



Universiteit
Leiden
The Netherlands

Deepening the uncertainty dimension of environmental Life Cycle Assessment: addressing choice, future and interpretation uncertainties.
Mendoza Beltran, M.A.

Citation

Mendoza Beltran, M. A. (2018, October 9). *Deepening the uncertainty dimension of environmental Life Cycle Assessment: addressing choice, future and interpretation uncertainties*. Retrieved from <https://hdl.handle.net/1887/66115>

Version: Not Applicable (or Unknown)

License: [Licence agreement concerning inclusion of doctoral thesis in the Institutional Repository of the University of Leiden](#)

Downloaded from: <https://hdl.handle.net/1887/66115>

Note: To cite this publication please use the final published version (if applicable).

Cover Page



Universiteit Leiden



The handle <http://hdl.handle.net/1887/66115> holds various files of this Leiden University dissertation.

Author: Mendoza Beltran M.A.

Title: Deepening the uncertainty dimension of environmental Life Cycle Assessment: addressing choice, future and interpretation uncertainties.

Issue Date: 2018-10-09

Acknowledgements

Four years researching the topic of uncertainty have taught me that it is hard to be sure about anything, but a sure fact is that these past years would have not been possible without the unconditional support and presence of many people to whom I here dedicate some deserved words.

I would like to start by thanking four scientist whose endless commitment to science inspired me throughout these years. Jeroen, without your guidance and dedication this achievement could have not been possible. Thanks for bringing the light back in the dark moments and for teaching me that the answer is hardly ever “42”. Arnold, thanks for masterly running the stage from behind the scenes and for making me aware of “the other sides of uncertainty”. I believe they deserve more than a word and I wish I could have dedicated more space to them. Detlef, more than a promotor you are a mentor. Thanks for about 10 years of lessons and for the infinite scientific inspiration. Although I am sure we will meet again, “so long and thanks for all the fish”. Reinout, it was a true honour having you as a probability teacher. Thanks for making the complex and abstract, so tangible and simple. I really enjoyed our discussion about how god is a mathematician.

My stay in CML started earlier during my master’s degree. Back then, I had the pleasure of studying with teachers who not only inspired me during this degree but who also inspired my career further. Ruben, without you this PhD probably would had never happened. Thanks for helping me figure out that this was the path to pursue and for encouraging me to always think outside of the box. Ester, Rene, Arjan, Luran, I cannot be grateful enough with you for being part of the minds consolidating the field of Industrial Ecology. Thanks for your relentless persistence and for planting the seed of curiosity in me.

At CML I also had the pleasure of working together with talented researchers who inspired every day at work. Patrik, you deserve special thanks for IDREEM and for teaching me the meaning of “fingerling” among other concepts. Benjamin, Coen, Laura B., Jeroen A., Guanchao, Mingming, Valentina, Alexandra, Stefano and Krijn, no words can express how many memories I take with me but most of all I thank you all for sharing your passion for science with me. Sebastiaan, my roomie, my friend. No words can express the admiration I have for you and for your work. Thanks for many years of friendship and for always motivating me to go beyond. In my last years at CML many “young pros” came to CML and despite it being a relatively short time that I shared with some of them, I take lots of memories shared with them too: Bernhard, Nabeel, Bertram, Cherry, Leon, Anne, Yingjii, Georgios, Carlos S., Glenn, Amy, Efe, Yujia, Mili, Ellen, Daniel, Henrik, Carlos B., Chimere, Franco, Rita, Yelitz, Alexander, Elizabeth, Giovanni M., Subodh, Marinda, Giulia and Laura S, thanks for the good times. Life in the Netherlands was much better thanks to the support and unconditional friendly

smile of four wonderful ladies, Suus, Esther, Joyce and Jori. Thanks so much for making the harsh Dutch weather easier to bare. To other CML academic and administrative staff among which Jan, Martina, Peter, Maarten, Rianne, Els, Jasper, Paul and the many more that I might be forgetting, thanks for a wonderful time and for being part of a great place to be.

I would also like to dedicate some words to the members of the IDREEM project with whom I shared four years and endless memories in the strive to implement integrated multi-trophic aquaculture in Europe. Specially Chiara, Danilo, Richard, Joao, Dror, Dafna, Oded, Johan, Celine, Demetris, Alexis and Adam, thanks for IDREEM and for teaching me so much about fish. Shreya, I did not forget you. Thanks for your support with data gathering in IDREEM and for flying all the way from the US for this experience.

This chapter would not be complete without thanking all the people that are indirectly part of this achievement. To my “PBL family” Jasper, Andries, Marc, Rineke, Oreane and Maarten: Ik hoop dat het leven zal ons nog een keer samen brengen. Ik probert nog steeds met mijn Nederlands... het is nooit te laat. Bedankt voor het delen van mijn eerste stapjes in onderzoek en heel veel meer.

I also want to thank my Unilever colleagues, specially Sarah and Henry, for their patience and emotional support during the last phase of this thesis.

To my family abroad Carmen E., Bas, Carina, Nic, Pili, Paul, Lia, Juliette, Fanny, Jamal, Sophia, Jorge, Julia, Maurice, Jeanette, Andrea, Justin, Elena, Aya, Kath, Dalia, Rafa, Lara, Elias, Tjerk, around 12 years of friendship with you are also part of this thesis. To my recently “officially acquired” family Ana, Miquel, Sergi, Isa and Nora, thank you for the good times and emotional support. Mona and Mafe, thanks for a life together and for pushing me to finish. To many other family members in Colombia, whose names I cannot list here as it would take many pages, thanks for always being there.

This thesis is dedicated to the two women of my life, my mother Clemencia and my grandmother Isabel. Mami, you are the personification of determination, courage, perseverance and infinite love. Without your example I would have never pursued a science career. Abue, you are the example of ceaseless action and will to learn. Thanks for showing me that there is always something to learn and that “If you search you will find”. Beyond the two women of my life I want to dedicate this thesis to women in science. Their endeavour to make science accessible to women, made it possible for girls, like me, to pursue a career in science. Hopefully we will be more in the future.

Finally, the universe would not be complete without the three men of my life. To my dad Cesar, I am infinitely thankful for sparking the love for nature. In the end I kind of followed your example, I am an accountant!... of the environment. To my brother Cesar, I am grateful to life for making you my big brother. I want to thank you for your nihilist, anarchist views because they are a source of inspiration to me (you did

not see that one coming). What would be of a scientist without the capacity of being critical? Last but not least, David. You literally made the last point of this thesis possible, so I want to finish it with your name. I think we have become poetry together, like that of Bécquer: “What is poetry? you ask, while fixing your blue pupil on mine. What is poetry! And you are asking me? Poetry...is you”. I can't wait for the new adventures to begin! Simply thank you for all, David.

Curriculum Vitae

María Angélica Mendoza Beltrán was born the 26th July 1983 in Bogotá D.C., Colombia. She completed her high school studies at Gimnasio Iragua in Bogota where she also earned the degree of International Baccalaureate in Chemistry, Biology and English in 2000. Between 2001 and 2006 she finalized her studies in Environmental Engineering at University of Los Andes in Bogota. Afterwards she travelled to the Netherlands and earned an MSc degree in Industrial Ecology at Leiden University in 2008. She then worked at the PBL - Netherlands Environmental Assessment Agency, as a junior policy researcher between 2008 and 2012. She worked in topics like reductions of emissions from deforestation and forest degradation (REDD+), international climate policy, climate change scenarios and production-consumption systems analysis. She participated in international modeling exercises such as the Energy Modeling Forum (EMF) and the Representative Concentration Pathways (RCPs) part of the climate scenarios of the Intergovernmental Panel on Climate Change (IPCC) fifth Assessment Report (AR5). In 2013, she became affiliated to the Institute of Environmental Sciences (CML) of Leiden University in The Netherlands, as a leading researcher of the work package on environmental sustainability in the EU FP7 project Increasing Industrial Resource Efficiency in European Mariculture (IDREEM). She worked in collaboration with aquaculture SMEs and research institutes. Between 2014 and 2018 she wrote her PhD thesis on uncertainty in Life Cycle Assessment at CML in Leiden University. Since the end of 2017 and up to present, she has been working at Unilever in the United Kingdom as a sustainability scientist.

Publications

Publications in peer-reviewed journals

- 1 Cox, B., C.L. Mutel, C. Bauer, A. Mendoza Beltran, and D.P. van Vuuren. **2018**. Uncertain Environmental Footprint of Current and Future Battery Electric Vehicles. *Environmental Science & Technology* Accepted: acs.est.8b00261. <http://pubs.acs.org/doi/10.1021/acs.est.8b00261>.
- 2 Mendoza Beltran, A., V. Prado, D. Font Vivanco, P.J.G. Henriksson, J.B. Guinée, and R. Heijungs. **2018**. Quantified Uncertainties in Comparative Life Cycle Assessment: What Can Be Concluded? *Environmental Science & Technology* 52(4): 2152–2161. <http://pubs.acs.org/doi/10.1021/acs.est.7b06365>.
- 3 Mendoza Beltran, A., Mutel, C., Cox, B., van Vuuren, D., Font Vivanco, D., Deetman S., Edelenbosch O. Y., Guinée, J. and Tukker, A. When the background matters: Using scenarios from Integrated Assessment Models in Prospective LCA. **Submitted** to *The Journal of Industrial Ecology*.
- 4 Mendoza Beltran, A., M. Chiantore, D. Pecorino, R.A. Corner, J.G. Ferreira, R. Cò, L. Fanciulli, and J.B. Guinée. **2017**. Accounting for inventory data and methodological choice uncertainty in a comparative life cycle assessment: the case of integrated multi-trophic aquaculture in an offshore Mediterranean enterprise. *The International Journal of Life Cycle Assessment*. <http://link.springer.com/10.1007/s11367-017-1363-2>.
- 5 Hof, A.F., den Elzen, M.G.J. and Mendoza Beltran, A. **2016**. The EU 40 % greenhouse gas emission reduction target by 2030 in perspective. *Int Environ Agreements*. DOI 10.1007/s10784016-9317-x
- 6 Villares, M., Isildar, A., Mendoza Beltran, A. and Guinée J. **2016**. Applying an ex-ante life cycle perspective to metal recovery from e-waste using bioleaching. *Journal of Cleaner Production*. Vol 129:315–328. <http://dx.doi.org/10.1016/j.jclepro.2016.04.066>
- 7 Mendoza Beltran, A., Heijungs, R., Guinée, J. and Tukker, A. **2015**. A pseudo-statistical approach to treat choice uncertainty: the example of partitioning allocation methods. *The International Journal of Life Cycle Assessment*. DOI 10.1007/s11367-015-0994-4
- 8 Overmars, K.P., Stehfest, E., Tabeau, A., van Meijl, H., Mendoza Beltran, A. and Kram, T. **2014**. Estimating the opportunity costs of reducing carbon dioxide emissions via avoided deforestation, using integrated assessment modelling. *Land Use Policy*. Vol41: 45–60.
- 9 Vliet van, J., Hof, A.F., Mendoza Beltran, A., Berg van den, M., Deetman, S., den Elzen, M.G.J, Lucas, P.L. and Vuuren van, Detlef. **2014**. The impact of technology availability on the timing and costs of emission reductions for achieving long-term climate targets. *Climatic Change*. Vol 123:559–569 DOI 10.1007/s10584-013-0961-7.
- 10 den Elzen, M.G.J., Mendoza Beltran, A., Hof, A., van Ruijven, B. and van vliet, J. **2013**. Reduction targets and abatement costs of developing countries resulting from global and developed countries' reduction targets by 2050. *Mitigation and Adaptation Strategies for Global Change*. Vol 18:491–512

- 11 Chuwah, C., van Noije, T., van Vuuren, D., Hazeleger, W., Strunk, A., Deetman, S., Mendoza Beltran, A. and van Vliet, J. **2012**. Implications of alternative assumptions regarding future air pollution control in scenarios similar to the Representative Concentration Pathways. *Atmospheric Environment*. Vol 79, 787-801. <http://dx.doi.org/10.1016/j.atmosenv.2013.07.008>
- 12 van Ruijven, B.J., van Vuuren, D., Van Vliet, J., Mendoza Beltran, A., Deetman, S. and den Elzen, M.G.J. **2012**. Implications of greenhouse gas emission mitigation scenarios for the main Asian regions. *Energy Economics*. Vol 34: S459–S469. doi:10.1016/j.eneco.2012.03.013.
- 13 Van Vliet, J., van den Berg, M., Schaeffer, M., van Vuuren, D., den Elzen, M.G.J, Hof, A.F, Mendoza Beltran, A. and Meinshausen, M. **2012**. Copenhagen Accord Pledges imply higher costs for staying below 2°C warming. A letter. *Climatic Change*. Vol 113:551–561 DOI 10.1007/s10584-012-0458-9.
- 14 Wardenar, T., van Ruijven, T., Mendoza Beltran, A., Vad, K., Guinée, J., and Heijungs,R. **2012**. Differences between LCA for analysis and LCA for policy: a case study on the consequences of allocation choices in bio-energy policies. *The International Journal of Life Cycle Assessment*. Volume 17, Number 8, Pages 1059-1067.
- 15 Van Vuuren D.P, Stehfest E., den Elzen M.G.J, Kram T., van Vliet J., Deetman S., Isaac M., Klein Goldewijk K., Hof A., Mendoza Beltran A., Oostenrijk R. and van Ruijven B. **2011**. RCP 2.6: exploring the possibility to keep global mean temperature increase below 2°C. *Climatic Change*. Volume 109, Numbers 1-2, 95-116.
- 16 Mendoza Beltran, A.; den Elzen, M.G.J.; Hof, A. F.; van Vuuren, D.P.; van vliet, J. **2011**. Exploring the bargaining space within international climate negotiations based on political, economic and environmental considerations. *Journal of Energy Policy*. Volume 39, Issue 11, Pages 7361-7371
- 17 Hof, A.F, den Elzen, M.G.J., Mendoza Beltran, A. **2011**. Predictability, equitability and adequacy of post-2012 international climate financing proposals. *Environmental Science and Policy*. Vol 14 (6). Pp. 615-627.
- 18 Den Elzen, M.G.J., Hof, A.F, Mendoza Beltran, A., Grassi, G., Roelfsema, M., van Ruijven, B., van Vliet, J., van Vuuren, D.P. **2011**. The Copenhagen Accord: Abatement costs and carbon prices resulting from the submissions. *Environmental Science and Policy*, 14 (1), pp. 28-39.
- 19 Boons, F. and Mendoza, A. **2010**. Constructing sustainable palm oil: how actors define sustainability. *Journal of Cleaner Production*. Vol 18. pp. 1686 – 1695.

Other Publications

- 20 Mendoza Beltran, M.A., F. Pomponi, J.B. Guinée, and R. Heijungs. **2018**. Uncertainty Analysis in Embodied Carbon Assessments: What Are the Implications of Its Omission? In: *Embodied Carbon in Buildings Measurement, Management and Mitigation*, ed. by F Pomponi, C De Wolf, and A Moncaster, 3–21. Springer.
- 21 Hughes, A, Corner, R.A, Cocchi, M., Alexander K.A., Freeman S., Dror A., Chiatore M., Gunning D., Maguire J., Mendoza Beltran A., Guinée J., Ferreira J., Ferreira R. and Rebours C. **2016**. *Beyond Fish Monoculture: Developing Integrated Multi-trophic Aquaculture in Europe*. ISBN 9788889407400. Italy. Available at: http://www.idreem.eu/cms/wp-content/uploads/2016/09/IDREEM_FINALREPORT_2109.pdf

- 22 Arild Angelsen, Caroline Wang Gierløff, Angelica Mendoza Beltrán and Michel den Elzen. **2014**. REDD credits in a global carbon market: options and impact. Nordic Council of Ministers. TemaNord 2014:541.
- 23 Mendoza Beltran, A. and Guinée, J. Goal and Scope Definition for Life Cycle Assessment of Integrated Multi-Trophic Marine Aquaculture Systems. Conference article. LCA Food **2014**. San Francisco. USA.

Presentations

LCA Food 2014, San Francisco, USA.

- A probabilistic approach to deal with uncertainty due to the methodological choices in LCA.

Aquaculture Europe 14, San Sebastian, Spain.

- Benchmarking life cycle environmental impacts of Integrated Multi-Trophic Aquaculture (IMTA) production: where is the I?

International Society of Industrial Ecology Americas Chapter, Bogota D.C., Colombia.

- Benchmarking environmental impacts of Integrated Multi-Trophic Aquaculture (IMTA) production: accounting for inventory and choice uncertainty in a comparative decision context
- Analyzing the life cycle environmental impacts of Integrated Multi-Trophic Aquaculture using a pseudo-statistical approach to treat choice uncertainty