

Final Project Announcement

This is the final newsletter of the RELIEF project. After almost 4 years of hard work, the PhDs are close to the finish now with excellent progress in their research towards improving the reliability of environmental footprint analyses. Their findings show that a quantitative understanding of sources of variability and uncertainty is important to formulate practical recommendations to reduce environmental footprints. How can consumers effectively reduce their environmental footprint of everyday activities, such as showering and doing the laundry? How can farmers reduce the environmental footprint of crop production? What are the main drivers of variability between biodiversity footprints of nations and how can these be reduced? What sources of uncertainty need to be tackled with high priority to better understand the chemical footprint of consumer products? The RELIEF project not only answers these questions, but also provides tools to deal with the same type of questions for the large portfolio of products and services that are used in our society.



Mark Huijbregts - Project Coordinator



The RELIEF Team, September 2018, Vienna, Austria.



RELIEF in Numbers



Training



As the training manager in RELIEF, I am proud that all ESRs followed the training program with success. With a shared basis including a secondment to Unilever, an in-depth course on life cycle modelling, business awareness and workshop organization, they each followed their own path, getting the most out of it for their own development. The variety of options within the training program were fully utilized: the ESRs took skills courses such as article writing or presenting, as well as topic specific courses such as linear models and ecotoxicology. Some ESRs also went on secondments to partner institutions like Østfold research and Stanford university. It has been a great journey and I am happy to have seen each of them grow over the years.

Rosalie van Zelm
Training Manager

Project coordinator Mark Huijbregts teaching in the Radboud summer school "advances in life cycle assessment modeling", August 2018



RELIEF EXPERIENCES



ESRs' Experiences Within the RELIEF Project



The RELIEF project was an exciting experience in which I learned how universities and industries can collaborate to perform applied research~ Sadegh Shahmohammadi

I have learned how science is capable of informing the business to make sustainable decisions. ~ Valerio Barbarossa



In the past three years, I have been working at a university, a large company, and a non-profit research organization. It has been very rewarding and interesting to experience which aspects of their work motivate people in these different environments.” ~ Mélanie Douziech

The RELIEF PhD provided us with the opportunity to learn from world class researchers in the field of LCA and sustainability as well as to work with reputable researchers in a business which is renowned for their game-changing application of sustainable innovations in business. I can say that I have learnt a lot! ~ Wan Yee Lam



The RELIEF project created a space for fruitful collaboration - bringing together people from different scientific disciplines to generate results that are relevant in both a scientific and business decision-making context. ~ Sandra Marquardt

We organized a session on “Quantifying the uncertainty and variability of footprints and implications for policymaking” at the SETAC LCA Case Study Symposium in Vienna

The aim of the session held on the 26th of September within the SETAC Life Cycle Assessment (LCA) Case Study symposium in Vienna was to bring together speakers from the industrial and academic sectors to discuss uncertainty and variability in environmental footprint analyses.



Sadegh presenting his findings on the drivers of the variability in showering habits



Valerio pitching his poster on the climate change impacts on freshwater species

Common findings across the presentations were that

- Variability between regions and the choice of the impact assessment method both influence the range of the computed impact assessment results greatly.
- Uncertainty can arise from different data gathering techniques, even when expert judgment is asked.
- A reduction in sampling uncertainty can increase the reliability of ecotoxicological impact metrics.
- Ex-ante LCAs require to consider even more uncertainty sources.

This series of talks highlighted the importance of accounting for the uncertainty and variability when conducting LCAs of products or activities. It further showed that LCA results can vary greatly depending on the assumptions made.



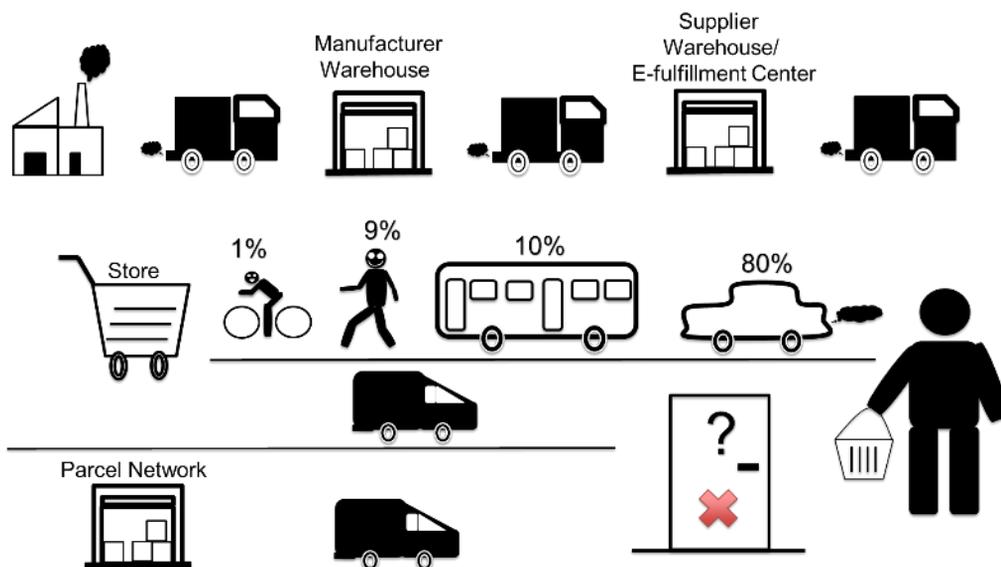
Wan Yee explaining the objectives of her study on the variability in greenhouse gas footprints of crops



Mélanie describing the method followed to quantify the potential ecotoxicological impact of chemicals

Stochastic comparison of the environmental footprints of online versus traditional retailing

A number of studies have deterministically compared the environmental impacts of different retailing channels. However, their conclusions are sometimes contradicting. While some of these studies claim that e-commerce has environmental benefits over traditional retailing, other studies argue that e-commerce could have a higher environmental impact. In my 3rd paper, we would like to have a better understanding of the environmental footprints of retailing. We are using a large number of datasets to probabilistically compare the GHG emissions of different retailing channels associated with Fast Moving Consumer Goods (FMCGs) in different countries.



The figures presents 3 different retailing channels: Bricks & Mortar, Bricks & Clicks and Pure Players

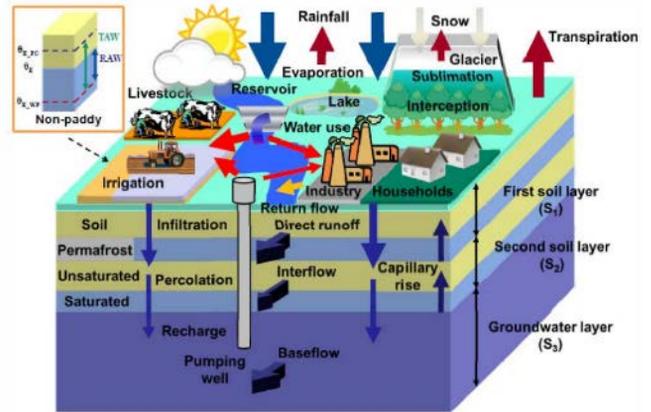
Sustainability by Design: A Case Study of the Ice Cream Cabinets

In our previous studies, we investigated the variability in the environmental footprints associated with consumer behavior. In my 4th paper, we focus on the variability in the GHG emissions of ice-cream cabinets and we investigate how a company could reduce its greenhouse gas footprints associated with storage of frozen products. We design and perform an experiment to investigate how the variability in cabinet temperature, ambient temperature and cabinet size influences the energy use of ice cream cabinets.

Towards a Global-Scale Framework to Quantify Freshwater Biodiversity Footprints of Consumer Products

Climate change impacts on the world's freshwater fish species

Currently, we are working on assessing climate change impacts on ~5,000 freshwater fish species worldwide distributed. We use water availability and temperature as proxy variables for the natural habitat of the species. By employing the process-based hydrological model PCR-GLOBWB, we are able to project future changes in water flow and temperature. We are currently finishing to analyze the impacts stemming from the adoption of different representative concentration pathways scenarios and global climate models combinations.



Schematic representation of the process-based hydrological model PCR-GLOBWB (version 2.0) used for future projections of water availability and temperature

Special Session at the International Conference Water Science for Impact

Valerio organized and co-chaired with Aafke Schipper the session titled "Impacts of global environmental change on freshwater biodiversity." The session was a success, and saw a number of speakers from different expertise background illustrating the many challenges involved in modelling impacts on freshwater ecosystems as well as the variety of possible approaches to tackle them.

Impacts of current and future dams on fish species worldwide

Habitat fragmentation due to damming of waterways, is another key stressor impacting the health and distribution of freshwater ecosystems. In this study, we look at how the habitat connectivity of fish species occurring in watersheds worldwide, is affected by damming. We will not only look at current, but also at future dams that are either under

construction or planned, to highlight species of future concern and hotspots in watersheds worldwide.

Secondment at Stanford University

Valerio ended his secondment at Stanford University. He worked side-by-side with scientists from the Natural Capital project on modelling the impacts of dams-driven fragmentation on the world's fish species.

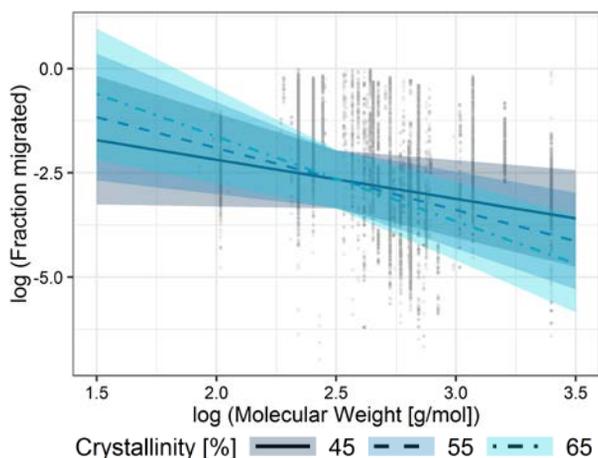
Secondment at Østfold research

After my stay at Unilever, I spent 2.5 months at Østfold research in Fredrikstad, Norway. We collaborated with Cecilia Askham, senior researcher at Østfold research, to develop a model of the migration of chemicals from plastic packaging into food. Given Østfold research's collaborations, I met with experts



lønningspils in the Oslo office of Østfold research

of Norner, a polymer manufacturing company. Using their advice, we developed a linear mixed-effects model using parameters of the chemical, packaging, and food as well as the temperature and duration of contact. This model overcomes the limitations of the currently available deterministic models, namely the limited applicability domain and rather low predictive power.



Dependency of the fraction migrated to the chemical's molecular weight and packaging's crystallinity

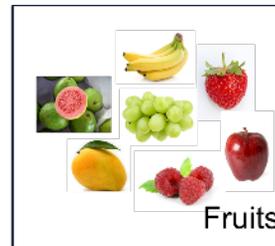
Overall, my stay at Østfold research gave me valuable insights into the ways of working of a non-profit research institute. The kindness of Cecilia and the collaborators at Østfold research made me feel very welcome. This project was further a collaboration with Alexi Ernstoff from Quantis, an environmental sustainability consulting group, who provided the database of migration experiment results we used for the model fitting. She also gave very useful feedback on the parameter choice and framing of the study.

Final steps

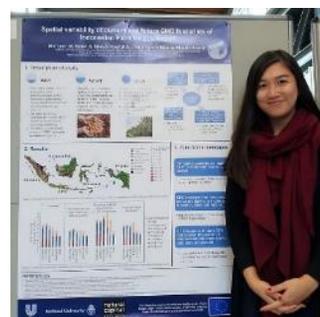
Our research so far showed that the small number of species is the main source of uncertainty in the ecotoxicological assessment of chemicals. I am therefore now increasing the toxicity dataset by using interspecies correlation estimation equations (ICEs) to determine effects of more species. ICEs estimate the ecotoxicity of a species to a chemical from the known ecotoxicity of another species to the same chemical. We use estimated ecotoxicity values for fish, daphnia, and algae as starting points. We will apply this approach to a large set of chemicals with experimental data to assess the reduction in uncertainty and quantify the potential bias resulting from the use of estimated values only. This method will contribute to increase the reliability of ecotoxicological impact assessments.

Improving the reliability of greenhouse gas footprints of agro-based products

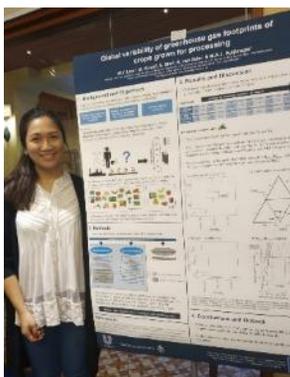
- Since the last newsletter, Wan Yee has moved on from working on the paper 'High resolution spatial analysis reveals large variability in greenhouse gas (GHG) footprints of palm oil' to working on understanding the drivers of variability of GHG footprints of global crop production for 26 crops. This was done using a global dataset of 4470 observations covering the years 2013-2016 and spanning 22 countries.



- Wan Yee presented both pieces of work at conferences: the SETAC LCA Case Study Symposium in Vienna and the LCA Food Conference in Bangkok. In Bangkok, she won a communication award for presentation 'High resolution spatial analysis reveals large variability in greenhouse gas (GHG) footprints of palm oil'.



SETAC LCA Case Study Symposium, Vienna



LCA Food Conference, Bangkok



Terrestrial biodiversity footprints

Assessing different futures – for my second paper, we are investigating the biodiversity impacts of different forward looking scenarios. These scenarios are linked to global targets as defined in the Sustainable Development Goals and established international projections, such as the Shared Socio-economic Pathways. Analyzing such targets and scenarios through the biodiversity lens can help support moving towards formulating development strategies that align people, planet and profit.



Source: "Triple bottom line & sustainability: the science of good business" published by Sustainability Illustrated (April 8, 2014) [retrieved September 14, 2018]
<https://www.youtube.com/watch?v=2f5m-jBf81Q>

Bridging the gap – A key concern moving forward will be to translate our macro-scale insights into relevant information for strategic decision-making. In this context, we will explore the feasibility of using hybrid LCA – a methodology linking macro-scale multi-regional input-output model components with LCA. This work will be done in collaboration with our project partners at NTNU including an additional secondment in Norway.



Publications Until 15 Dec 2018

- **FLO1K, global maps of mean, maximum and minimum annual streamflow at 1 km resolution from 1960 through 2015**

Barbarossa V, Huijbregts M.A.J, Beusen A.H.W., Beck H.E., King H., Schipper A.M. (2018), *Scientific Data*

- **Tracking current and forecasting future land-use impacts of agricultural value chains. 67th Discussion Forum on Life Cycle Assessment, 3rd of November 2017, Zurich, Switzerland.**

Kulak M., Sim S., King H., Lam W.Y., Marquardt S., Huijbregts M.A.J. (2018), *International Journal of Life Cycle Assessment*.

- **Quantifying variability in removal efficiencies of chemicals in activated sludge wastewater treatment plants – a meta-analytical approach**

Douziech M., Conesa I.R., Benítez-López A., Franco A., Huijbregts M., van Zelm R. (2018), *Environmental Science Processes and Impacts*.

- **Quantifying drivers of variability in life cycle greenhouse gas emissions of consumer products—a case study on laundry washing in Europe**

Shahmohammadi S., Steinmann Z., Clavreul J., Hendrickx H., King H., Huijbregts M.A.J. (2017), *International Journal of Life Cycle Assessment*.

- **Variability of greenhouse gas footprints of field tomatoes grown for processing: inter-year and inter-country assessment**

Lam W.Y., Van Zelm R., Benítez-López A., Kulak M., Sim S., King J.M.H. & Huijbregts M.A.J. (2017), *Environmental Science and Technology*.

- **Estimation of chemical emissions from down-the-drain consumer products using consumer survey data at a country and wastewater treatment plant level**

Douziech M., Van Zelm R., Oldenkamp R., Franco A., Hendriks A.J., King H. & Huijbregts M.A.J. (2018), *Chemosphere*.

- **Developing and testing a global-scale regression model to quantify mean annual streamflow**

Barbarossa V., Huijbregts M. A., Hendriks A. J., Beusen A. H., Clavreul J., King H. & Schipper A. M. (2017), *Journal of Hydrology*.

PRESENTATIONS



Presentations Until 15 Dec 2018

LCA Food 2018, Bangkok, Thailand, October 17-19, 2018

- Global variability of Greenhouse Gas Footprints of Crops Grown for Processing: Intercrop, Interyear and Intercountry Assessment – Lam WY.
- Spatial variability in Greenhouse Gas Footprints of Palm Oil Production in Indonesia- Lam WY

International Conference Water Science for Impact, Wageningen, The Netherlands, 16-18 October 2018

- Impacts of climate change on the world's freshwater fish species- Barbarossa V.

SETAC Europe 24th LCA Symposium, Vienna, Austria, 24-26 September 2018

- Incorporating climate change impacts on local freshwater fish species richness in LCIA- Barbarossa V.
- Spatial variability of current and future GHG footprints of Indonesian Palm Oil production- Lam WY.
- Global variability of Greenhouse Gas Footprints of Crops Grown for Processing: Intercrop, Interyear and Intercountry Assessment- Lam WY.
- The influence of species number on the reliability of relative ecotoxicological impact assessments of shampoo- Douziech M.
- Consumer Behaviour and the Environmental Footprints of Showering- Shahmohammadi, S.

SETAC 2018, Rome, Italy, May 14-18, 2018

- Drivers of variability and uncertainty in the chemical footprint of shampoos- Douziech M.
- The Influence of Consumer Behaviour on the Greenhouse Gas and Water Footprints of Showering- Shahmohammadi S.



PRESENTATIONS



Presentations Until 15 Dec 2018- Continued

67th LCA Discussion Forum, Zurich, Switzerland, November 3, 2017

- Variability of Greenhouse Gas Footprints of Crude Palm Oil production in Indonesia- WY Lam.

20th Annual Conference on Global Economic Analysis, West Lafayette, USA, June 6-9, 2017

- Terrestrial Biodiversity Footprints of Nations – A Multi-Regional Input-Output Model to Trace Biodiversity Impacts Along Global Supply Chains- Marquardt S.

SETAC 2017, Brussels, Belgium, May 8-11, 2017

- The influence of spatial and technological parameters on the removal efficiencies of surfactants and fragrances in activated sludge wastewater treatment- Douziech M.

European Geoscience Union General Assembly 2017, Vienna, Austria, Apr 23-28, 2017

- Global-scale high-resolution (~1 km) modelling of mean, maximum and minimum annual streamflow - Barbarossa V.

Natural Capital Symposium 2017, Stanford, United States, Mar 20-23, 2017

- Variability and Uncertainty of Biogenic Greenhouse Gas Emissions of Palm Oil production-Lam WY.

LCA Food 2016, Dublin, Ireland, October 19-21, 2016

- Developing Statistical Models for estimating Greenhouse Gas Footprints of Field Tomato Production- Lam WY.



PRESENTATIONS



Presentations Until 15 Dec 2018- Continued

ISES Meeting in Utrecht, the Netherlands, October 10-13 2016

From consumer use surveys of personal care products to chemical emission estimates at wastewater treatment plant level- Douziech M.

SETAC Case Study Symposium, Montpellier, France, Sept 20-22, 2016

- Quantification of Variability in the Life Cycle Greenhouse Gas Footprint of Laundry in Europe- Shahmohammadi S.

SETAC Europe 26th Annual Meeting in Nantes, France, May 22-26, 2016

- Estimates of chemical emissions resulting from the use of personal care products- Douziech M.
- Developing a Data-Driven Model to Quantify Farm-Specific Greenhouse Gas Emissions for Open-Field Tomato Production on a Global Scale- Lam WY.

The ESRs will continue and future work can be found on the REIEF website:

<https://relief-project.eu/>

