. Given that seafood LCAs have largely been limited to seafood production systems, little effort has been dedicated to understanding life cycle impacts of post-production stages and in particular the implications of seafood losses that occur within them. Building on results of existing, methodologically consistent production-focused seafood LCAs, we model the additional node-specific greenhouse gas emissions and impact of node-specific losses (including consumption in excess of recommended daily nutritional need) of fresh and frozen supply chains delivering product into Toronto, Canada. Results indicate that seafood losses that occur in post-production stages, particularly at the consumer level, substantially amplify the GWP of consumed seafood products. Addressing overconsumption of seafood products at the consumer level will reduce losses and reduce the GWP of consumed seafood products.

Keywords: *seafood; LCA; food losses; food waste; food consumption; greenhouse gas emissions*

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Organizational Life Cycle Assessment towards Sustainability: A Case Study of Thai Vegetable Oil Company

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Abstract

The aim of this study was to assess the potential environmental impacts associated with the organization's activities by using Organizational Life Cycle Assessment (O-LCA). The scope of study was the organization's life cycle activities of a Thai Vegetable Oil Company. The system boundary was based on the organization's activities under their operational control which was based on the cradle-to-grave approach that included direct activities, indirect upstream activities, and indirect downstream activities. The unit of analysis is per organisation that included the company's activities that are operationally controlled. The inventory data associated with the organisation activities, at the facility level, were based on the primary data collecting from the internal recording systems and the environmental accounting systems based on the annual production in 2014 (January to December). Except for the personnel transport, the data collections were done by using questionnaires to ask about the transport method (type of vehicle, type of fuel, and distance to transport from their living places to the factories). The impact methodology selected was ReciPe as the characterization factors were mostly updated and generally used widespread. In overall, the raw material production was the key hot spots contributing to significant impacts in most of the categories considered. Except for the impact on marine ecotoxicity and water depletion, they were largely attached to the transport of raw materials. When considering the impacts associated with direct activities, the biomass use was the major contributor to the impacts on marine eutrophication and terrestrial acidification. In terms of climate change, the impact was mainly associated with the use biomass, followed by the use of fuel oil and diesel. For the indirect activities, raw material production (soy bean) was the key hot spot significantly contributing to all impacts. For the indirect downstream activities, the distribution (by truck) was the key hot spot leading to substantial impacts in all categories. However, the impact on marine eutrophication was mainly from the waste management. The results of O-LCA were used as the strategic environmental management for further improving their environmental performances, which were: calculating the environmental impacts of soybean production and transport from different sources and taking it into account for purchasing decision, changing the trucks from EURO-4 to EURO-5, changing the fuel to be 100% from biomass to become a fossil-free factory, changing the packaging materials to be biodegradable plastic, and creating sustainable value chains. O-LCA is seen as a useful tool to identify the potential risks/ impacts along the life cycle activities and derive the hot spots where the further improvement can be done. The results of O-LCA were used to support the development of sustainability roadmap and strategic environmental management system. Sustainable value chain can also be created along the supply chain, by working with the associated suppliers as an integrated business system. The O-LCA could be done annually for keep tracking on the environmental performances of whole organisation.

Keywords: *Life Cycle Assessment (LCA), Organizational LCA, Sustainability, Thailand, Vegetable oil*

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Ecological footprint assessment towards sustainable rice cultivation in Thailand

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Abstract

Rice is consumed as a staple food in many parts of the world. Thailand is the sixth largest producer and the largest exporter of rice in the global market. This study aims to determine the ecological footprint (EF) of conventional and organic paddy rice cultivation in Thailand based on life cycle assessment approach. The study areas of conventional paddy rice are Suphanburi, Kanchanaburi, and Pathumthani provinces in central Thailand whereas the study areas for organic paddy rice are Chiang Mai, Nongkhai, and Phatthalung provinces in northern, northeastern, and southern Thailand, respectively. The functional unit was set in terms of global hectare (gha)/hectare (ha)–year. The life cycle inventory was collected from previous literature and government databases. The EF was distinguished by the six categories of inputs for rice cultivation as fuel, electricity, chemicals, raw materials, water, and cropland which were converted to the sum of the total EF. EF of conventional paddy rice cultivation for Suphanburi, Kanchanaburi, and Pathumthani provinces were 11.0, 11.0, and 11.9 gha/ha–year, respectively, whereas those of organic rice cultivation for Chaing Mai, Nongkhai, and Phatthalung provinces were 23.3, 14.7, 10.9 gha/ ha–year, respectively. The highest value was determined for cultivation in Chiang Mai because of the high amount of water and energy requirement. The EF of forest providing rain and irrigation water was the major source of resource use accounting for 68% of the total EF. The results obtained are intended to support policy makers for developing strategies on sustainable rice production and to encourage the plantations in areas that have less EF as the first priority.

Keywords: *greenhouse gas emissions, global hectare, organic rice, paddy rice, water use*

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Joining environmental impacts and health impacts of an individual's dietary choices

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Abstract

Several of the 2017 Sustainable Development Goals (SDG) are directly related to the type of food people consume, either in terms of affecting their health (SDGs 2 and 3) or their environmental footprint (SDG 13) . This work evaluates how the two are related for a European sample population and looks at Global Burden of Disease dietary risk factors to determine where men and women can most improve their health while also minimizing their environmental footprint. Results indicate that increasing vegetable and nut/ seed intake would go far in reducing health consequences but would also be associated with slightly higher environmental impacts. Eliminating red and processed meat would be beneficial for both health and environment, and milk consumption is nearly equal in terms of health benefits and environmental impacts. Both men and women need to alter their diets, however the ways in which they should be changed differ.

Keywords: *Life Cycle Assessment (LCA), health, disability adjusted life years, diet, sustainable*

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Making More Sustainable Food Choices: A Comparison of Environmental and Nutritional Impacts and Benefits of Pizzas on Health

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Abstract

We currently lack comprehensive metrics that evaluate foods by accounting for both their environmental and nutritional effects. To address this gap we propose an approach that employs the DALY Health Index (DANI), an epidemiology-based nutritional assessment tool that quantifies the health burden associated with foods in disability adjusted life years (DALYs) , within the Combined Nutritional and Environmental Life Cycle Assessment (CONE-LCA) framework. We demonstrate this approach with a compelling case study of a popular mixed dish in the U.S. diet, pizza, to highlight the complexity and challenges of multi-ingredient dishes in LCA. Our analysis shows a correlation between environmental and nutritional health impacts for this food category, and showcased the potential of the approach to help make informed sustainable dietary food choices and substitutions.

Keywords: *LCA; nutrition quality; human health; sustainable foods; mixed dishes*

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Sustainability Assessment of Highland Maize Cultivation in Northern Thailand

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Abstract

Maize is one of major commercial crops in Thailand and used as a feedstock for animal feed manufacturing. Thailand's domestic maize production has been increasing continuously in the recent years due to a strong and growing demand for domestic feed. The Northern of Thailand is the largest maize-producing region. Increasing in maize production in the Northern region, however, creates environmental and health problems such as deforestation, degradation of ecosystems and haze pollution. Considering its economic importance and environmental and health impacts, the current maize production requires a sustainable manner. The objective of the present study is to assess sustainability of maize production in the Northern Thailand targeting in Chiang Mai province. The assessment focuses on environmental dimension and done in accordance with international guidelines of The Sustainability Assessment of Food and Agricultural Systems (SAFA) by the Food and Agriculture Organization. Potential environmental impacts are evaluated throughout the life cycle of maize cultivation in terms of greenhouse gas emission. Baseline practices of the current maize cultivation are evaluated using a pilot set of environmental sustainability indicators. Hotspots and areas of improvement were identified. The outcomes of this study could support policy-making in sustainable production of maize at both regional and national levels.

Keywords: *maize, sustainability assessment, food security, northern, Thailand, SAFA*

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Food-Environment-Poverty nexus

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Abstract

The Sustainable Development Goals (SDGs) of the United Nations encompass various social and environmental targets. Trade-offs among them are possible, if not likely. We analyze what progress towards ending *poverty* (SDG1) implies for the *environment* in terms of carbon (related to SDG13), land (related to SDG15), and water (related to SDG6) footprints. To do this, we link consumption data of 166 nations, in which consumers are subdivided into four income groups, to the multi-regional input-output database EXIOBASE, which is extended with characterization factors typically used in life cycle assessment. The results shows that *food* dominates the footprints of all income groups, and especially those of the poorest households. There is a weak decoupling between total and food expenditure. Eradicating extreme poverty leads to a slight increase in environmental impacts by 1.9-5.6% . This highlights the challenge faced on the way towards the SDGs, and points to the food sector as an opportunity area for improvement.

Keywords: *consumption inequality; impact assessment; input-output analysis; scenario; Sustainable Development Goals; trade-offs*

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Opportunities for increased ecosystem services from incorporation of spatial and temporal diversity in crop rotations

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Abstract

Land resources are becoming progressively more constrained with increasing demands for food, feed, fiber, and now fuel production. Developing strategies to intensify crop production without increasing the negative impacts on water, soil, and air resources are critical. Much of the best agricultural lands are dominated by corn-soybean rotations with winter fallow periods. There has been interest in spatially diversifying and temporally intensifying production of the farm landscape to improve water quality. Winter cover crops are one strategy to reduce nutrient losses over winter, but they have not been widely adopted. Harvested cover crops, or double crops, of winter small grains are common in some regions. Our objective in this study was to evaluate whether possible revenue sources would be sufficient to incentivize expansion of double cropping given regional differences in hurdle rates. One potential revenue source is payments for ecosystem services. A second possible source of revenue comes from local markets for the use of winter crop residues. To estimate potential revenue from ecosystem service programs, we used the biogeochemical model DayCent to quantify nitrate leaching, nitrous oxide emissions, and soil carbon for alternative crop rotations. We found that the addition of a winter crop (temporal intensification) to standard crop rotations reduces negative environmental impacts and increases total biomass production. The regulating ecosystem services of climate regulation through increased soil organic carbon and reduced soil N_2O emissions had a higher economic value than water purification with reduced nitrate leaching. Stacking the changes in standard economic returns with payments for ecosystem services (PES) provided sufficient incentive for adoption of temporal intensification in southern regions with more growing degree days. Obtaining adequate incentives for temporal intensification in the northern regions with lower growing degree days could occur if there are adequate local markets for the straw byproduct. Winter rye was never profitable in our simulations and was always less profitable than other double crop options. Winter barley was closer to overcoming hurdle rates since it has less impact on soybean yields than winter wheat north of the 40th parallel. Given current PES payment levels, the addition of local markets for winter crop residue are crucial to incentivizing double cropping. Establishment of a bioenergy market for biomass would be likely to provide such a market and could incentivize wide spread planting of winter barley as a double crop in corn-soybean rotations.

Keywords: *barley straw; cellulosic ethanol; crop residue; corn stover; payments for ecosystem services; agricultural intensification.*

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Measuring the impact on employment and paid wages as a consequence from mechanization of the sugarcane harvesting in Thailand

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Abstract

The aim of this study is to measure the impact on employment and paid wages/income in sugarcane production due to the mechanization of harvesting systems. The analytical approach uses survey data, literature and national data to measure; 1) how the level of employment and wage/income depend on the characteristics of cane workers, crop cultivation and employment; 2) the potential number of employment and income/paid wages of different harvesting practices; 3) the impact results of different scenarios of job-to-job transitions. The study focuses on male/female workers, aged 18-65, occupied in sugarcane production. The data are obtained from site surveys, as well as the published records of the Office of Agricultural Economics and the National Statistical Office. The results show that the potential number of employed-farm workers is reduced by mechanization. In contrast, the paid wages of employed-farm workers for mechanical harvesting can be improved to be higher than manual harvesting. However, the impact on employment with the job changes after establishing mechanical harvesting needs further discussion and analysis on trade-off between employment reduction on harvesting and employment generation in the other jobs. Moreover, the provision of skill development training from government and private sector should be introduced to farm workers in order to minimize the impact of employment reduction and low paid wages/income. The study does not cover all employment generated by the supply chain of agricultural machinery due to lack of data. A recommendation for future study is to collect more data of the number of non-employment and job-to-job transition (arrival rate of new job) in order to investigate the effect on employment flows due to the change of sugarcane harvesting.

Keywords: *Sugarcane production; Mechanization; Harvesting; Employment; Paid wage; Thailand*

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Code: LCAF-2018-07-00139

Feed eco-design: how to make a good decision? Part 1- Uncertainty analysis of feed formulation

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Abstract

The purpose of this study was to consider the uncertainty of environmental impacts of main feedstuffs produced in France due to different processes and areas of production, and its effect on eco-feed formulation. For energy consumption and climate change, and for many feedstuffs, the use of national average data of environmental impacts is sufficient for the eco-design exercise of feed manufacturers. Despite this, it is necessary to complete the ECOALIM dataset with more detailed data for maize and wheat.

Keywords: *environmental impacts, LCA, feed, formulation, databases, uncertainties*

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Feed eco-design: how to make a good decision? Part 2- rebound effects of eco-feed production

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Abstract

This study takes place in a context where the feed manufacturers have access to eco-labeling databases which allow them to do eco-design and produce feeds with less environmental impacts. First results of eco-feed show substitutions between feedstuffs compared to standard feed. Therefore, the objective of this study is to identify the rebound effects of the production of eco-feed for pigs if the practice becomes widespread in France. A mind map was built with 5 experts to identify in a qualitative way the panel of different consequences. We then focused on the one concerning the change of crop rotations to produce eco-feed. We chose a virtual territory dedicated to produce the feedstuffs for a pig farm and assessed the environmental impacts by LCA using different functional units and perimeters. The situation with the production of eco-feeds can appeared better or worse compared to the production of standard feeds. This work underlines the complexity of eco-design and the limit to do it with data from attributional LCA. It is necessary to complete the databases by information to make the users aware of the rebounds effects invisible during the eco-design process.

Keywords: *environmental impacts, Life cycle assessment, feed, formulation, crop rotations, regional scale*

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Environment and Social Sustainability Assessment of Maize-based Broiler Feed

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Abstract

Chicken meat production is one of the main exports in Thailand, then feed production required increasingly demand. The feed production supply chain has to consider the sustainability issue in agricultural and food systems. In this study focuses on the environmental and social sustainability of poultry feed production, including maize cultivation, maize aggregation and feed production through the sustainability assessment tool. The results found that the environmental dimension of the Atmosphere and the Materials and energy reveal good sustainability, whereas the Human safety and health and the Labour rights are good for social dimension. However, other themes of the Environment and Social in each stakeholder have to be considered for the sustainability of agricultural and food system.

Keywords: *Sustainability; Environment; Social; Feed production; Food system*

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Assessing SAFA Economic Resilience of Maize Supply Chain in Thailand

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Abstract

An increasing demand of global meat consumption and more awareness on worldwide sustainable production and consumption have caused feeding industry to be scrutinized. Sustainability Assessment of Food and Agriculture Systems (SAFA) indicators of Economic Resilience is applied to evaluate economic impacts of the promotion of Good Agricultural Practice (GAP) on maize and how its trend on improving maize sustainable production. Semi-structured interviews and in-depth interviews are implemented to collect economic and social data from all stakeholders in both GAP and non-GAP certified maize production supply chain in 3 provinces that GAP on maize is widely practiced. The result shows that SAFA indicators of Economic Resilience are suitable for assessing a sustainability of Thai maize production supply chain. Yet it needs some changes in definition and rating conditions in some indicators to make it more compatible with Thai production context. In overview, the general production and the GAP production are rated as moderate level and their average score are not much different. Farmers are the most important player for the sustainability of Thai maize supply chain since 2/3 of economic resilience indicators mostly depend on their performances. Farmers' score of investment, vulnerability and local economy themes are mostly in limited and moderate levels. Identifying hotspots and key player could help to improve economic resilience and increase the sustainability of Thai maize production rapidly.

Keywords: *Maize, supply chain, SAFA, Economic resilience, GAP*

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POSTER PRESENTATION

SESSION 1-A
LCA METHODS

Code: LCAF-2018-07-00256

Developing product category rules for bio-based plastics – need for Harmonization

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Abstract

Bio-based plastics might be called the plastics of the future as they are not directly depending on fossil resources and also provide new material properties like compostability. However, how to select the proper, most environmentally friendly plastic for a specific application is still challenging. Life Cycle Assessment (LCA) is an internationally widely accepted and standardized tool for determining and comparing comprehensively the environmental performances of products. To improve the comparability of LCA results, the definition of specific LCA rules for product groups (Product Category Rules, PCR) in compliance with ISO 14040/ 44 is often required. Such common rules for bio-based plastics are currently missing, although of high demand for different industry sectors. Moreover, current LCA standards and guiding documents allow for different options regarding the methodological treatment of many relevant aspects for bio- based plastics. The aim of the work presented here is to identify these given options and to highlight inconsistencies in the current LCA guiding for bio-based plastics as a basis for ongoing PCR development. For this, documents of different types and guiding levels (e.g. standards, PCRs, scientific literature) were screened regarding their handling of aspects specifically relevant for bio-based plastics including the modelling of the agricultural cultivation stage. The outcome of this review is that the current guiding state is far away from being called consistent leading to confusion in modelling and most likely inconsistent LCA results. This work underlines the need for developing new harmonized rules for bio-based plastics to guarantee a fair comparability and hence, sound decision making.

***Keywords**: bio-based materials; bioplastics; product category rules (PCR); harmonization; life cycle assessment (LCA)*

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Code: LCAF-2018-07-00221

Economic and environmental performances of French dairy farms: analysis combining economic and environmental databases

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Abstract

French dairy farms owe their diversity to their level of intensification (e.g. use of concentrate feed) (Depeyrot, 2017). To understand links between intensification and sustainability better, we combined economic indicators from a representative sample of French dairy farms (FADN) with the French life cycle inventory database of agricultural products (AGRIBALYSE) in an environmental analysis. For each farm, economic (annual added value, operating subsidies, annual working time of farm workers) and environmental indicators (climate change, soil organic matter depletion, water depletion, mineral and fossil resource depletion) were generated. The sample of farms was divided into four groups according to a proxy of intensification: the percentage of silage maize in the herd ration (<5%, 5-10%, 10-30%, >30%). Intensive dairy farms, which incorporated >10% of silage maize in the feed ration, had better economic performances, particularly added value, but worse environmental performances, particularly water and mineral and fossil resource depletion. In contrast, extensive dairy farms, which incorporated <10% of silage maize, had better environmental performances, particularly mineral and fossil depletion but worse economic performances, particularly the level of operating subsidies. Extending the approach by considering other sustainability indicators and analyzing other farm systems could be a way to increase the knowledge about sustainability of farming systems.

Keywords: *AGRIBALYSE, dairy farm, economic and environmental sustainability analysis, Farm Accountancy Data Network (FADN), MulticritEria AssessmeNt of Sustainability (MEANS)*

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Code: LCAF-2018-08-00113

Including soil carbon and land use changes to comparison of carbon footprints of beef production systems

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Abstract

Dairy beef production of major Finnish importer countries, namely Denmark and Germany, to Finnish production was compared taking into account the effect of emissions due to carbon stock changes and from land use changes. Also, uncertainties of the comparison were estimated.

The carbon footprints of beef from Danish and German dairy bulls are significantly lower than Finnish, when compared without including emissions from carbon stock and land use changes. This is mainly due to the average efficiency of feed production and the structure of production. There does not seem to be significant differences in carbon sequestration of the home-grown feeds on mineral soils between the three countries, and the inclusion of those emissions does not change conclusions of the comparison. In all countries, feed production seems to release carbon from the soil instead of sequestrating.

In contrast, the inclusion of emissions caused by changes in land use of soybean meal seems to alter the comparison between countries, and in particular, the emissions from Danish and German bull, while in Finland no soy is used for cattle. There are various methods available for the assessment of emissions of land use changes, and depending on the method used also the conclusion of comparisons between countries differ.

This study shows challenges in comparison of different LCA studies with evolving methodologies, but can still indicatively shed light on the differences of greenhouse gas emissions of the studied beef production systems and the causes for differences between them including the effect on emissions of changes in carbon stocks and land use.

Keywords: Soil carbon change, land use change, greenhouse gas, beef production, LCA

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A framework to account for the potential environmental impacts that may arise from genetic changes in pigs

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Abstract

We have developed a framework to account for the environmental impacts that may arise from genetic changes in pigs. An LCA model was built for a typical commercial Danish pig system, taking into account a number of pig traits that may be genetically correlated; the traits included were both sow- and growing pig-related. Through testing traits systematically both one at a time and in correlated clusters, i.e. accounting for the fact that some traits are genetically correlated, our model was able to show the importance of considering correlation between traits when modelling the environmental impact of breeding strategy. The model was highly sensitive to average daily gain between 30-100kg and energy used for maintenance, but also for clusters containing typical sow performance traits, such as weight gains and losses through gestation and lactation, and lactation feed intake. In future work we will consider how changes in these traits will affect the environmental impact of pig systems. This is the first time an LCA capable of showing the implications of breeding strategies for environmental impact has been developed for pig systems.

Keywords: *LCA; pigs; breeding; genetic trait, LCA, sensitivity*

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Sources and analysis of uncertainty in attributional and consequential life cycle assessment of agriculture and bioenergy production

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Abstract

Life cycle assessment (LCA) is intended as a quantitative decision support tool. However, the large amount of uncertainty characteristic of LCA studies reduces confidence in results. To date, little research has been reported regarding the comparative sources of uncertainty (and their relative importance) in attributional and consequential LCA. This paper explores these differences based on a review of recent LCA studies, with a focus on agricultural and bioenergy studies. The review found that less than half the studies in the past three years reported uncertainty analysis, and that Monte Carlo sampling was the most popular method used for uncertainty analysis, regardless of LCA type. There are many different sources of uncertainty in LCA, which can be classified as parameter, scenario or model uncertainties. Parameter uncertainty is most often reported, although the other types are considered equally important. There are also sources of uncertainty specific to each kind of LCA – in particular related to the resolution of multi-functionality problems (allocation in attributional LCA and the definition of market-mediated substitution scenarios in consequential LCA). Improved methodologies are necessary in order to better account for both the shared and unique sources of uncertainty in attributional and consequential LCA.

Keywords: *life cycle assessment; attributional; consequential; uncertainty; Monte Carlo*

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A fair comparison of GHG emissions and nutritional quality of 4 ready-to-eat meals

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Abstract

This study assesses and compares the greenhouse gases (GHG) emissions of four ready-to-eat meals, taking into account their nutritional quality. The selected meals have a different composition. They consist of a portion of vegetables and are served with beef (meal 1), rice (meal 2), salmon (meal 3), and chicken (meal 4). The nutrient rich food index 9.3 (NRF9.3) and the global warming potential (GWP) are assessed for all meals, using the Life Cycle Assessment (LCA) methodology. The results show the stage of ingredient production (cropping, farming) as the main contributor to the GHG emissions. The meat-based meals generate the highest GHG emissions. When adjusted by 100 grams of food, GHG emissions vary from 0.24 (meal 2, rice and vegetables) to 1.95 kg (meal 1, beef and vegetables) of CO_2 equivalent while, when adjusted by 300 kcal, they vary from 0.60 (meal 2) to 4.63 kg (meal 1) of CO_2 equivalent. In terms of nutritional quality, meal 1 has the highest nutritional score among the 4 meals under study. Finally, the GHG emissions of the meals were adjusted by the NRF9.3 scores, and showed that the nutritional score of the meals can affect the results.

Keywords: *climate change, ready-to-eat meals, LCA, nutritional value, functional unit*

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A Study on the Establishment of LCI DB to Action to EU Food Product Environmental Regulations

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Abstract

In 2013, the EU announced the 'Resource Efficiency Roadmap' for 2020 to provide transparent environmental information on its products. In addition, it has announced the establishment of 'Single Market Green Products' in order to minimize environmental impacts such as minimizing pollutants emitted from products and saving resources and to enable comparison of environmental impacts. New environmental regulations, starting in 2020, require the disclosure of high-quality environmental information on food. As a result, the development of a high-quality environmental information database is accelerated, and the EU has created the ILCD Data Network to encourage DB registration in each country. However, Korea LCI DB does not meet the ISO requirements.

The purpose of this study is to develop an LCI database and to develop PCR for EPD certification in order to estimate the environmental footprints of one of major processed foods exported from Korea to Europe. The aim of this study is to estimate the environmental footprint of six major environmental impact factors. These results will be used as data to help export food products of the domestic food industry respond to the European PEF scheme.

Keywords: *Food, Processed food, LCI DB*

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Code: LCAF-2018-07-00292

Critical review process of an LCA comparative assertion: a case on beverage packaging waste management alternatives

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Abstract

According to ISO 14040 and 14044 standards for Life Cycle Assessment (LCA) , when the environmental results of a comparison among different products or systems are intended to be disclosed to the public, a critical review is needed. This paper presents an adapted methodology to perform critical reviews of complete sustainability assessments, including not only the environmental part but also the economic and the social analysis. The suggested methodology has been tested in a real case study which analyses different packaging waste management alternatives is Spain.

Keywords: critical review, panel, LCA, beverages, waste management

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Code: LCAF-2018-07-00381

Environmental burden of Japanese fishery

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Abstract

The evaluation of environmental burden based on input-output analysis is widely recognized. As to the field of fisheries, however, there was a problem that all the fishery and aquaculture were respectively classified into a big frame and evaluated in an existing input-output analysis. To solve such a problem, the authors designed the macro-analysis method which divides fisheries into some sectors by adding fishery statistics to the input-output analysis. Moreover, an appropriate indicator to the fishery evaluation was examined by taking dynamic data such as the haul, the amount of production, and the operation days. Resultingly, the difference of the environmental burden on each sector about the fishery type, the fish type, and the aquaculture type was able to be shown clearly. It is considered that the macro analysis can be effectively used into the fishery policy toward the fishery because this method can comprehend the fishery industry in the view of top-down.

Keywords: *Japanese Fishery; Input-Output table; Fishery Statistics; Macro-Analysis; Environmental Burden; CO_2 Emission*

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Joint assessment of compaction and erosion impacts on soil productivity

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Abstract

Life Cycle (Impact) Assessment (LC(I)A) includes the assessment of impacts on natural resources such as soil. However, to date only single impact assessment methods for single soil degradation processes and no integrated method exist. Therefore, this work aims at helping to close this gap by combining the assessment of two important soil degradation processes, compaction and erosion, with regard to soil productivity loss. Preliminary results show that improved Life Cycle Inventories are needed but that the suggested framework and its technical implementation work. It is further shown that a new model is needed to translate soil losses due to erosion into yield losses. Final modeling and analysis still need to be performed.

Keywords: *Soil quality, Soil degradation, Yield loss, Life Cycle Impact Assessment, Agriculture, Regionalization*

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Eco-innovation strategies in the food industry: application to the spirit drinks sector

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Abstract

The application of innovation measures in the industrial sector points to significant progress towards the goal of sustainable development introducing eco-innovation strategies, which can move towards more environmentally-friendly production and consumption processes. In this sense, the aim of this work is to contribute to the sustainable development of the spirit drinks sector by means of the definition eco-innovation strategies that will be focused mainly on increasing the utilization of wastes to obtain co-products and the efficient use of resources. In particular, the strategies proposed will be applied to a beverage company dedicated to the elaboration of artisanal gin and vodka located in Cantabria (northern Spain) with the aim to develop a corporative ecolabel to launch the product in new green markets.

Keywords: LCA; beverages; waste management

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Code: LCAF-2018-07-00299

From the field to the farm - scaling up life cycle assessment towards eco-design at farm-level

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Abstract

Transitioning towards more environmentally friendly agriculture starts with change of practices at plot level, while strategic decisions are taken at farm level. Implementing eco-design in agriculture requires therefore reasoning at both plot and farm levels. Collecting detailed data for each farm plot is, however, a daunting and time-consuming task, and there is a need for an approach that facilitates data collection for life cycle assessment at farm level. To this effect, we propose a framework that allows establishing a case–by–case typology of land use types and activities for winegrowing systems based on criteria linked to farm management: existence of farmer blocks, grape variety, type of wine, sensibility to diseases, and other characteristics such as slope, soil type or local climate. This typology will be tested first for the environmental assessment of two farms as case studies, with the aim that it becomes a tool to enable winegrowers to assess and compare farm management options.

Keywords: *Life Cycle Assessment, eco-design, practice change, typology, farm level*

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SESSION 1-B
FROM FARM TO TABLE

Code: LCAF-2018-07-00308

A Comparative Life Cycle Assessment of Fresh Imported and Frozen Domestic Organic Blueberries Consumed in Indiana

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Abstract

Blueberries are a crop with significant economic value and nutritional quality. Consumption of locally grown produce is generally considered more environmentally sustainable, but blueberries cannot be grown in all regions of the U.S. in all seasons. During winter months, consumers in Indiana have the choice of purchasing domestically grown frozen blueberries or fresh blueberries imported from outside the country, most commonly Chile. Although freezing uses more energy than refrigerating blueberries, the long transport distance between Chile and Indiana makes the consideration of which alternative is more sustainable a non-trivial question. Therefore, in this study, a comparative Life Cycle Assessment (LCA) was conducted to evaluate the environmental performance of Chilean fresh organic blueberries and frozen organic blueberries produced in two representative states in the U.S. This cradle-to-consumer LCA covered the farming and harvesting, processing, transportation, and storage stages. The farming and harvesting, postharvest processing and transportation were identified as the environmental hotspots. The imported fresh blueberries were more sustainable than domestic frozen blueberries in terms of acidification, global warming, ozone layer depletion, human toxicity, fresh water and marine aquatic ecotoxicity, and photochemical oxidation, as well as human health endpoint impact. Whether consumers should choose the frozen or fresh blueberries was found to be highly sensitive to the length of frozen storage and the type of refrigerant used.

Keywords: *Life cycle assessment; Organic blueberry; Freezing; Refrigeration; Transportation; Storage.*

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Code: LCAF-2018-06-00019

Environmental impact of Danish beef ready to eat – hotspots and mitigation options

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Abstract

The aim of this study was to examine the environmental impact of beef products covering the entire chain from farm until ready to eat at home. Hotspots were investigated and mitigation options suggested. Primary production accounts for the major share of environmental impact per kg beef ready to eat and major effort should be given to minimize this impact. The production system from which the beef originate has a huge impact on the environmental impact per kg meat. The impact was much lower for beef from the dairy system compared with the beef bred systems. The slaughtering process causes a very low impact, but there was found a huge potential for reducing the environmental impact per kg beef product if it is possible to increase utilization of the slaughtered animal by production of new edible products not produced now. Also, reduced waste of potential edible food especially at household has a huge potential as a mitigation option.

Keywords: *primary production, slaughtering, cooking, food waste, type of beef consumed*

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Code: LCAF-2018-07-00135

The environmental impact assessment of malting barley production in the North of Spain: a case study

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Abstract

Barley is not only the main raw material for brewing, but also is one of the main environmental contributor of the beer. Because of that it is essential to study the environmental impact of malting barley production in representative areas such as Alava (North of Spain), with more than 13,345 ha of barley. The objectives of this study are: i) to evaluate the environmental impact of the production of malting barley based on LCA methodology in a very representative agricultural cooperative, ii) to acquire knowledge of cultivation practices so that, the program that will be developed within the LIFE AGROGESTOR (LIFE16 ENV/ES/287) project (now at preliminary step) will advise agricultural cooperatives what cultivation practices should be carried out. For all categories, production of fertilizers and the process of fertilization have been the main contributors. For global warming 71% of the final result is derived from fertilizer acquisition and soil N_2O emissions from fertilization. The use of AGROgestor platform will be the key to reduce the environmental impact of crops such as barley. Since, according to the environmental indicators, they will propose more efficient cultivation practices for the collective management.

Keywords: *Malting barley, acidification, eutrophication, global warming, photochemical oxidation, LCA*

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Code: LCAF-2018-07-00246

Food trays with less environmental impact

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Abstract

As a response to the increasing environmental concerns about food packaging, can the use of fillers be considered as a way to reduce their impact on environment? In this study, a food tray made of virgin polypropylene (PP) is environmentally compared to an alternative one made of virgin PP and talc based mineral filler, Granic 1081 produced by GCR Group in Tarragona, Spain. The results showed that the replacement of virgin plastics (PP) in food packaging by mineral master batches (at some portions) may help to reduce environmental impacts, while keeping the required mechanical properties, like flexural modulus and impact strength, same or even better.

Keywords: *Climate change; food packaging; life cycle assessment; polypropylene with mineral fillers*

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Code: LCAF-2018-07-00127

Environmental impact assessment of dietary scenarios: a review on methods

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Abstract

Dietary patterns have manifold impacts on human health and the environment. Impact assessments are employed to compare impacts of single food items or of diets as a whole, either in their current state or for theoretical scenarios. However, conclusions from impact assessments focusing on theoretical scenarios are diverse, and occasionally even contradicting. The role of animals and types of production are key aspects of these discussions. Therefore, the aim of this study is to analyse the methodological choices that cause these differing conclusions. We find that consideration of food-system-wide consequences of dietary change in the impact assessment, differentiation between land use categories, and production units are central for determining which theoretical dietary patterns are more or less sustainable and for understanding the role of animal-source food.

***Keywords**: diets, scenarios, impact assessment, methods, sustainability strategies*

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Code: LCAF-2018-07-00125

Life Cycle Assessment of earthworm dried meal production as food/feed source – a preliminary study

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Abstract

Food waste has already been recognized as an important global issue affecting the sustainability of the food supply chain. The production of food waste lead to an unnecessary exploitation of natural resources (land, water and fossil energy) and greenhouse gas emissions (GHG) production. The need of other sustainable solutions has become a key driver. A possible strategy is the recycle of the fruit and vegetable waste (FVW) as growth substrate for the production of fresh earthworms, further processed into dried meal. The aim of the present study was to assess the environmental impact of the bioconversion of FVW into earthworms dried meal as new food/ feed source. The results showed that earthworms currently have high environmental impacts due to the energy used during the processing of fresh earthworms into dried meal. Enhancing earthworm productivity and reducing the energy consumptions of the processing process is necessary to make earthworm dried meal a sustainable source of food/feed for human and animal nutrition.

Keywords: *Earthworm dried meal, Novel food/feed protein, Environmental impact, Life Cycle Assessment, Sustainability.*

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Code: LCAF-2018-08-00001

Environmental assessment of the supplementation of specialty feed ingredients in swine and poultry production

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Abstract

Challenge in livestock production is combining best possible use of resources with least impact on the environment. Specialty feed ingredients (SFIs) e.g. amino acids and phytase in broiler and pig diets improve animal performance by better utilize the feed helping to reduce nutrient inputs to the system (Kebreab, 2016). This follow up study evaluates potential impacts of additional SFIs in diets: non-starch polysaccharide enzymes, protease, probiotics, phytogenics, and organic acids.

A cradle-to-farm-gate LCA according to ISO 14044 is conducted to calculate the environmental performance of pig and broiler production with and without supplementation of SFIs for the regions of Europe, North America and Australia. The functional unit is 1 t of animal live weight at farm gate.

Feeding the additional SFIs in diets to broilers or pigs further reduces global warming potential (GWP) by around 3% compared to the baseline diet. Supplementation as well decreases eutrophication and acidification up to 5% because supplemented diets contain less base feed ingredients. The feed conversion ratio (FCR) has a significant influence on the potential environmental impacts, which magnitude of change equal the impact of the SFIs on the FCR. The production of the SFI itself has only marginal impact.

With improved FCR due to SFIs supplementation, the amount of base feed ingredients required for meat production decreases.

Although the SFIs supplementation decreases the environmental impacts, the reduction is small since the baseline diets are already well adjusted. Nevertheless, animal feed supplementation is an important step towards a more sustainable supply chain of broiler and pig meat

Keywords: broiler; feed efficiency; life cycle assessment; livestock emissions; pigs; specialty feed ingredients.

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Code: LCAF-2018-07-00213

Life cycle assessment of zinc source in animal feeding

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Abstract

Trace elements are essential dietary components in livestock nutrition, but they also exhibit a strong toxic potential. The objective was to evaluate the environmental impact of the oxide zinc (Zn) source HiZox®, with low amounts of heavy metals, using the methodology of life-cycle assessment (LCA). The process which contribute the most for the impact were the Zn extraction, due to the high primary Zn needed, and the manufacturing process, as a result of several dissolution and purification steps to obtain the product. As perspective, modelling the production chain until manure disposal and accounting the speciation of Zn in animal wastes could improve LCA results, providing solid information on the potential impact of Zn in the receiving environment.

Keywords: *environmental impact; heavy metal source; manufacturing; zinc oxide*.

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Code: LCAF-2018-07-00247

The Effect of Carbon Sequestration on the Environmental Implications of a Pecorino Romano PDO Sheep Supply Chain

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Abstract

The aim of this work was to evaluate the role of soil carbon sequestration on the Global Warming Potential of the main Italian sheep cheese supply chain. A LCA study was performed in a medium-large scale dairy plant of 'Pecorino Romano PDO-Protected Designation of Origin' and highlighted that when soil carbon sequestration was accounting for, the environmental performances of the Pecorino cheese quite improved. Considering the large dominant contribution of the milk production phase, the extensive and grassland-based farming systems can effectively contribute to reduce the environmental impact of the dairy sheep supply chain.

Keywords: *Dairy supply chain; Sheep cheese; Grassland based farms; Carbon Footprint; Carbon sequestration.*

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Code: LCAF-2018-07-00177

Environmental impacts caused by soybean losses during logistics

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Abstract

Brazil is one of the largest grain producers in the world. To distribute this production to other countries, storage and road transportation processes are necessary. Regarding overall grain's life cycle, the main environmental hotspot is unvaried located at crop production. Thus, if there are losses due mismanagement of the logistic chain, more grains need to be produced to meet the demand, hence more impacts are caused. In this context, we carried out a Life Cycle Assessment (LCA) to evaluate the impacts from the compensation of logistic losses in the soybean production flow from Paraná State (Brazil -BR), approaching improvements possibilities. In the baseline scenario, to deliver 1,000 kg of soybean for shipping (functional unit - FU), 9.5 kg of grains are lost. These losses represent emissions of 4.52 kg CO_2 eq. for Climate Change, 0.0138 kg SO_2 eq. for Terrestrial Acidification and 0.0041 kg P eq. for Freshwater Eutrophication. In addition, 19.81 m2a of Agricultural Land Occupation and 0.6163 kg oil eq. for Fossil Depletion are demanded. Results that are indicatives that, although representing less than 1% of all grain production, logistic losses are an important driver on environmental impact generation. Environmental impact reduction is possible through improvements on vehicles operation and road management, greater availability of warehouses and a better synchronization between supply and demand.

Keywords: *Grain losses, logistics, efficiency, soybean, Paraná, Brazil.*

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Code: LCAF-2018-07-00340

Evaluation of Greenhouse Gas Emissions from Chicken Meat Production: a Japanese case study

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Abstract

The purpose of this study was to assess greenhouse gas (GHG) emissions from a chicken meat production system in Japan, and to identify the most impactful processes associated with large-scale GHG emissions using life cycle assessment (LCA). GHG emission was estimated from the four processes involved in chicken meat production, viz., feed production, livestock management, manure treatment, and meat processing. The data used for inventory analysis were obtained from literature data, and site data through a location survey. GHG emissions during 1 kg chicken carcass meat production ranged from 1.85 to 3.34 kgCO_2e, owing to differences in emission factors. The feed production process had the largest impact—67% of the total GHG emissions, and the estimated emission factors indicated reliance on domestic feed production. The impact of manure treatment at broiler chicken farms was 13 to 17%. The contribution of composting was particularly large, because of CH_4 and N_2O emissions.

Keywords: *livestock production; chicken meat; life cycle inventory analysis; GHG emissions*

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Code: LCAF-2018-08-00002

Towards a viable livestock industry – How can data make animal protein more sustainable?

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Abstract

Measuring environmental impact in animal protein value chains has become increasingly important for the livestock industry. Combining livestock production know-how with environmental impact data through digital technologies aims to achieve more efficient and sustainable operating processes and animal protein products. This publication demonstrates how the chicken production value chain can be analyzed utilizing life cycle assessment (LCA) based modelling and software tools. The methodology deployed for case studies in Asia Pacific was BASF's Eco-Efficiency Analysis (EEA), which considers environmental impacts alongside costs. The results show the magnitude and location of environmental impacts in the chicken value chain. The holistic impact assessment creates extensive transparency that allows for the implementation of targeted measures to improve overall product sustainability.

Keywords: *Eco-Efficiency Analysis (EEA), Eco-Efficiency Manager (EEM), life cycle assessment (LCA), life cycle costing (LCC), environmental impact, economic performance, animal protein value chain*

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Code: LCA-2018-07-00053

Environmental impact of wheat production from an Italian farmers' cooperative

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Abstract

Wheat is a staple food that provides between 70-90% of the calories and between 66-90% of all the proteins consumed in developing countries (Kole, 2006). In 2016, according to FAO (FAOSTAT, 2016), the world wheat production amounted to 749,460,007 t with the following countries as the major producers: China (131,689,035 t), India (93,500,000 t), Russia (73,294,568 t), USA (62,859,050 t) and Canada (30,486,700 t). In Italy wheat production totals 8,037,372 t; durum wheat represents 60% of total production and is cultivated on 1,198,974 ha of land. Such type of wheat is vital for the production of pasta, bread, couscous and other products.

Italy is one of the largest world pasta producers and half of its production occurs in the southern region named Apulia (Renzulli et al. 2015). Pasta production often implies the use of different types of durum wheat with different characteristics. This is because the final product depends on certain parameters imposed by regulations (e.g. the Italian UNI 10709 and UNI 10940) and on characteristics (for example the colour of the pasta) which are defined by the policies of the producing companies.

Since one of the main key issues of LCA applied to the agri-food sector is the lack of regionalized and specific data (Ruviaro et al., 2012), this study intends to define an environmental profile, via the use of an LCA based on detailed and reliable inventory data, of a certain mixture of different types of durum wheat from the Apulia region, used by a pasta producing company.

Specifically, the study is carried on a " cradle to gate" basis which includes raw material production and acquisition (including fertilizers and pesticides) and the use of fuel and lubricant for the agricultural operations detailed according to the machine, the soil conditions and the number of operations carried out. This approach required the collection of detailed data, which was traced via an agreement between the pasta producer, the mill and a cooperative formed by different wheat producers. Primary data were gathered from 61 wheat farmers in the Foggia province for a total area of 1,162.45 ha and are referred to the 2015/2016 harvests. The wheat collected by the farmers' cooperative amounts to 5,499.95 t and had to have the following minimum qualitative characteristics: minimum protein content 14% ; good gluten quality; minimum color 22; hectoliter weight 79 kg/hL; impurities 2% ; maximum percentage humidity 13%. The most cultivated crop varieties are Iride, Saragolla and Sfinge which ensure good yields (for the investigated area) due to their good agronomic and technological characteristics. The average yield is 4.73 t/ha.

In conclusion, this work allows a precise identification of the environmental hotspots of the aforementioned durum wheat production by using detailed and specific primary agricultural inventory data.

Keywords: *Wheat, Life Cycle Assessment, Durum Wheat, Agri-food systems, pasta production*

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CODE: LCAF-2018-02-00303

Sustainability of plant protein vs protein of animal origin

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Abstract

The Norwegian research project aims to cover the sharply increasing demand for plant-protein based foods with products based on Norwegian grown faba beans, peas, oats and some processing residues, e.g. rapeseed press cake. Social and environmental sustainability assessments are now being carried out to test the concequences of replacing part of the current protein consumption (75 % animal origin) with these plant protein resources. Initial results shows that peas and beans have significantly lower impact than beef and milk, pr kg protein, for all impact categories considered. However, there remains some issues that must be solved before accurate comparisons can be made. There is disagreement in the scientific community on how to calculate the effect of Soil Carbon Change, which can have a large effect on the GWP of crops and meat. Furthermore, ways of calculating the impact of building infrastructure, and the results thereof, differ widely in different publications. Proponents of continued high meat consumption also point to a number of factors normally beyond the scope of LCA: 1. beef and mutton use grass resources unsuitable for other production. Meat has better protein quality than plants. 3. The biodiversity of pastures can be high and 4. Meat production is important in Norway to maintain national self sufficiency.

This project will attempt to also take these factors into consideration in the assessments of sustainability concequences of a partial shift from animal based to plantbased protein in Norway.

Keywords: Norway; plant protein; animal protein; sustainability; social; LCA.

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SESSION 1 - C
FOOD SECURITY

Code: LCAF-2018-08-00106

Comparative Social Life Cycle Assessment of conventional and area based rice production: A case study in north-eastern Thailand

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Abstract

This contribution compares social performances of conventional and area based rice production along the life cycle of the product. Social Life Cycle Assessment is used in the analysis. The site selected is in Ubon Ratchathani province, the largest rice grower in Thailand. Key three stakeholder groups are examined, i.e. workers, local community, and value chain actors (rice farm owners and machine contractors). The results show that the "area based" approach can deal with labor inadequacy and high labor cost problems during planting and harvesting. This is because the area based approach promotes more mechanized cultivation. Moreover, the area based approach can benefit the farm owners in all the social indicators studied, i.e. net income, market security, access to loan and technology development, and women empowerment. Although this will result in slightly lower social performances for workers and machine contractors, it may be traded off with the labor insufficiency problem.

Keywords: *Social life cycle assessment; rice; area based agriculture*

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SESSION 1 - D
WAYS TOWARDS SDGs

Code: LCAF-2018-07-00114

"APIVALE", an experimental platform for an integrated approach to organic waste recycling and valorization

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Abstract

Agriculture lies at the heart of organic waste recycling and valorization (e.g., organic matter, energy, nutrients). This challenge requires producing scientific knowledge, developing technical and organizational innovations and a more holistic approach to better consider possible synergies within regions. Organic wastes are subjected to many biological, chemical and physical processes that modify their composition, generate emissions to the environment and ultimately affect nutrient availability for plants and soil fertility. Improved knowledge about these processes is required to quantify their emissions more accurately (for evaluation) and to reduce them (for mitigation). Several public research institutes in western France, including IRSTEA, INRA, ANSES, University of Rennes 1, CNRS and Southern Brittany University, decided to share their experimental facilities, equipment and skills in a multimodal platform called " APIVALE" to develop an integrated approach to organic waste recycling and valorization. This platform will be opened internationally within research projects to other research institutes, to applied research and to industry.

Keywords: *Platform, infrastructure, organic wa ste, emission, treatment, LCA*

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Code: LCAF-2018-07-00108

Environmental interests of agricultural biogas plants: the functional unit matters!

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Abstract

Environmental performances of agricultural anaerobic digestion are complex to assess since the objectives of this kind of facility are numerous. Hence, the choices of the boundaries and functional unit of the life cycle assessment are crucial. This study assesses environmental impacts of 10 on-farm anaerobic digestion scenarios involving pig or dairy cattle manure, different sizes of plant (from small (50 kW) to large (200 kW)) and different post-treatments of digestat (direct spreading, phase separation, drying belt, biological treatment, composting, and export from Brittany (northwestern France)) . Environmental burdens were assessed by LCA for climate change, eutrophication, acidification, non-renewable energy demand and land occupation. Different functional units were selected to address three main objectives: producing renewable energy, decreasing environmental impacts of the farms, and managing livestock manure. The results show advantages and disadvantages of anaerobic digestion according to the functional unit and impact considered. Three performance criteria were highlighted in the study: balancing the N: methanogenic potential ratio of the input material, optimizing the heat produced, and using cover during storage.

Keywords: *anaerobic digestion, multifunctional system, emission factors, animal production.*

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Food loss evaluation based on food balance sheet framework (Thailand)

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Abstract

Nowadays, Food produced for human consumption around the world lose or disposal about one third of the total food or account as 1. 3 billion tons per year (FAO, 2013) . Furthermore, the energy consumed by one of every four food calories produced for humans is not being consumed, and if account this food waste into cultivated area, it would amount to 1,920 million square meter (WRI, 2013). As a result, the global collaboration was established with the aim to decrease food loss (FL) and food waste (FW) along food supply chain (FSC) through commitment on SDGs 12. 3. According to fool loss evaluation is a challenge in terms of method/ standards and access to data all food supply chains that are being developed and/ or tested. In Thailand, the food loss/ waste data along food supply chain is still in the process of development. Food Balance Sheet (FBS) were the main source of data used in the evaluation and appraisal of the world food situation from FAO presenting including Thailand. Therefore, the evaluation of food loss based on the existing Food Balance Sheet (FBS) framework would be a basically quick solution for report and initial method to estimate food loss. It was proposed by FAO to suit as the first step food loss report with the annually official data. However, relevant data should be studied based on consistent food loss and food waste protocol launch by UNEP and FAO's and/or secondary data collected from reliable researches for reporting as a represent of Thailand. In addition to, considering reliability and uncertainty data.

Keywords: *Food Balance Sheet (FBS), Food loss evaluation*

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Carbon Footprint of Alfalfa production in Gansu Province China

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Abstract

Life cycle assessment methodology were used to quantify the carbon footprint (CF) of alfalfa production in different cropping patterns in Gansu Province which is the major area of alfalfa producing in China, and the potential measures for decreasing CF of alfalfa production in this province were investigated. Data were collected from farm survey in major regions of alfalfa cultivation in Gansu Province. Cropping pattern of alfalfa production in Gansu Province was classified into four types according to the level of nitrogen application and irrigation, and the irrigation water source. CF of alfalfa production was 0.02, 0.19, 0.22 and 0.64 kg CO_2 eq·kg^{-1} DM under four cropping patterns including NFNI (non-fertilization and non-irrigation) , SFNI (spreading fertilization and non-irrigation), SFRI (spreading fertilization and river irrigation) and SFWI (spreading fertilization and well irrigation), respectively. The SFWI pattern got the highest production with high input, while its CF was significantly higher than that of other patterns. With the exception of NFNI pattern, excessive fertilizer was used in other three patterns. Reducing the amount of applied N fertilizer will decrease CF of alfalfa production in Gansu Province. The combination of chemical fertilizer and manure will decrease CF in SFNI and SFRI patterns, but also the yield of alfalfa hay. So, the optimal ratio of chemical fertilizer to manure should be investigated further. The water-saving irrigation will be the major mitigation measure in SFWI pattern, while the integrated abatement potential of GHG emission should be evaluated including emissions from the production of pipes used in sprinkler and drip irrigation.

Key words: *alfalfa; carbon footprint; fertilization; irrigation; Gansu Province*

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Code: LCAF-2018-08-00035

Global variability of Greenhouse Gas Footprints of Crops Grown for Processing: Intercrop, Interyear and Intercountry Assessment

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Abstract

Understanding the drivers of variability of greenhouse gas (GHG) footprints of global crop production is important to identify opportunities for reduction and to enable more targeted GHG mitigation strategies within agricultural value chains. Past studies (Clavreul et al., 2017; Pishgar-Komleh et al. , 2017; Lam et al. , 2018) on tomato production have concluded that farm management factors are more important than climate and soil conditions in influencing the variability of GHG footprints of crop production. In this study, we used a dataset of 8174 farm-year observations across 48 countries. The assessment covered the years 2011 to 2016, analysing the interyear and intercountry variability of GHG footprints of 144 individual crops. All crops have been grown under Unilever's Sustainable Agricultural Code (SAC). We calculated the life-cycle GHG footprints from cradle to farm gate and used Spearman' s partial correlation coefficient to quantify the relative contribution of the direct drivers of variability: 1) yield of crop; 2) land use change, 3) fertilizer consumption and 4) energy consumption to the overall variability of the GHG footprints of crop production. With this, results can be used to identify the major drivers of the variability of GHG footprints of each crop and help inform sustainable agricultural production.

Keywords: *crops; life cycle assessment; greenhouse gas footprints*

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Estimating the Country-Level Water Consumption Footprint of Selected Crop Production

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Abstract

A rapid development in economic sectors has induced the water depletion in most of the developing country, particularly for Malaysia. This study estimates the water footprint of 15 selected crops (cash crops, vegetables, and fruits) in Peninsular Malaysia. The water footprint was determined based on the CROPWAT 8.0 and Penman Monteith model. CROPWAT 8.0 model was used to compute the evapotranspiration and crop water requirement (effective rainfall and irrigation requirement) of the selected crops grown in Peninsular Malaysia from 2005-2013 (9 years). The results indicated that the green water consumption footprint (129.8 m^3/ton - 1,586 m^3/ ton) was higher compared to the blue water consumption footprint (21 m^3/ ton - 931 m^3/ton) for all 15 crops cultivated in Peninsular Malaysia. The highest water footprint was found for cultivating rice for both off and main seasons with 2,265 m^3/ ton and 2,255 m^3/ ton, respectively due to the cultivation practices under flood conditions. In conclusion, water consumption for rice cultivation is higher compared to other agricultural crops and this will accelerate the competition on the consumption of clean water with the other sectors. However, the availability of water resource in Peninsular Malaysia is sufficient to fulfilling the demands for water at the present time.

Keywords: *Water consumption; water scarcity; water stress index; water footprint; agriculture sector; Malaysia*

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Code: LCAF-2018-07-00051

Biodiversity damage from land occupation for the main grain crops production in China

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Abstract

Agriculture, which is the major land user in China, potentially causes profound biodiversity loss nationwide, particularly in ecologically fragile areas. This shows a tension between terrestrial biodiversity (SDG 15) and food security (SDG 2). Therefore, quantifying the biodiversity impact associated with agricultural production and identifying the hotspots is necessary for taking acute action to reduce biodiversity loss. This study applied LCA-based characterization models to assess the potential biodiversity damage (BD) caused by land occupation for the production of China's main grain crops (i.e. rice, wheat, maize and soybean). The hotspot regions were identified for the production per kg crop and for the total production of the 4 crops in China's 31 provinces in 2015 were identified. To produce 1 kg crop, generally, both regional and global BD in southwest and south China held higher values than other regions due to high regional and global characterization factors (CFs). From the perspective of total production, provinces with high BD per kg crop and with high total production had the highest total biodiversity damage (TBD). Heilongjiang, Sichuan, Henan, Hebei, Shandong and Yunnan contributed 54.5% to the regional TBD. While Yunnan, Sichuan, Henan, Guangxi, Shandong, Hebei and Jiangsu accounted for 53.8% of the global TBD. Strategic actions in these hotspot regions would be the most beneficial in addressing biodiversity loss challenges.

Keywords: *Biodiversity loss; impact assessment; land regionalization.*

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ICGSI 2018

ORAL PRESENTATION

SESSION 2 – A
SUSTAINABLE RESOURCE USE

Code: ICGSI-2018-07-00012

Life cycle assessment of guayule as an alternative source of natural rubber

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Abstract

Guayule rubber is a domestic source of natural rubber in the United States (US). Cradle-to-gate full life cycle assessment (LCA) studies based on experimental data have not been conducted so far to evaluate whether it is a sustainable natural rubber resource. Previously, a cradle-to-gate LCA on guayule rubber production with electricity from its bagasse as a co-product (GRE) scenario was conducted using data from existing guayule literature to evaluate global warming potential (GWP). The GWP result of this GRE scenario was reevaluated by substituting results from a gate-to-gate LCA of drip irrigation - an LCA study conducted based on experimental data. The new GWP result of GRE scenario decreased by 160% compared to the previous GWP, i.e., 2.26 kg CO2 per one kg natural rubber. LCA results could assist industry, particularly for a new technology, to identify processes with major impact contribution (hotspot). More experimental trials should be performed to strengthen life cycle inventories, which is one of the crucial steps in conducting LCAs.

Keywords: *guayule; natural rubber; irrigation*

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Code: ICGSI-2018-08-00004

Innovative Carbon-Neutral Upcycled Products for Climate Change Mitigation and Circular Economy

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Abstract

The design and building industry used natural resources at around 40% of the total natural used for global economy. Especially the lifestyle products, they contributed a great impact on climate change as well as a high mitigation potential. This study was aimed to develop the innovative and low-carbon products for the design and construction industry. The design concept was based on the integration of product designing and carbon footprinting using the life cycle perspective. The life cycle of product covering raw material acquisition, manufacture, distribution, use and end-of-life treatment including transports related in all stages were taken into account in the design processes. The product design processes were implemented through the collaboration with 3 pilot cases. The potential environmental aspects associated with the whole life cycle of products were identified and integrated with the design for environment including marketing issues. The prototypes were developed by using wastes and simple production processes while controlling wastes to be minimum. At the same time, the inventory data associated with the life cycle of prototype were identified and collected for the calculation of carbon footprint. The carbon footprint values of candle holder (upcycling from steel scraps) , wallpaper (upcycling from recycled papers), and lamp (upcycling from rice straw-based board scraps) were 190 gCO_2e, 633 gCO_2e, and 4.95 $kgCO_2e$. The packaging was identified as a key hot spot for the candle holder, and it was resolved by adjust the design; to further reduce the environmental impacts, the number of welding was kept minimal while the strength was sufficient. The final waste disposals were the main cause contributing to the greenhouse emissions for the wallpaper and lamp. Thus, it was suggested to recycle or upcycle the wallpaper after end of life while the lamp' s components should be designed to ease the disassembling to facilitate the upcycling another time. The purchasing of carbon credit from a local project on greenhouse gas reduction was taken place to participate in the carbon offsetting program to be certified the carbon neutral label for social and environmental responsibility. It was expected that the life cycle design as well as carbon neutral label would be a marketing tool to differentiate with other similar products and increase market opportunities. In addition, this will stimulate the climate change adaptation and transform into the low-carbon society.

Keywords: *Carbon neutral label, Circular economy, Climate change mitigation, Life cycle design, Lifestyle and Upcycled products*

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Evaluation of Permanent Magnet Recycling Based on the Future Waste Forecast and Location Routing Problem

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Abstract

Recently, there has been an increased consumption of mineral resources, such as rare earth elements (REEs), because of the rapid increase in population and the development of industries, which boosts the demand for high-tech products such as batteries, motors, and mobile devices. There are several ongoing studies that evaluate the future demand for REEs and their potential for being recycled. However, no feasibility study has yet succeeded in achieving detailed cost estimation of recycling, including transportation or collection of wastes. Therefore, this study intends to estimate the future recycling cost (transportation, demagnetization, and separation) of the NdFeB-sintered magnets in Japan based on multiple regression analysis and a location routing problem. This study will contribute to ensure proper planning and evaluation of an REE recycling system in the future.

Keywords: *Recycle, Permanent Magnet, Hybrid Electric Vehicle, Waste Forecast, Location Routing Problem*

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Code: ICGSI-2018-07-00059

A Framework for Examining Stakeholder Technology Challenges in Transitioning to Zero Waste Manufacturing

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Abstract

Zero waste manufacturing (ZWM) offers Singapore a holistic approach to achieve its national advanced manufacturing goals while reducing waste generation, enhancing resource security, and moving towards a circular economy. A framework comprising six themes; (i) design for zero waste; (ii) smart waste audit and reduction planning; (iii) smart waste collection; (iv) high-value mixed waste processing; (v) collaborative platform for industrial symbiosis; (vi) waste-to-resource conversion and recycling is proposed for examining technical challenges waste generators, collectors, and recyclers face when transitioning to ZWM. This research reviews state-of-the-art technologies and research literature across all six ZWM themes. The global industry trends of internet-of-things, industry 4.0, the sharing economy, and the circular economy are also reviewed to examine how they can catalyze ZWM across the six themes. This research revealed that there are many mature technology options stakeholders along the waste value chain can adopt to shift Singapore towards ZWM. Internet-of-things technologies have enabled the successful deployment of smart waste collection systems and smart factories. These two industry examples can be learned from to apply internet-of-things technologies to address the current lack of connectivity between the different stakeholders that operate in different parts of the waste value chain which is critical for enabling ZWM. The findings of this research can help determine a strategic roadmap for Singapore to shift to a ZWM ecosystem.

Keywords: Zero waste manufacturing; circular economy; industrial symbiosis; internet of things; waste to resources

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Code: ICGSI-2018-07-00081

Mitigation of struvite formation in palm oil mill effluent (POME) treatment facilities

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Abstract

Struvite formation or generally known as scaling in palm oil mill effluent (POME) treatment system has long been identified to cause adverse impact on the efficiency of the POME treatment process. Its occurrence has become more common in recent years with the increase of nationwide palm oil milling capacity. This study determines the characteristic of struvite sample from a typical POME treatment facility and examines the influence of pH and temperature on these struvite samples. Struvite samples were collected from a piping set up of a POME treatment facility in a 50 tph palm oil mill. X-ray diffraction (XRD), energy dispersive spectroscopy (EDS) and solubility analysis were carried out on the sample. Composition of phosphorous element was found at 22.8% . Other elements were magnesium (Mg), 20.4% , carbon (C), 2.3%, hydrogen (H) 3.5% and nitrogen (N), 2.0%. Maximum solubility of 270.4 mg/L was achieved at pH of 3 and temperature of 40°C while minimum solubility of 122.1 mg/L was recorded at pH 7 and temperature of 25°C. The study concludes that although struvite is currently a problem in palm oil mill, it possesses a significant economic benefit as an alternative source of valuable fertilizer material that can be further exploited.

Keywords: palm oil mill effluent, crystal, phosphate, struvite, sustainability

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Code: ICGSI-2018-07-00024

Carbon Footprint of Zeolite A and Zeolite Y Derived from Bagasse Ash for CO_2 Adsorption

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Abstract

Carbon dioxide is the main gas for greenhouse problems. Carbon dioxide adsorption was studied from using zeolites derived from bagasse ash as adsorbents. Zeolites are aluminosilicate materials from alumina and silica sources. High silica from bagasse ash can be used as silica source for zeolite synthesis. This research was to compare carbon footprint of zeolite A and zeolite Y derived from bagasse ash for CO_2 adsorption. The results were evaluated through all steps as raw material, synthesis, usage and disposal steps. The functional unit was 0.3 grams of zeolites and the condition of CO_2 adsorption was at 300 ^{O}C with 5 L/hrs CO_2 flowrate. Carbon footprint of products were obtained followed by LCA methodology. The carbon footprint of zeolite A and zeolite Y derived from bagasse ash was 0.551 and 0.515 kgCO_2eq, respectively. The results indicated that zeolite Y from bagasse ash was obtained slightly lower carbon footprint than zeolite A. The CO_2 adsorption efficiency for zeolites Y was higher than zeolite A 4.78%.

Keywords: *Carbon footprint, Zeolite A, Zeolite Y, CO2 adsorption, Bagasse ash*

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SESSION 2 – B
SUSTAINABLE MATERIAL AND CHEMICAL USE

Code: ICGSI-2018-07-00082

Domestic Material Consumption (DMC) of Biomass in Thailand

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Abstract

Domestic Material Consumption (DMC) can be used as indicator to monitor material consumption pattern for nations. The evaluation could show material intensity per year, capita or GDP. Policy makers, private sectors or even scientists can benefit the result for multiple purposes. With the Sustainable Development Goal (SDGs), DMC becomes one important indicator in area of sustainable consumption and production (SCP) and inclusive growth. In 2015, Thailand has DMC equal to 547.13 million ton (8.06 ton/capita). This consist of Biomass 212.91 million ton (3.14 ton/capita), representing 39% of DMC. Comparing with other countries in Asia, Thailand has approximately lower DMC/capita than many. The contribution of biomass is highest proportion compare the other 3 categories (metal, non-metal and fossil fuel). The results from this research differ to UNEP SDG snapshot due to many criteria such as scope, boundary, source of data and conversion factor. In addition, DMC consist of various data sources from agriculture, industry to energy plus import/export information.

Keywords: *Domestic Material Consumption (DMC); Sustainable Development Goals (SDGs); SCP; Biomass*

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Code: ICGSI-2018-07-00010

Factors influencing sugarcane cultivation: A case study in Kanchanaburi province, Thailand

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Abstract

The study aims to evaluate the influence of fertilizer and water application on cane yield. Four sugarcane cultivation practices in Thailand were evaluated based on farm size. The results revealed that the water and fertilizer supplied were positively correlated with cane yield for farms managed according to good agricultural practices (GAP). On the other hand, for farms not following GAP, which is the usual case for current practice, water supplied was less correlated to the yield maybe because of insufficient irrigation which is expensive. To address the trade-off between irrigation cost and yield increase with increased irrigation, the eco-efficiency was taken into account to find out the appropriate cultivation option based on four existing sugarcane cultivation practices. The results show that for the current situation where water supplied to the sugarcane is insufficient, the large scale farming has highest eco-efficiency. The benefit came from high value added and lower greenhouse gas emissions from avoided cane trash burning. Meanwhile, the small scale farming had the lowest eco-efficiency because of the low yield and high greenhouse gas emission caused by cane trash burning. The irrigation system as well as the cultivation practice of small scale farming should be considered as the key to improve the sustainability of sugarcane.

Keywords: *Sugarcane, Cultivation, Correlation, Thailand*

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Code: ICGSI-2018-07-00068

Functional fillers as a part of green chemistry: LCA review

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Abstract

As a response to the increasing environmental problems of plastics perceived by society, in the recent years fillers have started to be seen as an alternative to those problems, since they can reduce the need for petrochemicals. However, is their use "greener"? To this end, a short review of LCA studies comparing environmental impacts of functional fillers against conventional materials was done. Results showed that although they are widely used, their environmental impacts are rarely studied; therefore a gap in the literature was found. Besides, it was observed that fillers may provide reduced environmental impacts of materials, while keeping the properties same or even better. In addition, LCA methodology used in the studies was reviewed in terms of functional unit, system boundaries; software, impact categories used; and inventory development method used.

Keywords: *Sustainability; composite; fiber; mineral; carbon footprint; thermoplastics*

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Code: LCAF-2018-07-00309

The production of organic fertilizer pellets from fruit and vegetable wastes

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Abstract

Food loss and waste is a real concern around the world. Traditional disposal of these wastes by landfilling emits large quantities of methane, a powerful greenhouse gas produced under anaerobic conditions. The alternative solution proposed by this study is to produce organic fertilizer pellets (OFP) to valorize fruit and vegetable wastes. The objective was to compare GHG emissions from both reference (landfilling) and alternative (OFP production) scenarios of fruit and vegetable wastes disposal. A life cycle approach was used, considering the collection of fruit and vegetable wastes at the grocery, the production of OFP (drying, grinding palletization) and the transport and spreading of OFP in the field. Both scenarios consider the cultivation of corn crop under a loamy soil. In the reference scenario, synthetic fertilizers are considered to provide the same required nitrogen dose (170 kg N ha^{-1}). Results show that emissions from the reference scenario (654.8 kg CO_2eq $Mg^{-1}_{residues}$) are relatively high as compared to the alternative scenario (39.8 kg CO_2e Mg^{-1} residues), which is mainly due to high emissions of methane from landfilling in the reference scenario. The proposed production of OFP from fruit and vegetable wastes is a sustainable, easy-to-implement strategy that can have a significant impact in reducing GHG emissions.

Keywords: *Greenhouse gas emissions; organic fertilizer; fruit and vegetable; food waste*

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Code: LCAF-2018-07-00230

Circular Brew: life cycle assessment of waste bread-based beer

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Abstract

Upcycle Ale was a limited beer batch produced in Sydney by craft brewer 4Pines in collaboration with Edge Environment and a number of its suppliers. The purpose of this batch was to develop a new recipe that replaced part of the barley with waste bread. The bread was recovered from a local bakery, toasted and added to the brewing mash. To understand if using a waste-based ingredient and adapting the brewing method carried an environmental advantage, a comparative life cycle assessment (LCA) was done against a standard beer by the same producer. The Upcycle Ale's footprint was shown to be 20% lower than that of a standard craft brew. More than due to the lower requirement for barley, this difference is due to the fact that all spent grain from the brewing of Upcycle Ale is offered to cattle farmers for feed, rather than landfilled. Further emissions reduction opportunities lie in the adoption of renewable energy sources to power the brewing process, since this is this the largest source of greenhouse gas emissions for both the bread beer and the standard beer.

Keywords: *Circular economy; food waste; craft brewing; beverages; carbon footprint*

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An environmental prospective study of Thai bioplastic policy

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Abstract

Global warming and resource depletion issues are becoming more and more crucial in the global scale. Moreover, increasing of plastic waste is also a broad impact to both land and ocean. PLA (Polylactic acid) bioplastic, one of the bio-material which produced from crop and could biodegradable, is getting more attention continuously. The life cycle of PLA study consists of the crop cultivation, starch production, glucose production, and PLA conversion including the transportation. The life cycle assessment (LCA) result of cassava-based PLA is needed to support bioplastic policy in Thailand. The environmental impacts were analyzed in term of global warming, acidification, human toxicity, and energy consumption issues. LCA with system expansion and various scenario case studies were applied in this study. An economic model, partial equilibrium, was used to evaluate an effect of the agriculture sector due to the increasing PLA production. Majority environment burden in this study came from the bioplastic conversion stage. Every 1 ton of cassava-based PLA resin generated 1,653–2,513 kg CO_2e in term of global warming potential impact. Furthermore, acidification and energy consumption categories per ton of PLA showed 8.5–12.0 kg SO_2 and 15,903–19,574 MJ, respectively.

Keywords: *Polylactic acid Bioplastic (PLA); system expansion and Economics analysis*.

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SESSION 2 – C
SUSTAINABLE WATER RESOURCE MANAGEMENT

---------- NONE ----------

SESSION 2 – D
SUSTAINABLE ENERGY AND MOBILITY

Code: Invited speaker

Sustainability of palm-based biorefinery to support bioeconomy

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Abstract

Palm oil industry is expected as one of the important players for supporting the Thai bioeconomy promotion policy since palm oil is nowadays used as the feedstock for food, feed, fuel as well as personal care. However, the sustainability of Thai palm oil industry is still under pressure due to the environmental concerns on waste management over the palm value chain. Biorefinery is therefore expected to be the promising option for enhancing the environmental and economic sustainability of the Thai palm oil industry. The study therefore assesses the environmental and socio-economic impacts of the existing palm value chain for food, fuel and oleochemicals in Thailand using the Life Cycle Assessment approach. The results reveal that the environmental impacts of the palm biorefinery systems are varied by the production technologies and the waste management practices used in each factory. The average life-cycle greenhouse gas emissions of crude palm oil, refined bleached deodorized palm oil and biodiesel are 0.89, 0.96 and 0.97 kg CO_2eq/ kg product, respectively. Palm milling has the highest number of full-time employment equivalent as compared to the other palm industries in the value chain. However, the more significant benefit is from the household income generation of the oil palm growers. Recommendations for enhancing the sustainability of the Thai palm oil industry via the appropriate pathway of biomass use for the value added products and the appropriate sustainability indicators adoption are discussed.

Keywords: *Palm oil; Biorefinery; Palm value chain; Sustainability; Life cycle assessment*

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Code: ICGSI-2018-07-00055

Are electric vehicles the key to improve environment in transport sector? – From a Well-to-Wheel perspective –

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Abstract

A Japanese Well to Wheel analysis is conducted in this study to discuss the role of electric vehicles for automotive CO2 reduction. The target automotive energies are hydrogen, gasoline and electricity and the target powertrains are electric vehicles (fuel cell vehicle, hybrid vehicle and battery electric vehicle) and a gasoline vehicle. The latest pieces of information available on input data of processes comprising the target automotive energy supply chain and the Japanese LCA database were used for the calculation.

Keywords: *Well to Wheel, CO2 emissions, Japan, Electric vehicles*

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Code: ICGSI-2018-08-00022

Life Cycle Assessment of Automated Container Port Logistics Systems

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Abstract

For more than two decades, automation technologies have been implemented in port logistics systems for increasing an efficiency and reducing environmental impacts of the worldwide container ports. However, there is still a limited study on the environmental assessment of automated port logistics system. Therefore, this study aimed to assess environmental impacts of different container ports logistics systems in Laem Chabang Port. Three different automation technology scenarios in the container handling and transport operations were developed. Fuel and electricity consumption demands - the foreground data - for each port operation are gathered from interview and literature review. The interview is conducted for the current Laem Chabang Port operation. The data relating to automated port scenarios were obtained from scientific literature. The background data were obtained from ecoinvent3 database. Life cycle assessment (LCA) are applied for port logistics operations to transport one twenty-foot equivalent unit (TEU) container in the port area. The Recipe2016 V1.1 method was used in life cycle impact assessment. Based on the comparison of the current operation of Laem Chabang Port, it is found that the automation technologies scenario with the lowest environmental impacts in this study is the implementation of automated stacking cranes, ASCs in the yard operation. However, the data collection from the different sources may cause of the different impact assessment results. The data from the specification and technical documentations of automation equipment manufacturing might give more precise calculation of energy consumption. Furthermore, the maintenance process, economic and social aspects for the investment of the new technology should be taken into account in a further study.

Keywords: *Automated Container Ports; Environmental Container Ports, Environmental assessment, Life Cycle Assessment, Sustainable Mobility*

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Code: ICGSI-2018-08-00071

Dynamic carbon accounting applied to energy policy scenarios: accounting for full lifetime carbon

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Abstract

Energy modelling is a central instrument for energy system planning. However, assessment of climate change impacts use static approaches and do not account biogenic carbon (C_{bio}) emissions. The present study addresses dynamic assessment shortcomings of bioenergy systems to assist energy policy-making. We propose a coupling strategy combining the TIMES-MIRET partial-equilibrium model with dynamic C_{bio} accounting models, towards dynamic LCA. TIMES-MIRET represents scenario-dependent outputs over long timeframe exploring optimisation options with detailed technology database. The C_{bio} models estimate the dynamic C_{bio} fixation and release flows of the biomass commodities. A full carbon sequestration cycle was modelled for both, before and after the final harvest. We compared both approaches. The model coupling showed the importance of introducing time in climate change impact assessment. The results with a complete carbon balance differed from fossil-based only, depending on the accounting approach used for C_{bio} modelling. The consideration of technological innovation and market dynamics in a transitioning energy system expands the assessment boundaries providing insights into optimisation and low carbon options driven by policy and decision-making.

Keywords: *C_{bio} model, coupling, carbon accounting, dynamic, partial-equilibrium, time.*

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Code: ICGSI-2018-08-00008

Cost-benefit analysis of bioethanol development in Thailand

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Abstract

This study aims at analyzing the net cost/ benefit to society of bioethanol development in Thailand following bioethanol production targets in the Alternative Energy Development Plan (AEDP). Socio-economic effects of bioethanol development are estimated based on the computable general equilibrium (CGE) model. Environmental effects of bioethanol promotion are incorporated into the model using the information on air emissions of fuel combustion and irrigation water consumption from existing research. The environmental effects are converted into monetary units using the monetary conversion factors for Thailand. The results show that increasing bioethanol production and use can bring about the net benefit to society of around 60 billion Thai Baht (THB) over 2016-2026. Not only does bioethanol promotion enhance real Gross Domestic Product (GDP), but also it helps create more jobs in the society. Besides, bioethanol promotion leads to less air emissions and irrigation water demand per unit of domestic production. The results of this study can support the sustainability analysis of bioethanol production as well as the decision making on biofuel development in Thailand.

Keywords: *bioethanol; computable general equilibrium; cost-benefit analysis; net benefit to society; sustainability*

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Code: ICGSI-2018-08-00051

Competitive use of sugarcane for food, biofuel and biochemical through the environmental and economic benefits

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Abstract

The existing sugarcane biorefinery i.e. sugar-electricity-ethanol is foreseen to be interrupted by the emerging of solar energy (PV) and electric vehicles (EV). This brings about the challenges for the industry to look for the new pathways of sugarcane biorefinery. The study aims to evaluate the environmental and economic performances of the new sugar-electricity-PLA systems compared with the existing sugar-electricity-ethanol system. The results revealed that the new pathways of sugar-PLA can generate the product values to be about 83-209 US$/tonne which it is higher than the existing sugar-electricity-ethanol system. However, this must be traded off with the increased environmental impacts due to the higher energy consumption. The pathway of changing the use of molasses from the ethanol production to the PLA production show the highest eco-efficiency. There still has a high potential for enhancing sugar-electricity-PLA system to the sugarcane industry through the improvement of electricity conversion efficiency from the bagasse.

Keywords: *Sugarcane; Biorefinery; Bioethanol; Poly Lactic acid; LCA; Eco-efficiency.*

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CODE: LCAF-2018-07-00333

Spatial variability in Greenhouse Gas Footprints of Palm Oil Production in Indonesia

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Abstract

This study provides the first estimates of GHG footprints of crude palm oil production at a fine spatial resolution (100m x 100m) and including forest edge effects. Estimates of districts varied by a factor of 10, ranging from 2.1 t CO_2 eq t^{-1} CPO in Hulu Sungai Tengah, Kalimantan Selatan to 22.8 t CO_2 eq t^{-1} CPO in Pontianak, Kalimantan Barat. We highlight the potential value of spatially explicit analysis for understanding the variation in average GHG emissions associated with PO production at a landscape/ jurisdictional level. Opportunities exist to reduce GHG emissions through better landscape management, improving yields and mill operations.

Keywords: *land use change; palm oil; spatial assessment; greenhouse gas footprints*

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Code: ICGSI-2018-08-00034

Ecological footprint of bioethanol from sugarcane sap and molasses in Thailand

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Abstract

Bioethanol is playing a promising role in the renewable energy sector in Thailand. An investigation on alternative feedstocks for producing bioethanol which require a small quantity of total land and water ecosystem is a real challenge. Sugarcane sap from cadmium contaminated areas in Tak province in western Thailand has been used as an alternative feedstock to produce bioethanol. This work is aimed at assessing the ecological footprint (EF) of bioethanol production from sugarcane sap from the contaminated areas together with the molasses from factories in the vicinity of the study area and investigating the EF of bioethanol from molasses. Functional units were defined as global hectare (gha) per hectare (ha)–year for sugarcane cultivation, gha/ tonne molasses, and gha per 1,000 L of bioethanol. Life cycle assessment approach was applied and life cycle inventory data were collected to calculate the EF. EF was evaluated through eight different categories including built up land, crop land, fuel, electricity, chemicals, raw materials, water, and wastewater. The EF of sugarcane cultivation was 9.72 gha/ha–year. The EF of forest was the main EF source and accounted for 95.9% of total EF. The EF of molasses was 1.04 gha/ tonne. The EFs of forest and cropland accounted for 78 and 20%, respectively. Total EF for 1,000 L of bioethanol from sugarcane sap together with molasses was 3.50 gha. The major EF sources were EF of forest (82% of total EF) and cropland (11%). Total EF for 1,000 L of bioethanol from molasses was 4.73 gha. It mostly originated from EF of forest (75%) and cropland (18%). The EF of bioethanol production mainly originated from EFs of the forest for providing the rain and irrigation water in sugarcane, molasses, and firewood acquisition. The EF of bioethanol from sugarcane sap and molasses was lower than that from molasses alone. The minimization of water use in sugarcane cultivation and bioethanol production should be targeted for reducing the EF of bioethanol.

Keywords: *alternative energy; cropland; global hectare*; *greenhouse emissions; water use*.

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Code: LCAF-2018-08-00037

Carbon Footprint Reduction of PET-Bottled Water in Thailand

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Abstract

The study was aimed to explore on the potential options for carbon footprint reduction of PET-bottled water produced by a local manufacturer in Thailand. The carbon footprinting of PET-bottled water was conducted in accordance to the national guideline on carbon footprint of product (TGO, 2015) and carbon footprint reduction (TGO, 2014), including the Product Category Rules (PCR) of beverage (TGO, 2016). The foreground inventory data were collected from a local manufacturer, with the proportion of the PET-bottled water in the market for about 20%, based on the annual production in 2015. The use and disposal phases were referred to the energy use at retailers and the partial recycling of PET bottles after disposal defined in the Product Category Rules of beverage products. The background inventory data (such as, electricity and water production) were gathered primarily from the national databases (TGO, 2016) and supplemented by the international databases (such as, injection molding process, blow molding process, extrusion process) where necessary. The carbon footprint results showed that the raw material production significantly contributed to the life cycle greenhouse gas emissions (58%), followed by the final waste disposal (17%) and use (14%), respectively. In the production process, the packing process generated up to 50% of the GHG emissions (Figure 2b) due to high GHG emissions from the packaging such as bottle (52 %) and lid (3 %) (Figure 2c). In 2015, the packaging was redesigned by reducing the thickness of bottle and lid which effectively reduced the GHG emissions by 13% and 43%, respectively (Figure 2d). Therefore, the carbon footprint was reduced from 2013 by 14% which be able to apply for the carbon footprint reduction label with the requirement of life cycle GHG emission reduction for at least 2%, from the Thailand Greenhouse Gas Management Organisation.

Keywords: *carbon footprint, carbon footprint reduction, life cycle assessment, PET-bottled water, Thailand*

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Code: LCAF-2018-07-00141

Database of food carbon footprints helps Public Sector in Sweden set and reach climate goals

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Abstract

RISE climate database of food contains carbon footprints of 750 food products typically consumed in Sweden. The database is currently used in a number of applications to support meal planning, target setting and follow-up of food purchases in the public food sector in Sweden. The database is developed continuously to improve the data quality. Furthermore, work towards making it publicly available is on-going, so that it can help more stakeholders who want to decrease their climate impact.

Keywords: *Carbon footprint; food, database; assessment tool; climate goal; public meals*

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Code: LCAF-2018-07-00152

Updated carbon footprint values for mineral fertilizer from different world regions

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Abstract

The production of mineral fertilizers, particularly nitrogen, contributes significantly to the carbon footprint of agricultural crops and food products. It is therefore important to use correct emission factors for fertilizer production, which represent current technology and efficiency of manufacturing specific fertilizer grades. The objective of this contribution is to provide life-cycle analysts with up- to-date carbon footprint reference data for the main fertilizer products globally.

At the last LCA Food Conference in 2016 we presented carbon footprint data for mineral fertilizers produced in Europe, Russia, US, and China with the technology baseline 2011. This dataset has now been updated and extended and is based on 2014 technology with global coverage representing ten main fertilizer production regions (Europe, North America, South America, Commonwealth of Independent States/ CIS, Africa, Middle East, South-East Asia, South Asia, China, and Oceania). The carbon footprint values were calculated with Fertilizers Europe's carbon footprint calculator tool (FE CFC). This FE CFC follows general LCA and carbon footprint rules, covers all main sources of greenhouse gases (GHG) emissions and has been reviewed by DNV GL to verify its completeness and correctness. While the European data are largely based on primary data reported by all Fertilizers Europe members for 2014, the data for the other regions are based on an expert evaluation of emissions from ammonia and nitric acid production in 2014.

Between 1990s and 2014, European CO_2e emissions per kg AN-N decreased from 8.69 to 3.42 kg or by about 60%. The reduction for UAN and urea was at 43% and 37%, respectively.

***Keywords**: fertilizer production, product carbon footprint, GHG emissions.*

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POSTER PRESENTATION

SESSION 2-A
SUSTAINABLE RESOURCE USE

Code: ICGSI-2018-10-00013

Environmental Situation of Thailand Evaluated by Thai Ecological Scarcity Method

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Abstract

The Thai Ecological Scarcity method is the life cycle impact assessment (LCIA) method that has been established based on the political distance-to-target approach, following the Swiss eco-factors 2013. The advantage of this LCIA method is that it better reflects the policy context and interests of Thailand, particularly linked with environmental policy implementation. This study uses the Thai Eco Scarcity method for evaluating the national environmental burdens of Thailand, comparing the current situation to the target status based on successful implementation of policy. The environmental interventions were classified into 16 categories such as greenhouse gas emissions, acidifying gas emissions, nutrient enrichment in water, mineral ores, energy resources, solid waste into landfills and so on. The result found the greenhouse gases, energy resources, and ozone depleting substances to be the high contributors due to their rapid increase and being far over the policy targets. It was also seen that environmental impact reduction of 32% could be achieved if all the existing environmental policy targets in Thailand were successfully implemented.

Keywords: *Thai Ecological Scarcity Method; political distance-to-target; national environmental situation.*

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SESSION 2-B
SUSTAINABLE MATERIAL AND CHEMICAL USE

------ NONE ------

SESSION 2 – C

SUSTAINABLE WATER RESOURCE MANAGEMENT

------ NONE ------

SESSION 2-D
SUSTAINABLE ENERGY AND MOBILITY

Code: ICGSI-2018-08-00020

Eco-Efficiency Assessment of Maritime Transport Systems

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Abstract

This study aimed to assess the eco-efficiencies of maritime transport systems, and to determine how various technologies can potentially reduce environmental impacts with economic viability. Four maritime transport scenarios representing the systems in and outside emission control areas with the use of various fuels and exhaust abatement technologies were assessed. End-point life cycle environmental impacts (damage to human health, ecosystem quality, and resource availability) , economic values and eco-efficiencies were compared. Based on the assessment, the shift from the maritime transport system using heavy fuel oil without exhaust abatement technology to the systems using low sulphur marine gas oil and/ or exhaust abatement technologies in the emission control areas possibly increased eco-efficiencies due to the environmental gains throughout the life cycle. Although the fuel and investment costs for the systems in the emission control areas were higher, the environmental benefits potentially outweighed the economic costs. The study could help support sustainable decisions on future emission controls to be adopted by other governments in the areas which are not currently controlled.

Keywords: *Maritime Transport; Emission Control Area; Life Cycle Assessment; Economic Assessment; Eco-Efficiency Assessment.*

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Code: ICGSI-2018-07-00016

Input Life Cycle Thinking to Raise Environmental Awareness and Change Customer Buying Decision on Eco-product by Applying EcoDesign Tools through Classroom Experiments

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Abstract

EcoDesign concepts and Life Cycle Assessment (LCA) based tools are applied with the aim to raise an environment awareness among university students. The Materials, Energy, and Toxicity Matrix (MET Matrix) and the Ten Golden Rules (10 GR) are introduced and applied to work on the in-class exercise about how to redesign eco-friendly instant noodle cooking tools and objects. Pre and post test about " An EcoDesign Product Perception and Behavioural Response" have been spread in order to test the effectiveness of the tools and the change in the buying-decision of an EcoDesign product. Based upon the results, both of the tools can enhance life cycle thinking and broaden knowledge of " EcoDesign" among tool users. MET Matrix encourages awareness in material selection and packaging design, while 10 GR promotes awareness in energy consumption in the production process. This knowledge effect their buying-decision when the price of the EcoDesign product is not exceeded 20% more than the price of a traditional one.

Keywords: *Life Cycle Thinking; EcoDesign Products; EcoDesign Tools*

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Code: ICGSI-2018-03-00090

A Gate-To-Gate Case Study of The Life Cycle Assessment of a Palm Oil Mill Integrated Waste Treatment

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Abstract

The increased production of palm oil has environmental effects, such as emissions of greenhouse gases (GHG). The large amount of GHG emission can threat the palm oil industry sustainability. The newest alternative waste management that might be developed is by utilizing the effluent of POME anaerobic digestion with EFB through integrated anaerobic decomposition process. The aim of this research is to evaluate palm oil mill integrated waste treatment that is reviewed from GHG emission so that can support sustainable of palm oil industry. A gate-to-gate study was carried out whereby the system boundary was set to only include the process of the palm oil mill integrated waste treatment. POME was treated in anaerobic digester with loading rate about 1.65 gCOD/L/day. Treated POME with dosis of 5; 10; 15; and 20 L/day was sprayed to the anaerobic digester that was filled of 25 kg of EFB. The results of research showed that integrated solid-liquid wastes treatment technology could reduce GHG emission about 286,39; 512,74; 636,44; and 466,58 kgCO_2e/ton FFB for dosis of treated POME 5;10; 15; and 20 L/day, respectively.

Keywords: *Palm oil, GHG emission, Life-cycle assessment, A Gate-To-Gate Case Study, palm oil mill integrated waste treatment*

Code: ICGSI-2018-02-00147

Cycle Costing and Environmental Impact Evaluation of Polylactic Acid from Cassava via Polymerization of Lactide Formation Process Natkrtta

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Abstract

The aim of this research is to study and assess the global warming potential (GWP) impact and life cycle costing (LCC) of cassava-based polylactic acid (PLA) via polymerization of lactide formation (PTL process) using the Life Cycle Assessment technique. The LCC was considered based on the costs of production, operating, environmental (externalities), and by products. The production cost was the summation of total capital cost and working capital. The cost of new equipment for different sizes was calculated using the exponential scaling expression. The key environmental burden considered in this work for environmental costs includes CO_2, CH_4, and N_2O. The functional unit was specified as 20,000 t of PLA. The system boundary was from the productions of cassava plantation, starch, sugar and lactic acid, lactide, polylactic acid, and transportation. It was found that the total GWP of PTL process was 4.18×107 kg CO_2 equivalent. Comparing the GWP value during PLA production, the present study showed lower value (0.45 kg CO_2 equivalent per kg PLA) than the GWP from the study of in Vink et al. (2015). The GWP value for 1 kg cassava starch was 0.35 kg CO_2 equivalent. This result agreed with the GWP for the production of 1 kg cassava starch in TGO (2016), who reported the average value of GWP of 0.40 kg CO_2 equivalent. The LCC and annual cost of PTL process were 401×103 million THB. The largest contribution was from operating used and environmental costs which produced over 90% of the total cost. The environmental cost contributed to 13% of the total cost

***Keywords**: cassava, polylactic acid, greenhouse gas emissions, life cycle costing*

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Code: ICGSI-2018-08-00017

Life cycle assessment of alternative energy production from municipal solid waste towards sustainable circular economy in Thailand

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Abstract

Alternative energy production from municipal solid waste could be solutions for the continuous increase in solid waste generation and energy demand. Improper pollution controls in waste treatment could pose environmental and health risks. This study aimed to assess the environmental impacts that occur throughout the life cycle of waste-to-energy systems in comparison with typical waste management systems in Thailand. Six waste management scenarios using various technologies with different efficiencies were assessed. The data were obtained from new and old WtE plants in Phuket, incineration sites with high energy recovery efficiency in China, Thai National life cycle inventory database and Ecoinvent 3 database. The ReCiPe 2016 v1.1 method was applied to assess the damage to human health, ecosystem quality, and resource availability. Based on the assessment, the shift from sanitary landfill and dumping systems to the incineration systems with energy recovery could reduce all damage impacts and should be promoted in national policies. The current incineration technology in Thailand could lead to the overall environmental impact reduction due to the substituted electricity generation from national grid. The main factors for the environmental impact reduction in waste management which could lead to sustainable circular economy in Thailand are high energy recovery efficiency and effective pollution controls.

Keywords: *Waste-to-Energy; Sustainable Energy; Renewable Energy; Municipal Solid Waste Management; Circular Economy.*

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