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## **Narrowing Variability by Global Sensitivity Analysis: Case Study of Swiss Household Consumption**

Conclusion: GSA of complete background inventories provides support for prioritized data collection and narrowing uncertainty range of impact results.

April 21, 2021 :: 77th LCA Discussion Forum

# Swiss household food consumption

Functional unit

food & non-alcoholic beverages [Froemelt et al., 2018]

Impact assessment method

IPCC 2013, climate change, GWP100a





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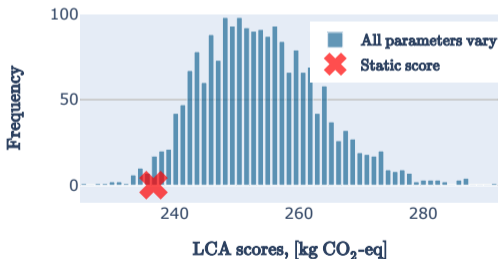
Impact assessment method

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Static LCIA score

237 kg CO<sub>2</sub>-eq

per month & per average Swiss household



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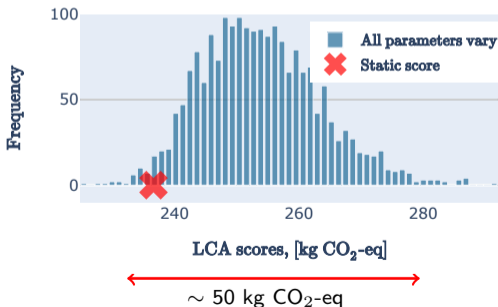
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$$\begin{array}{ccccccccc}
 \text{impacts} & \left[ \begin{array}{c} \phantom{[} \\ \phantom{]} \end{array} \right] & = & \text{impact} & \left[ \begin{array}{c} \text{env. flows} \\ \phantom{[} \\ \phantom{]} \end{array} \right] & \times & \text{env. flows} & \left[ \begin{array}{c} \text{activities} \\ \phantom{[} \\ \phantom{]} \end{array} \right] & \times & \text{products} & \left[ \begin{array}{c} \text{activities} \\ \phantom{[} \\ \phantom{]} \end{array} \right]^{-1} & \times & \text{products} & \left[ \begin{array}{c} \phantom{[} \\ \phantom{]} \end{array} \right] \\
 \text{SCORES} & & & \text{CHARACTERIZATION} & & & \text{BIOSPHERE} & & & \text{TECHNOSPHERE} & & & \text{DEMAND}
 \end{array}$$



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 \begin{array}{c} \text{impacts} \\ \left[ \begin{array}{c} \\ \end{array} \right] \\ \text{SCORES} \\ \underbrace{\hspace{2cm}} \\ \text{model output} \end{array} & = & \begin{array}{c} \text{impact} \\ \text{categories} \\ \left[ \begin{array}{c} \text{env. flows} \\ \end{array} \right] \\ \text{CHARACTERIZATION} \end{array} \times & \begin{array}{c} \text{env. flows} \\ \left[ \begin{array}{c} \text{activities} \\ \end{array} \right] \\ \text{BIOSPHERE} \end{array} \times & \begin{array}{c} \text{products} \\ \left[ \begin{array}{c} \text{activities} \\ \end{array} \right]^{-1} \\ \underbrace{\hspace{2cm}} \\ \text{model inputs / parameters} \end{array} \times & \begin{array}{c} \text{products} \\ \left[ \begin{array}{c} \\ \end{array} \right] \\ \text{DEMAND} \end{array}
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$$\begin{array}{ccccccc}
 \text{impacts} \begin{bmatrix} \phantom{0} \\ \phantom{0} \end{bmatrix} & = & \text{impact categories} \begin{bmatrix} \text{env. flows} \\ \phantom{0} \end{bmatrix} & \times & \text{env. flows} \begin{bmatrix} \text{activities} \\ \phantom{0} \end{bmatrix} & \times & \text{products} \begin{bmatrix} \text{activities} \\ \phantom{0} \end{bmatrix}^{-1} & \times & \text{products} \begin{bmatrix} \phantom{0} \\ \phantom{0} \end{bmatrix} \\
 \text{SCORES} & & \text{CHARACTERIZATION} & & \text{BIOSPHERE} & & \text{TECHNOSPHERE} & & \text{DEMAND} \\
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- Objective:
1. identify parameters in the **background databases** that contribute the most to the variability of LCA results
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  3. case study of Swiss food consumption

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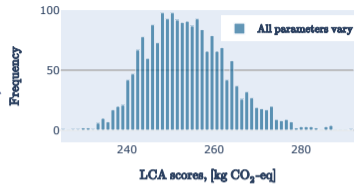
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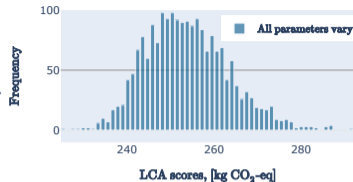
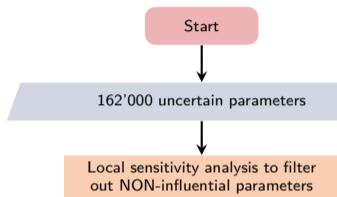
# GSA methodology

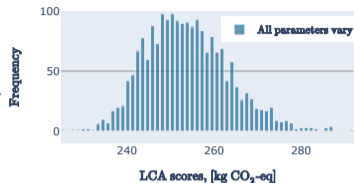
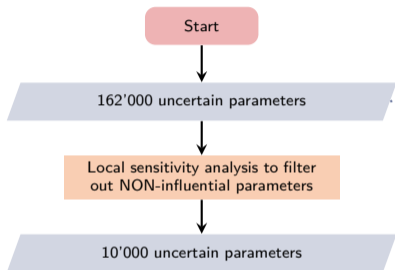
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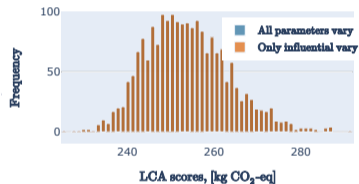
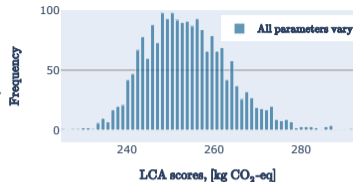
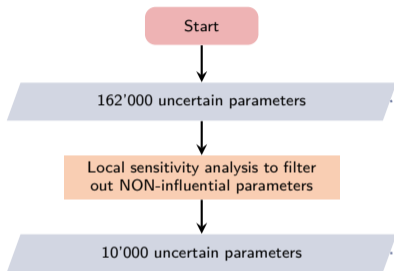
162'000 uncertain parameters

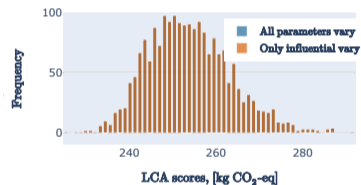
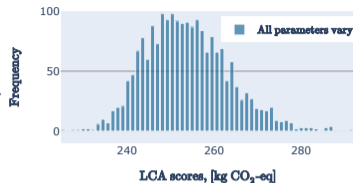
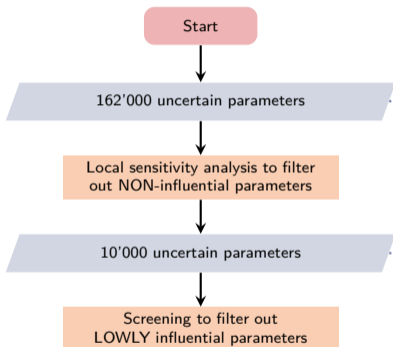


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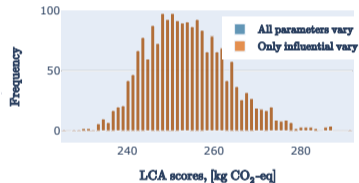
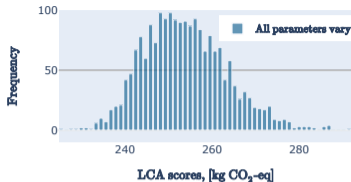
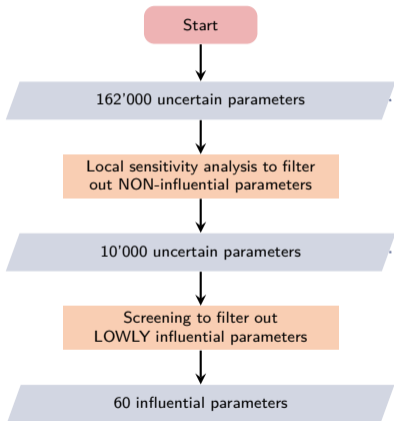


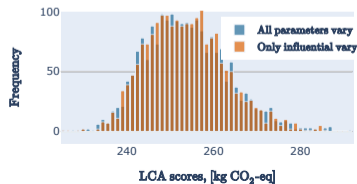
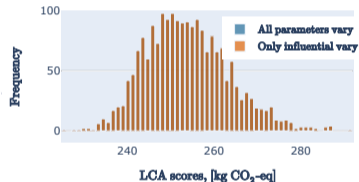
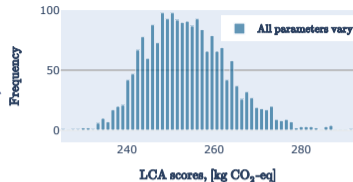
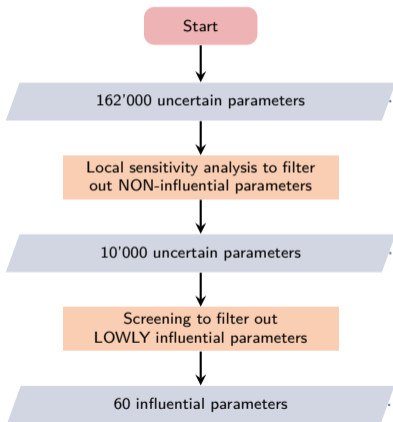


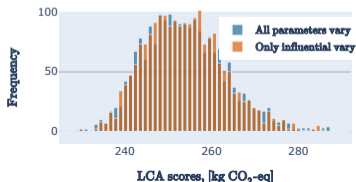
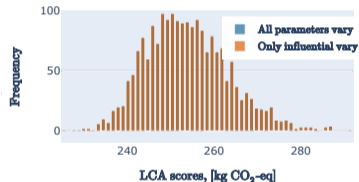
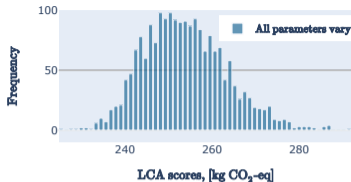
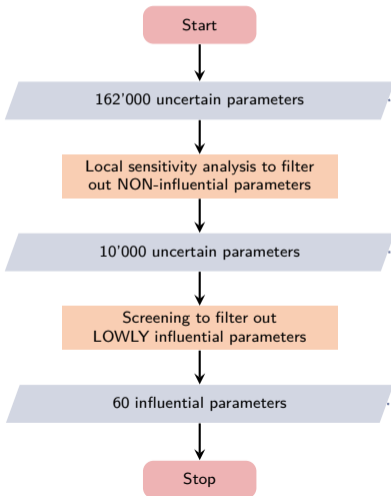


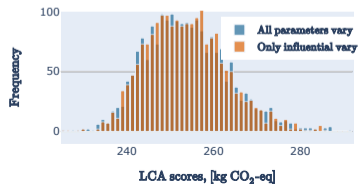
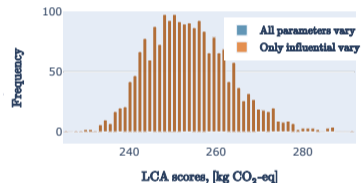
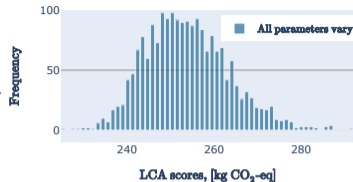
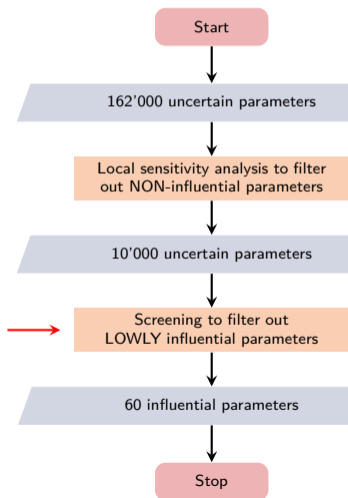




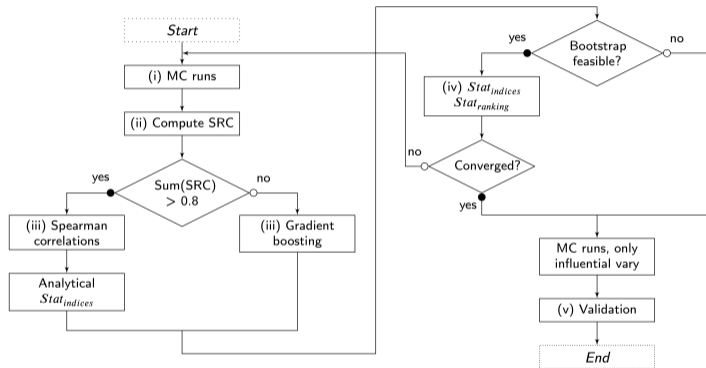






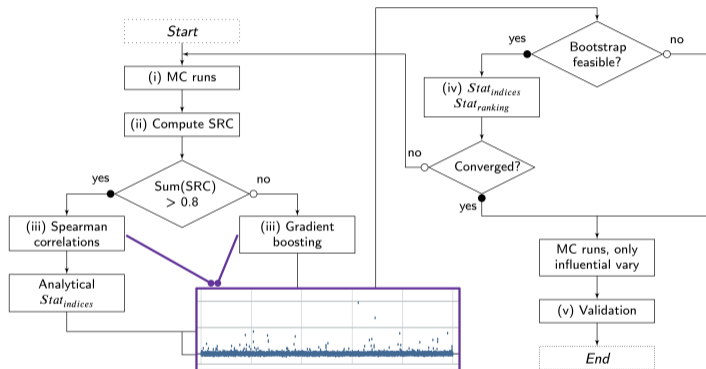


# Standardized screening protocol



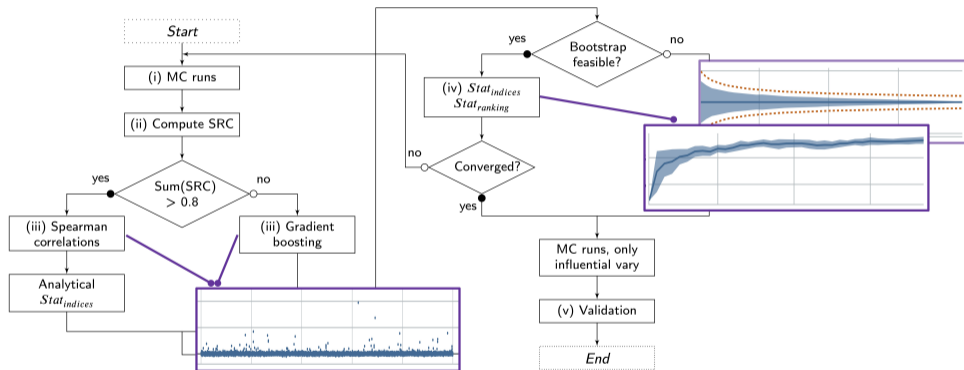
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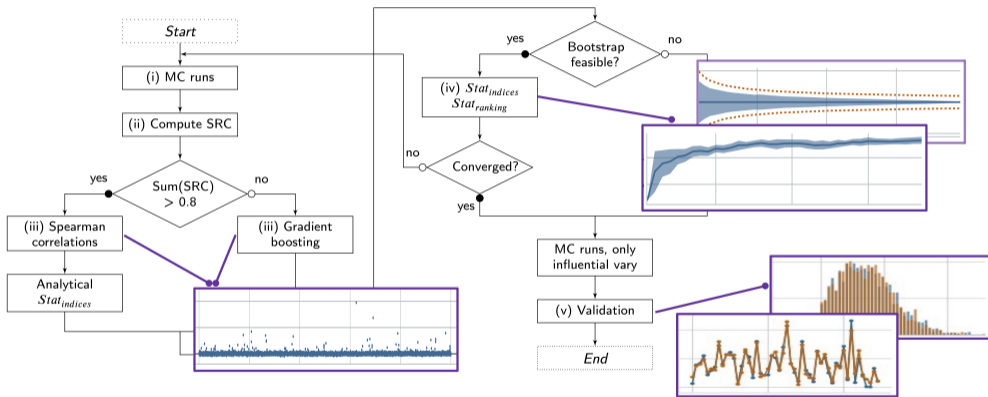
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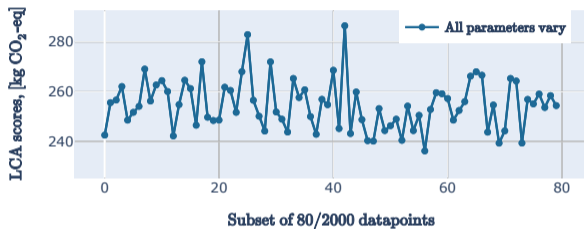
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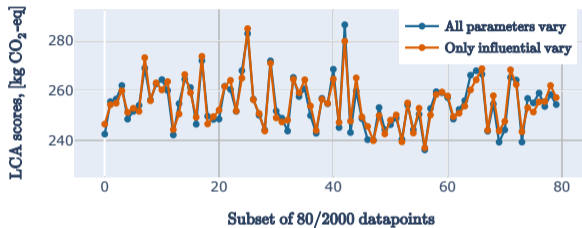
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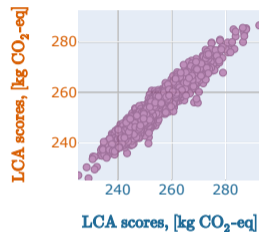
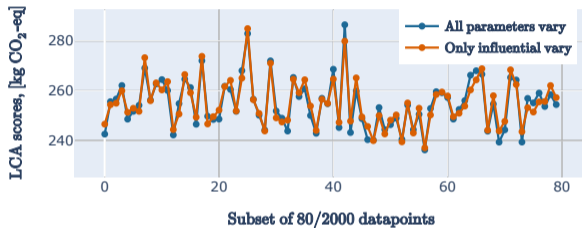
# Validation of GSA results



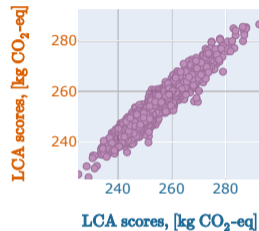
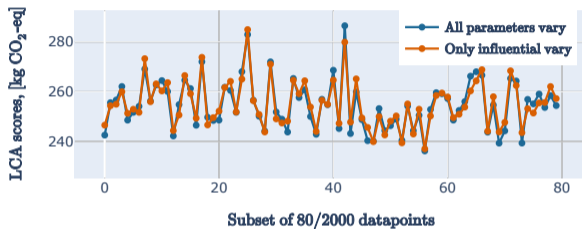
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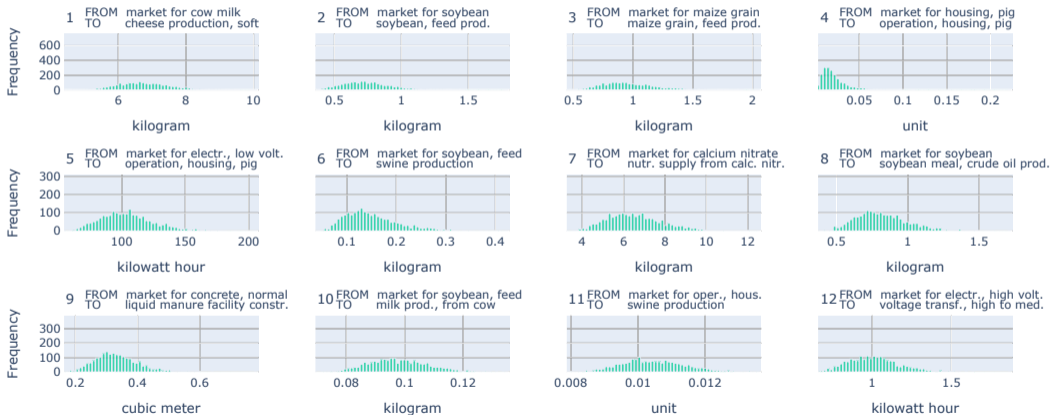
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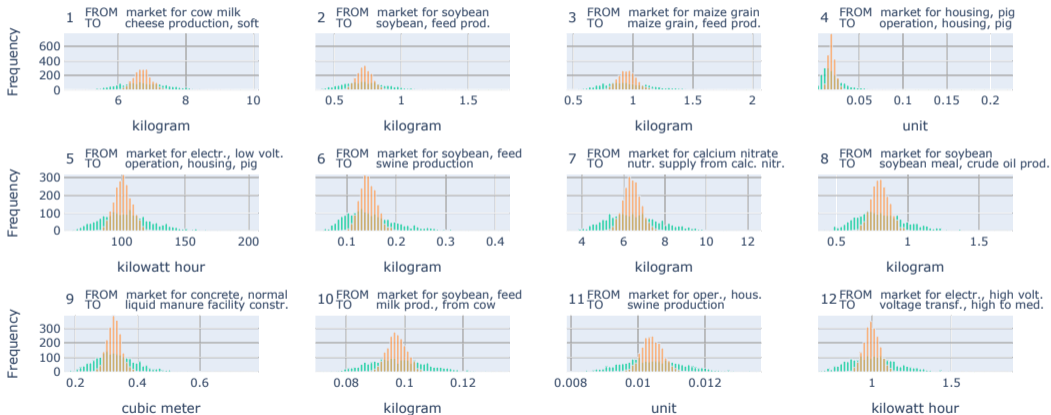


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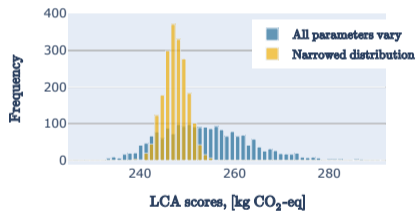
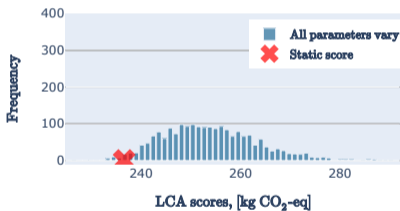


Correlation coefficients: 0.963 Pearson  
0.962 Spearman rank  
[Bonett and Wright, 2000]



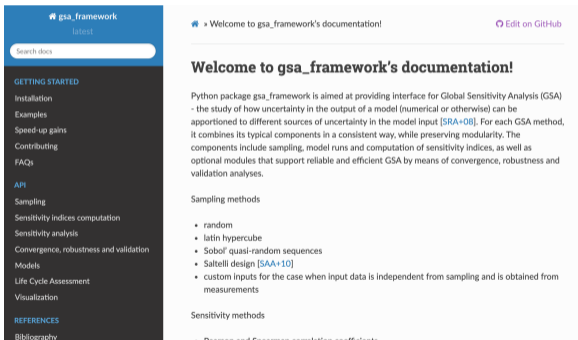


# Uncertainty reduction in LCA score



Open source python package:

[https://github.com/aleksandra-kim/gsa\\_framework](https://github.com/aleksandra-kim/gsa_framework)



The screenshot shows the GitHub documentation page for the `gsa_framework` package. The page has a dark sidebar on the left with navigation links and a main content area on the right. The sidebar includes sections for 'GETTING STARTED' (Installation, Examples, Speed-up gains, Contributing, FAQs), 'API' (Sampling, Sensitivity indices computation, Sensitivity analysis, Convergence, robustness and validation, Models, Life Cycle Assessment, Visualization), and 'REFERENCES' (Bibliography). The main content area features a breadcrumb trail, an 'Edit on GitHub' link, and a heading 'Welcome to gsa\_framework's documentation!'. The text describes the package's purpose in providing an interface for Global Sensitivity Analysis (GSA) and lists sampling methods: random, latin hypercube, Sobol' quasi-random sequences, and Saltelli design. It also mentions sensitivity methods, with the first one being 'Drees and Ioannidis correlation coefficients'.

gsa\_framework  
latest

Search docs

GETTING STARTED

- Installation
- Examples
- Speed-up gains
- Contributing
- FAQs

API

- Sampling
- Sensitivity indices computation
- Sensitivity analysis
- Convergence, robustness and validation
- Models
- Life Cycle Assessment
- Visualization

REFERENCES

- Bibliography

> Welcome to gsa\_framework's documentation! [Edit on GitHub](#)

## Welcome to gsa\_framework's documentation!

Python package gsa\_framework is aimed at providing interface for Global Sensitivity Analysis (GSA) - the study of how uncertainty in the output of a model (numerical or otherwise) can be apportioned to different sources of uncertainty in the model input [SRA+08]. For each GSA method, it combines its typical components in a consistent way, while preserving modularity. The components include sampling, model runs and computation of sensitivity indices, as well as optional modules that support reliable and efficient GSA by means of convergence, robustness and validation analyses.

### Sampling methods

- random
- latin hypercube
- Sobol' quasi-random sequences
- Saltelli design [SAA+10]
- custom inputs for the case when input data is independent from sampling and is obtained from measurements

### Sensitivity methods

- Drees and Ioannidis correlation coefficients



## Open source python package: [https://github.com/aleksandra-kim/gsa\\_framework](https://github.com/aleksandra-kim/gsa_framework)

gsa\_framework latest

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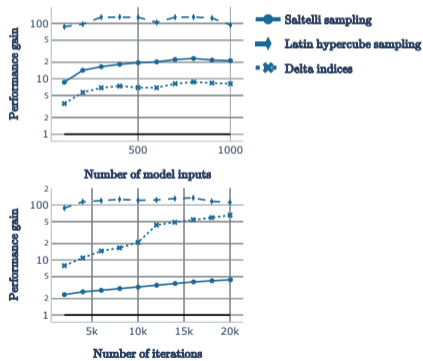
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#### Sensitivity methods

- Delta and Sobolj sensitivity coefficients



1. Uncertainty and Global Sensitivity Analysis are relevant tools to support decision-making and communicate LCA results.
2. Recent advances in efficient computations allow GSA of entire life cycle inventories.
3. Proposed GSA methodology and screening procedure allow robust estimations of sensitivity indices at lower computational cost.
4. Validation of the GSA results should be done at each step of the analysis.
5. Swiss consumption LCA model turned out to be quite linear.

# Acknowledgements

This work has received funding from the Swiss National Science Foundation (SNSF) within the framework of the National Research Program “Sustainable Economy: resource-friendly, future-oriented, innovative” (NRP 73) Grant-N407340\_172445.



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FONDO NAZIONALE SVIZZERO  
SWISS NATIONAL SCIENCE FOUNDATION



**Sustainable Economy**  
National Research  
Programme

Thank you!



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