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Literature review of eco-design and learning-based optimization methods

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Optimization Day 2024

Literature Review of

Eco-Design and Learning-Based Optimization Methods

Maryam Ashkbous

Samira Keivanpour

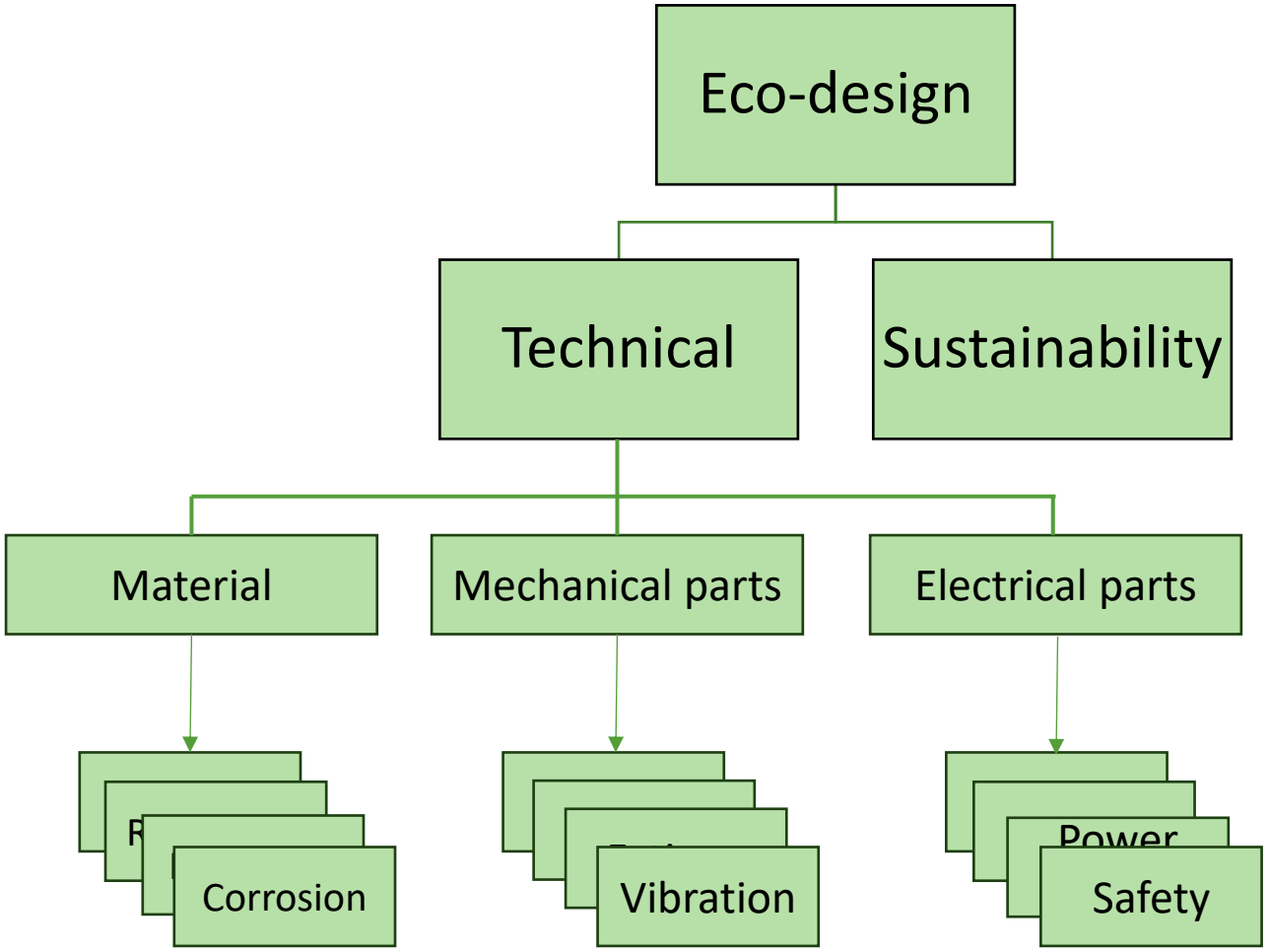
May 6, 2024

outline

- Introduction
  - Eco-design and it’s challenges
- Research Methodology
  - PRISMA
- Results
- Conclusion
  - Gaps and Future research trends

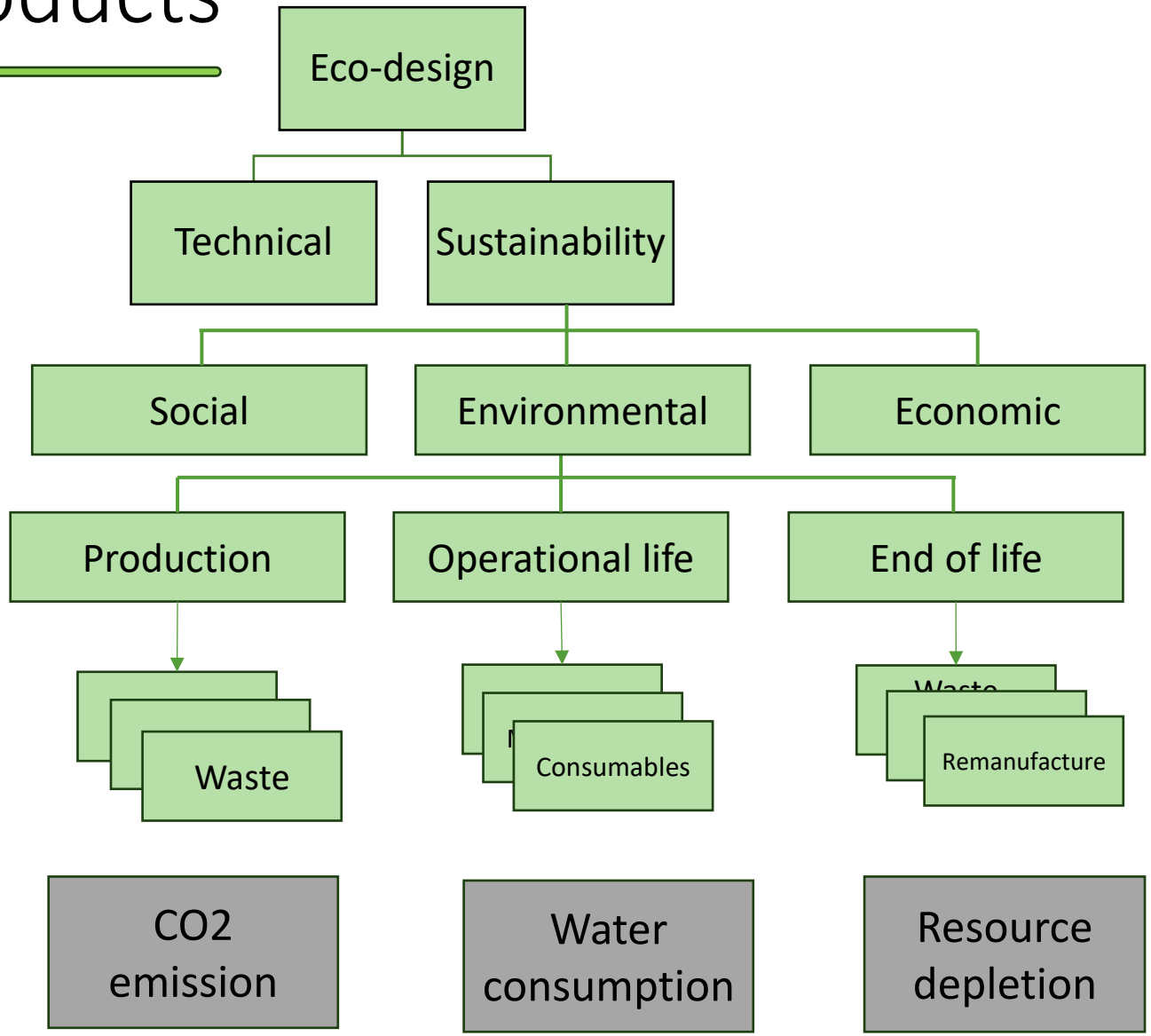
Eco-design of complex products



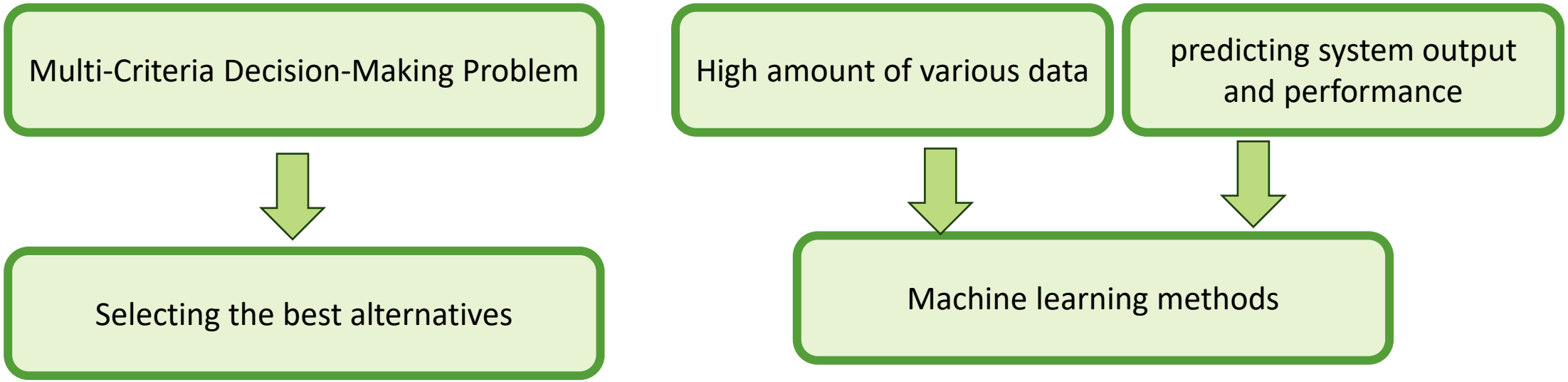


Eco-design of complex products





Eco-design of complex products



Contribution of machine learning in eco-design to develop decision support tools

Research methodology

Related research areas

Context

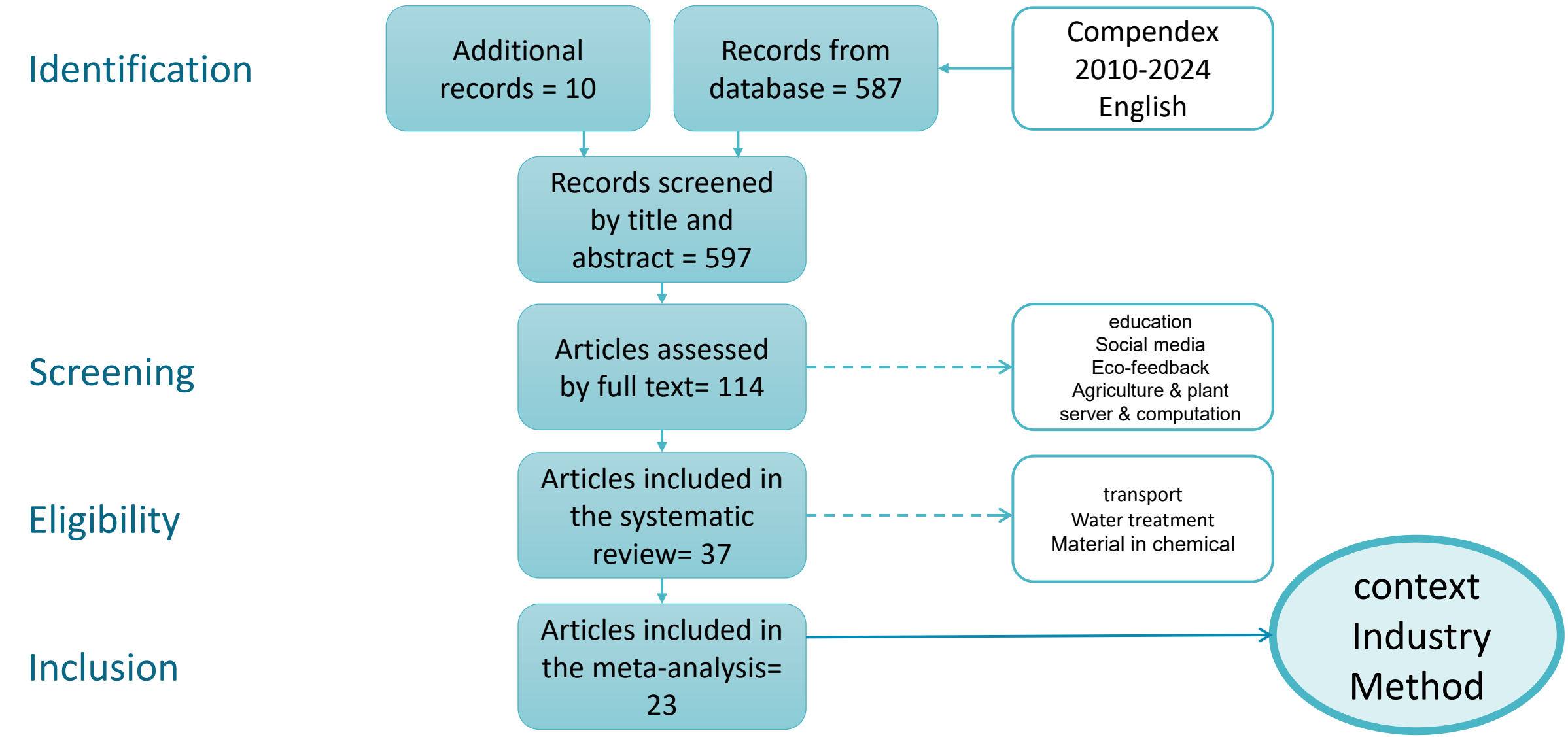
- Technical design
- Sustainability

Method

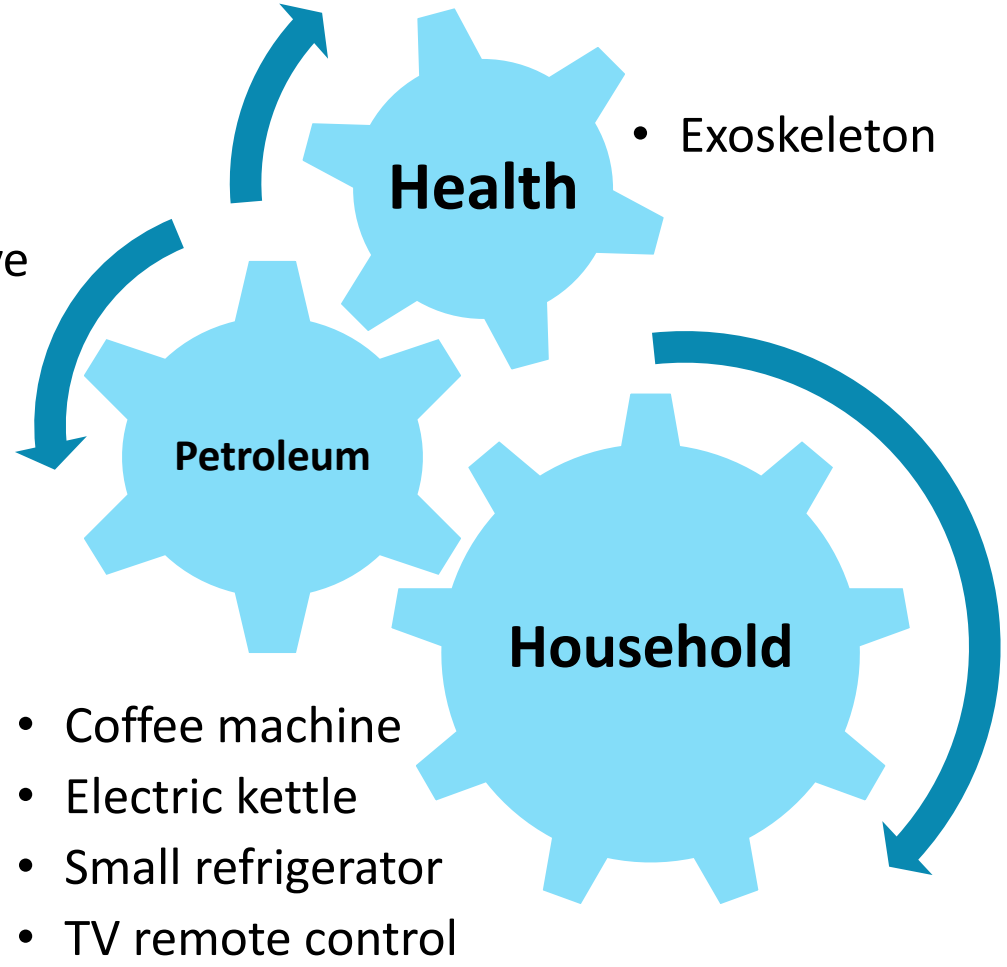
- Multi-Criteria Decision-Making (MCDM)
- Machine learning (ML)

Any combination of above subjects could be related to eco-design of complex products

Systematic review - PRISMA



Case studies in various industries



- Exoskeleton
- Pressure valve
- Turbine rear structure

Aerospace

- Coffee machine
- Electric kettle
- Small refrigerator
- TV remote control

Construction

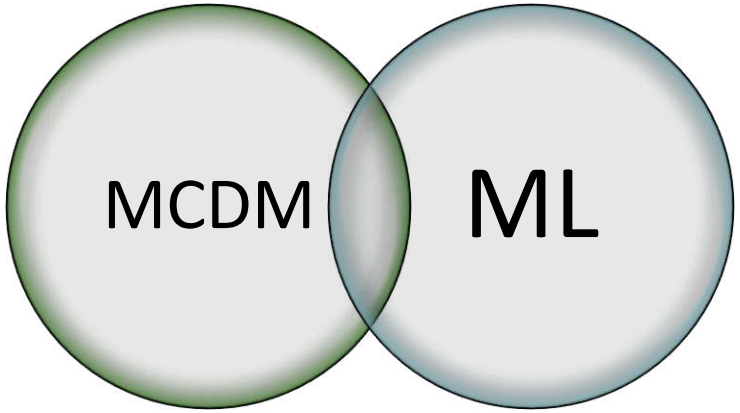
- Cement
- I-beam

Combination of context and methods

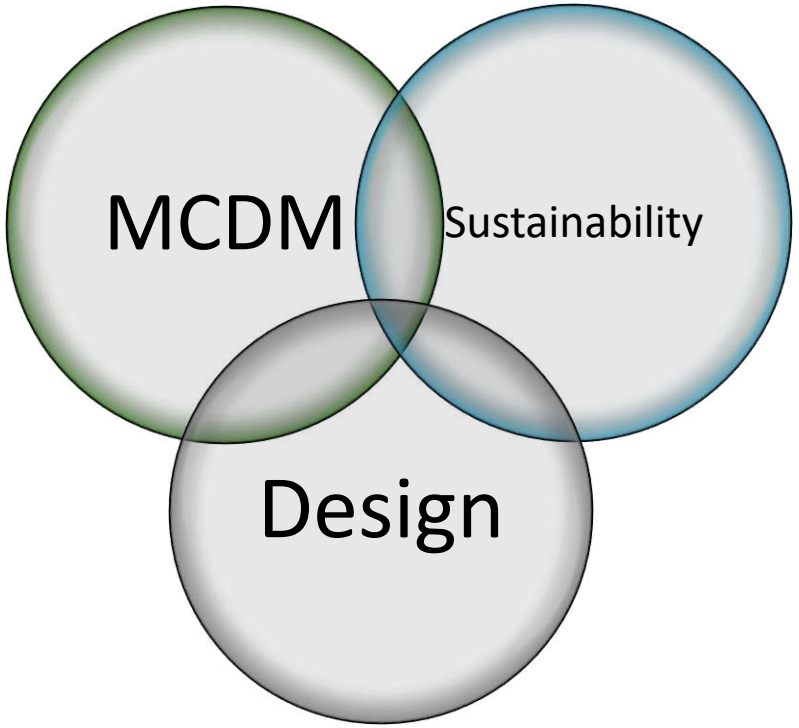
1 review paper



1 review paper
2 Regular papers

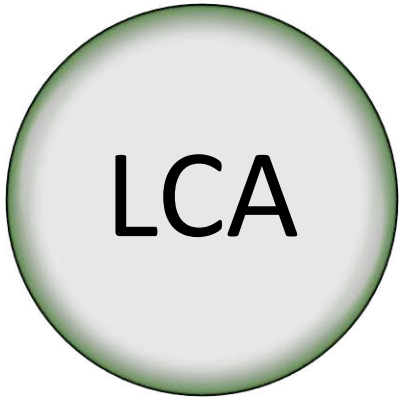


2 review papers
3 regular papers

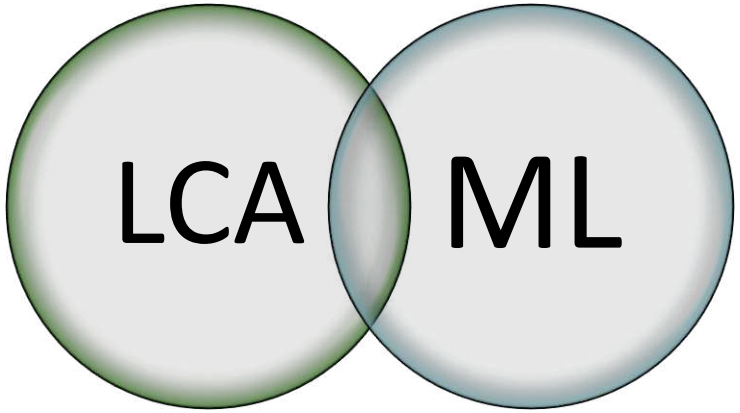


Combination of context and methods

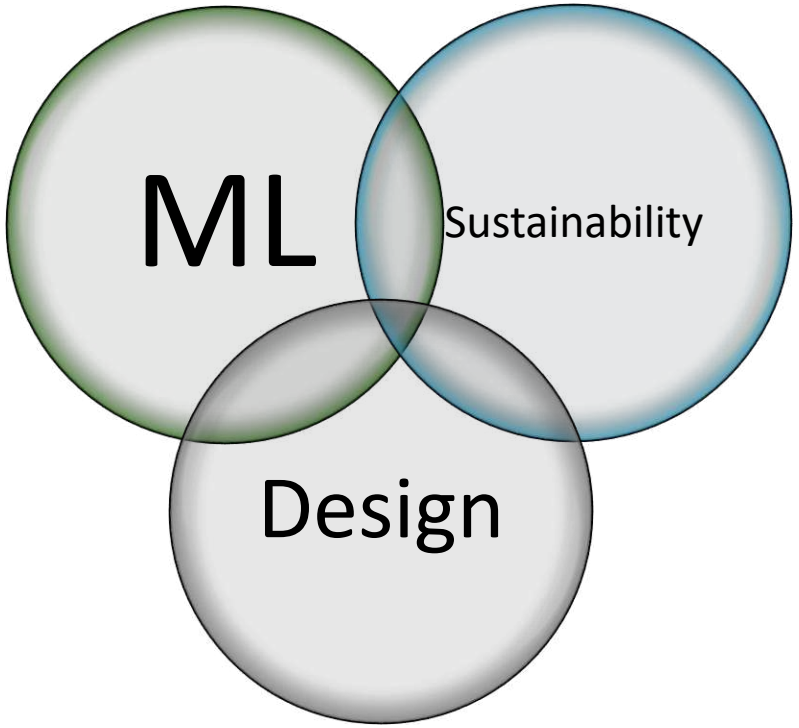
2 review papers



2 review papers
4 Regular papers

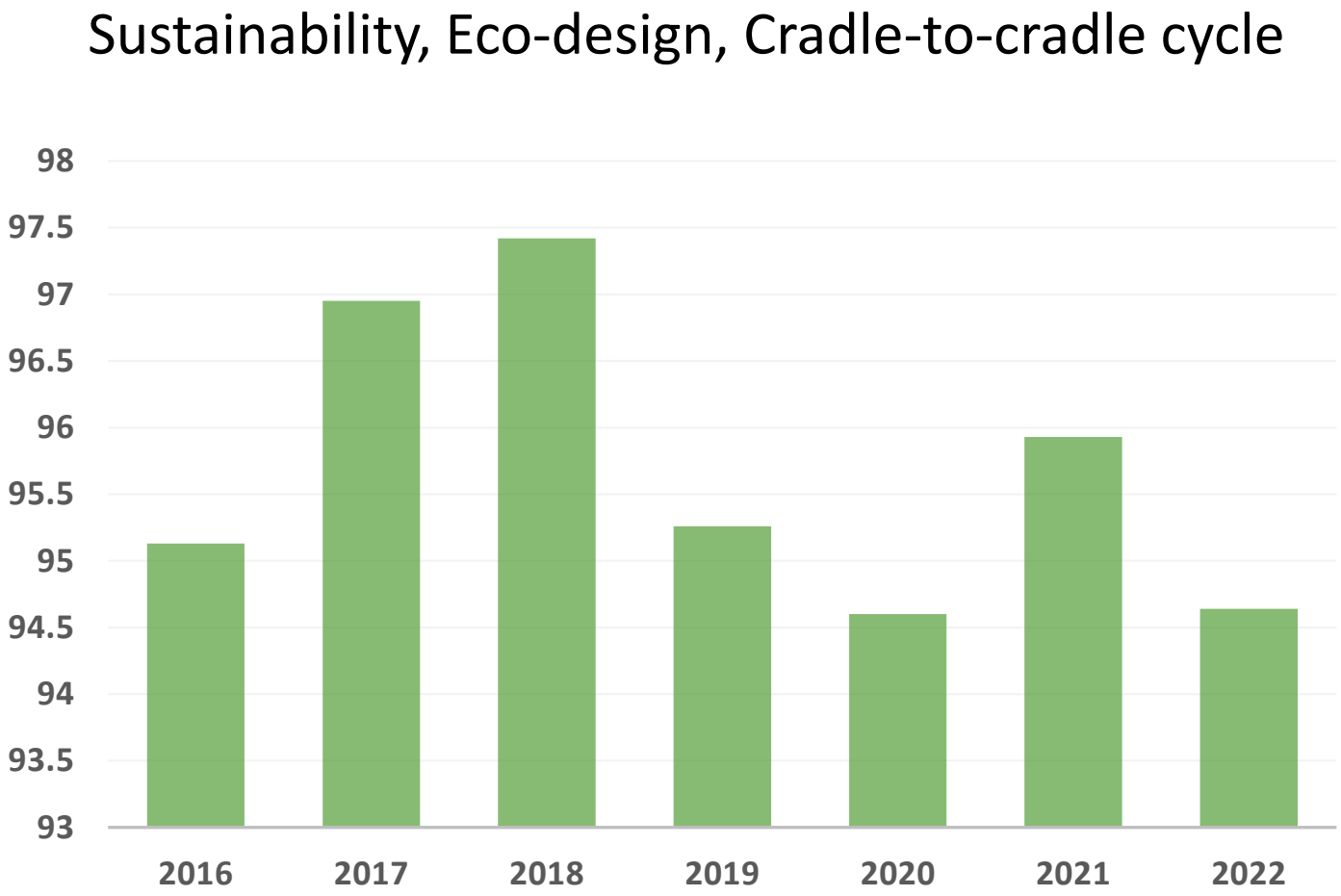


6 regular papers



Results

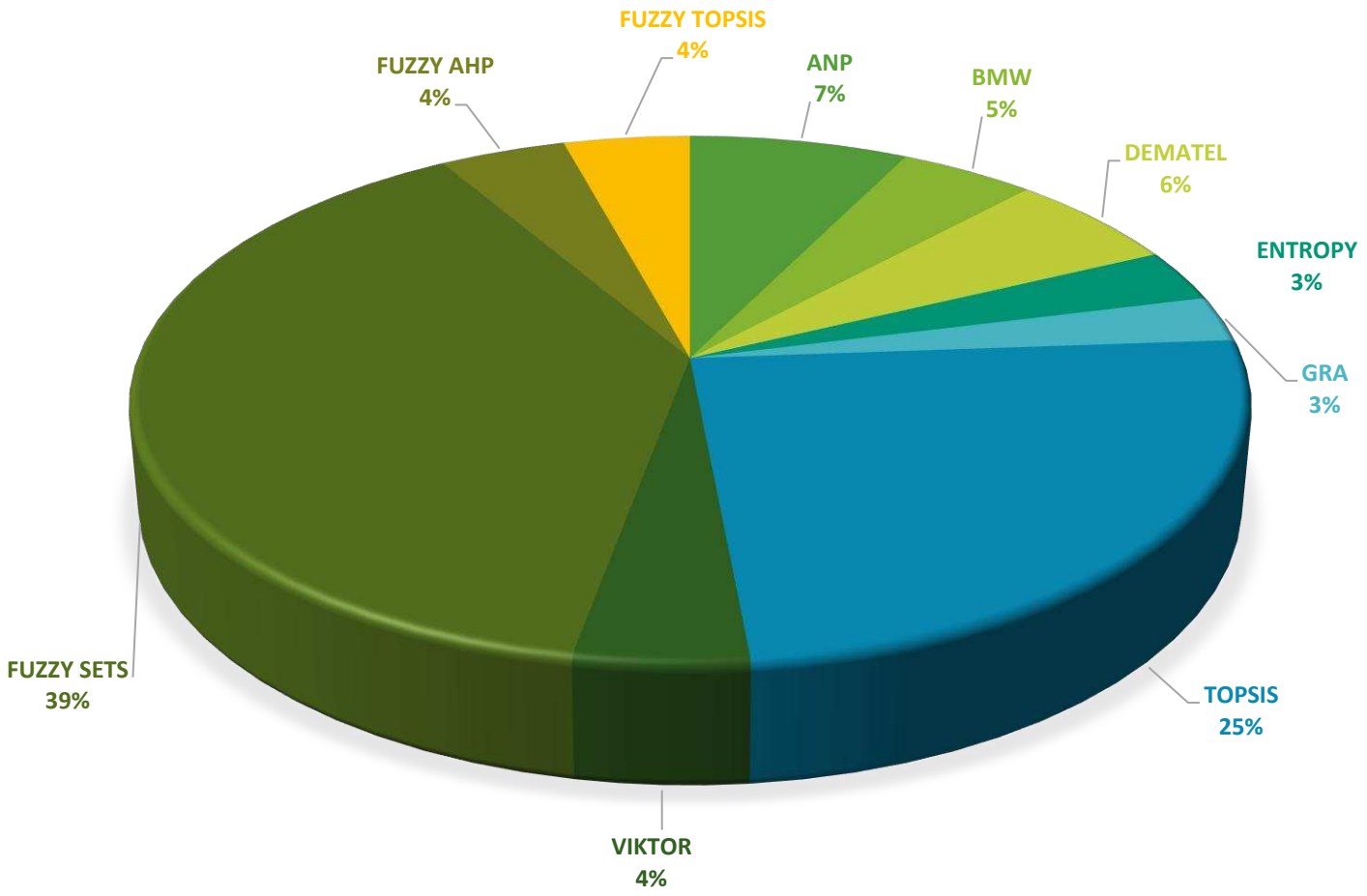
LCA SciVal prominence values



MCDM methods in sustainable engineering

Fuzzy sets → 39%

TOPSIS → 25%



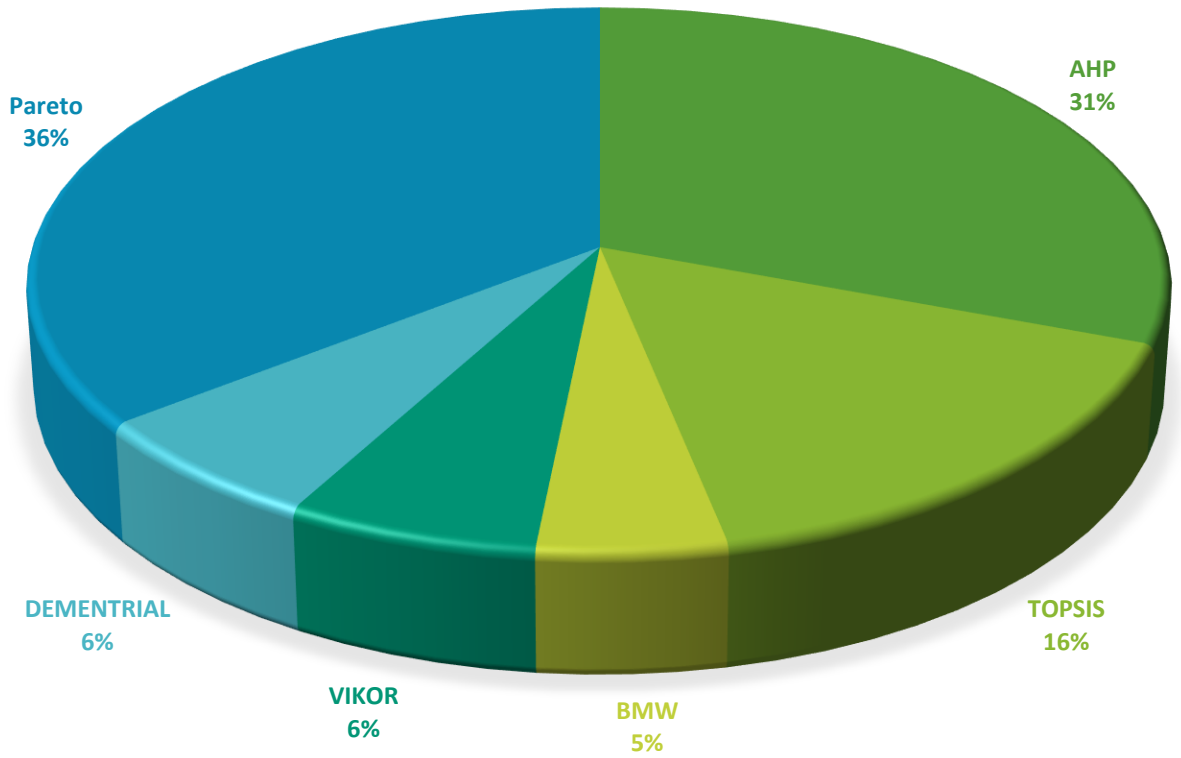
MCDM methods in product design

	AHP	TOPSIS	BWM	VIKOR	DEMENTRIAL	Pareto
Product design (electronic)	6	------	------	------	------	------
Product design (other)	2	7	3	4	2	7
Conceptual design	8	------	------	------	2	10
Design for end of life	3	3	------	------	------	5

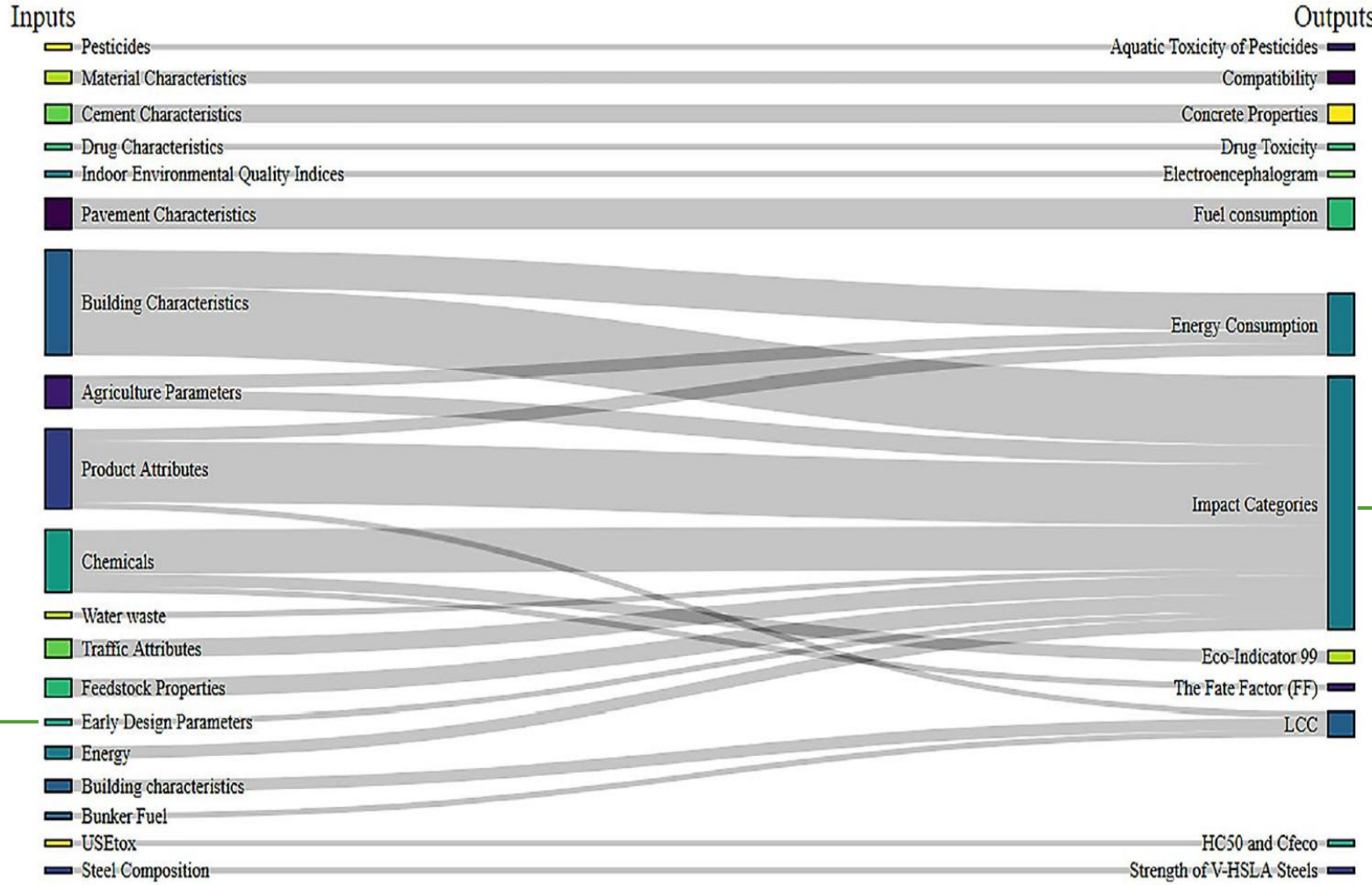
MCDM methods in product design

Pareto → 36%

AHP → 31%



inputs and outcomes of ML methods in LCA

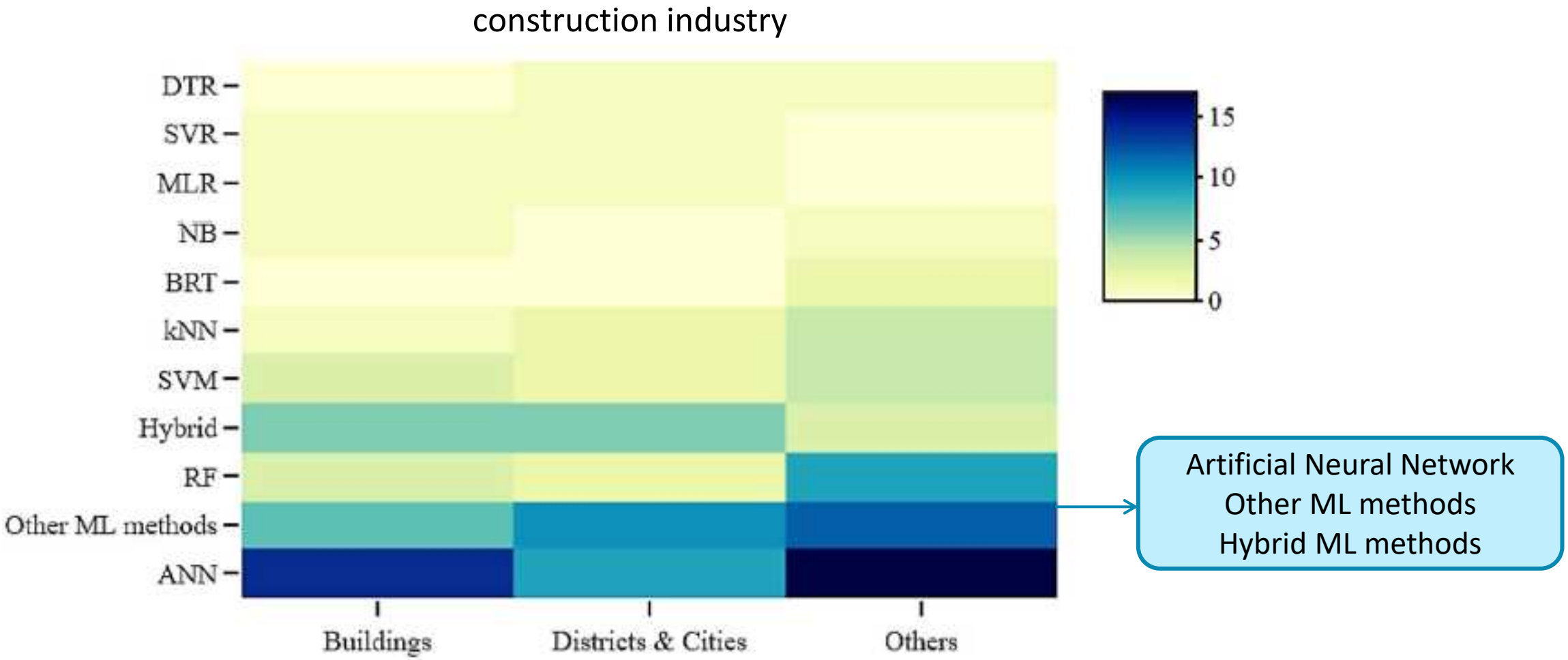


Impact categories

Early design parameters

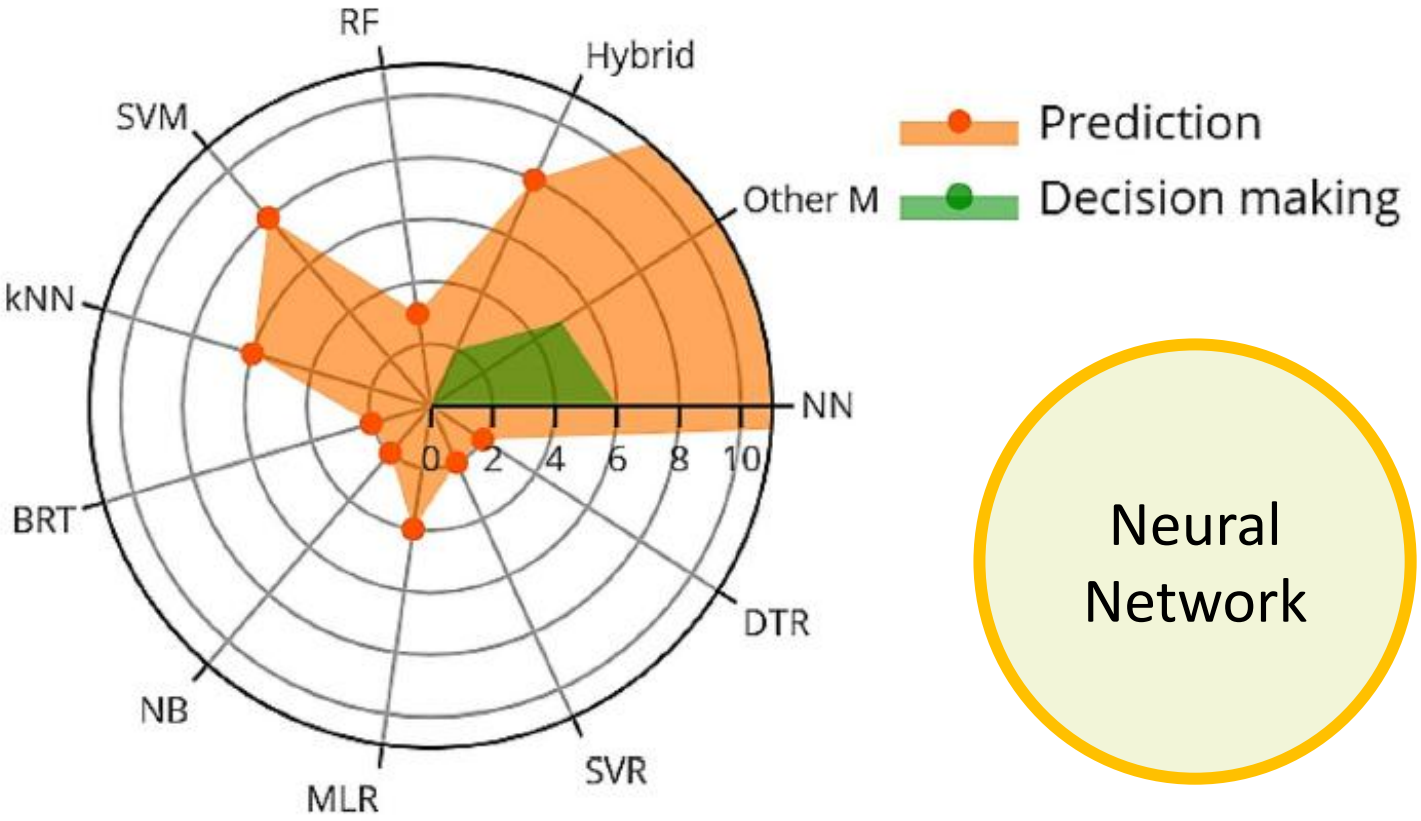
Ghoroghi, Ali, et al. "Advances in application of machine learning to life cycle assessment: a literature review." *The International Journal of Life Cycle Assessment* 27.3 (2022): 433-456. P. 18

Heatmap of ML methods in LCA



Ghoroghi, Ali, et al. "Advances in application of machine learning to life cycle assessment: a literature review." *The International Journal of Life Cycle Assessment* 27.3 (2022): 433-456. P. 17

Applications of ML methods in prediction and decision making



Neural Network

Other models

Hybrid models

Ghoroghi, Ali, et al. "Advances in application of machine learning to life cycle assessment: a literature review." *The International Journal of Life Cycle Assessment* 27.3 (2022): 433-456. P. 17

ML methods vs. conventional LCA methods

ML methods match the conventional LCA results accurately.

ANN advantages over conventional LCA method:

Decrease computational time

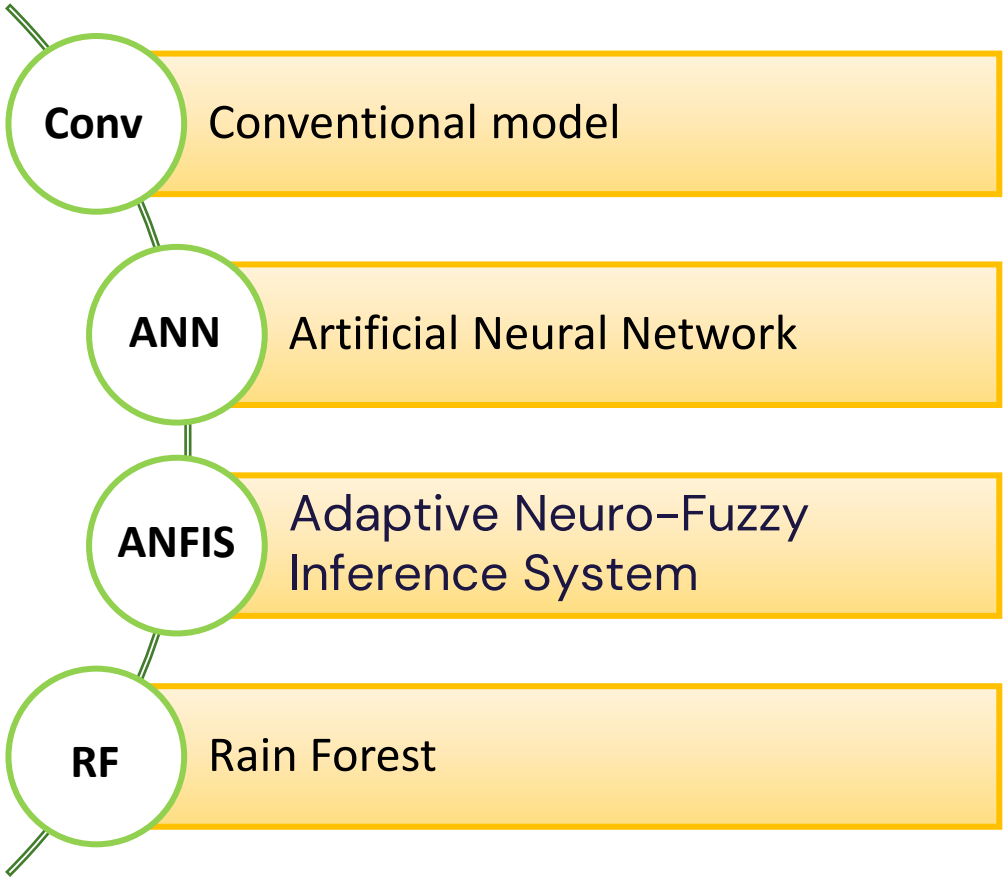
Increase accuracy

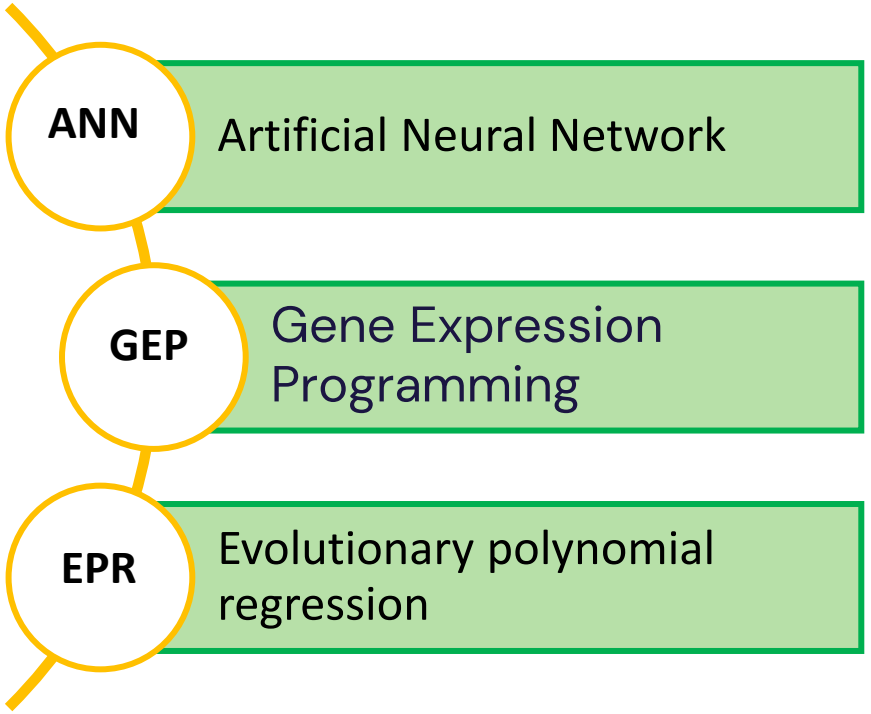
Reduce uncertainty

Challenge

Validity of model relies on reliability of dataset

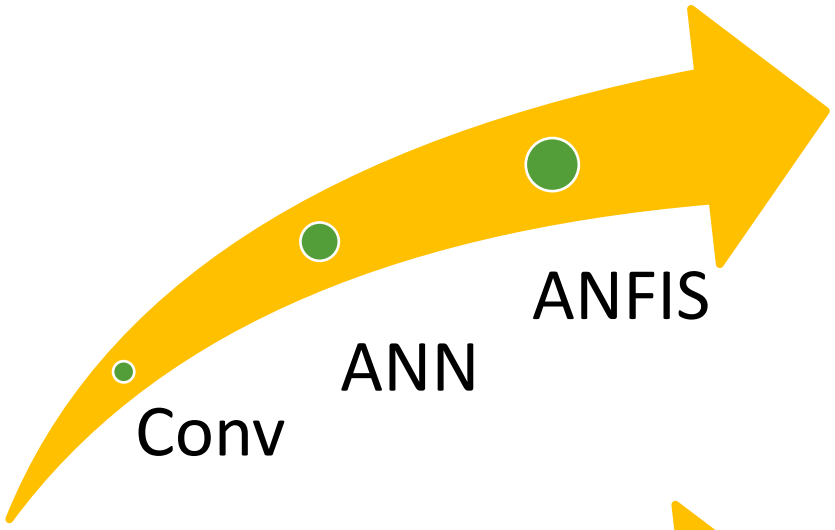
ML methods vs. conventional LCA methods

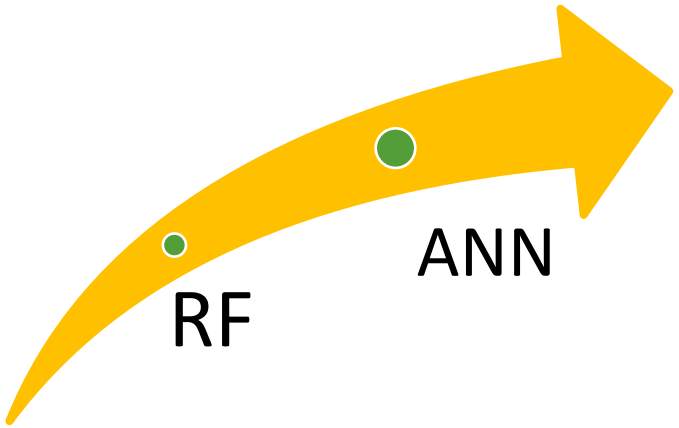


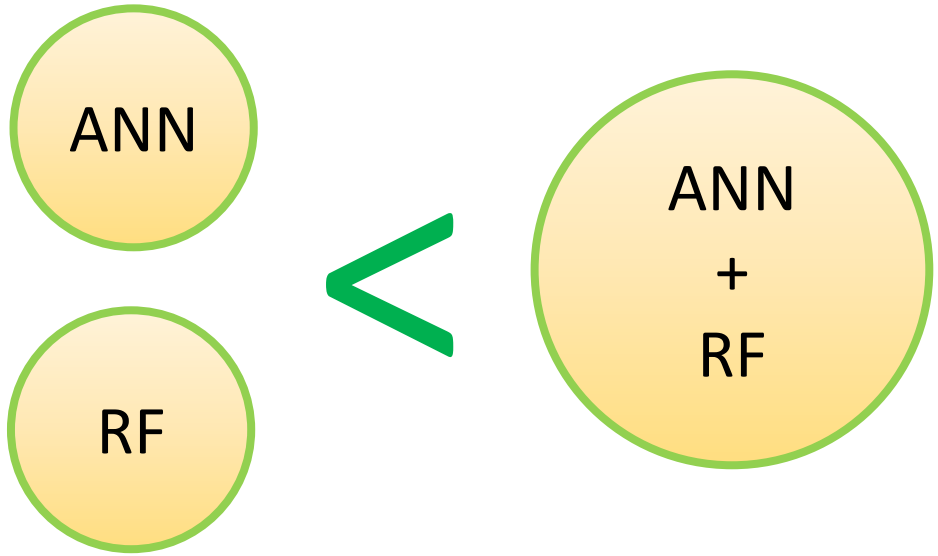


ML methods comparison in LCA

Based on R2 Coefficient

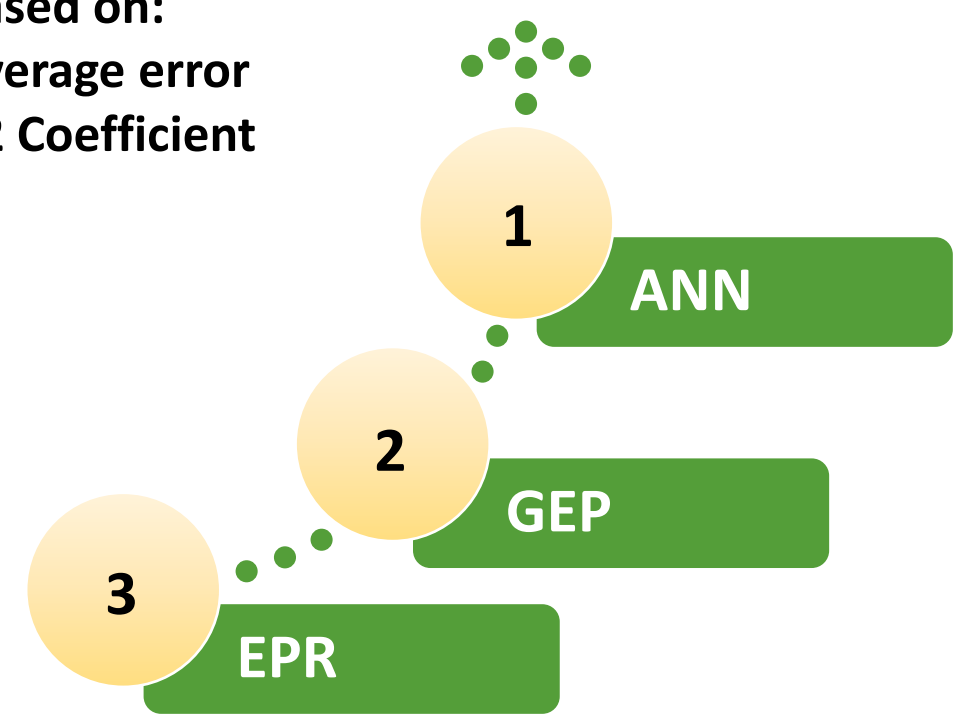


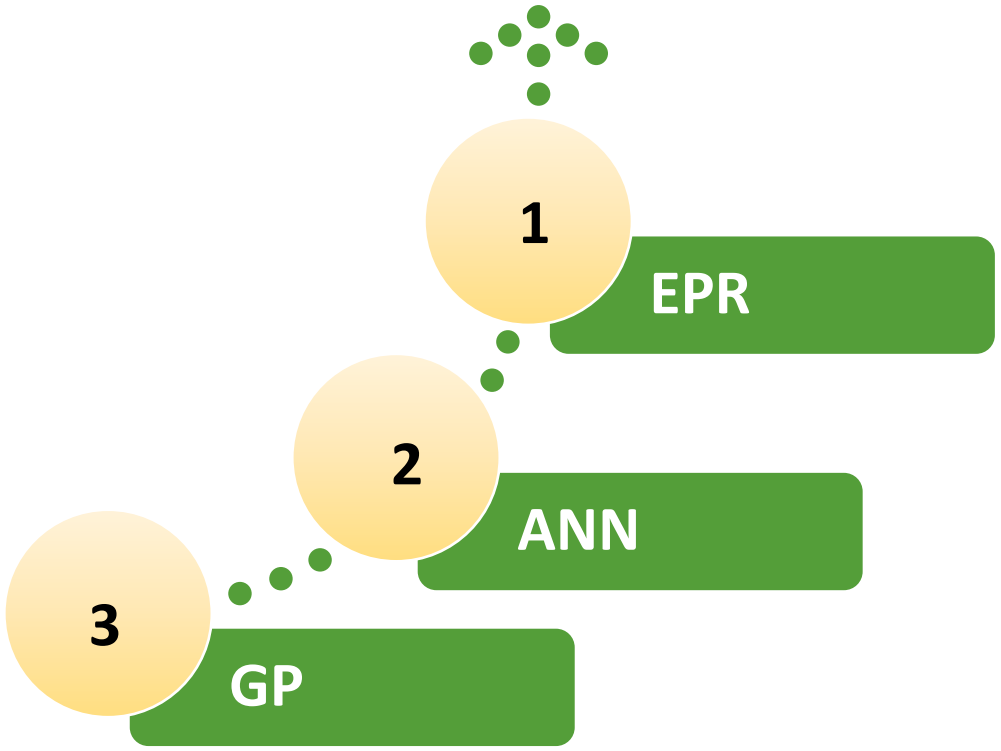




ML methods vs. conventional LCA methods

Based on:
Average error
R2 Coefficient





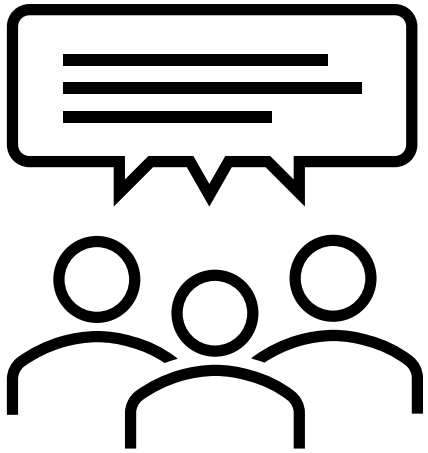
Artificial Neural Network shows better results than Genetic-based Algorithms

Gaps
&
Future research trends

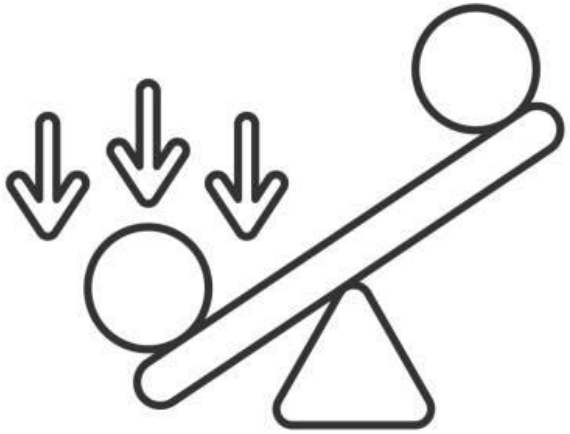
Gaps in MCDM methods

Weight determination

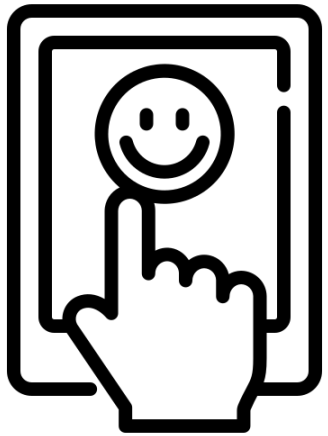
Expert's opinion



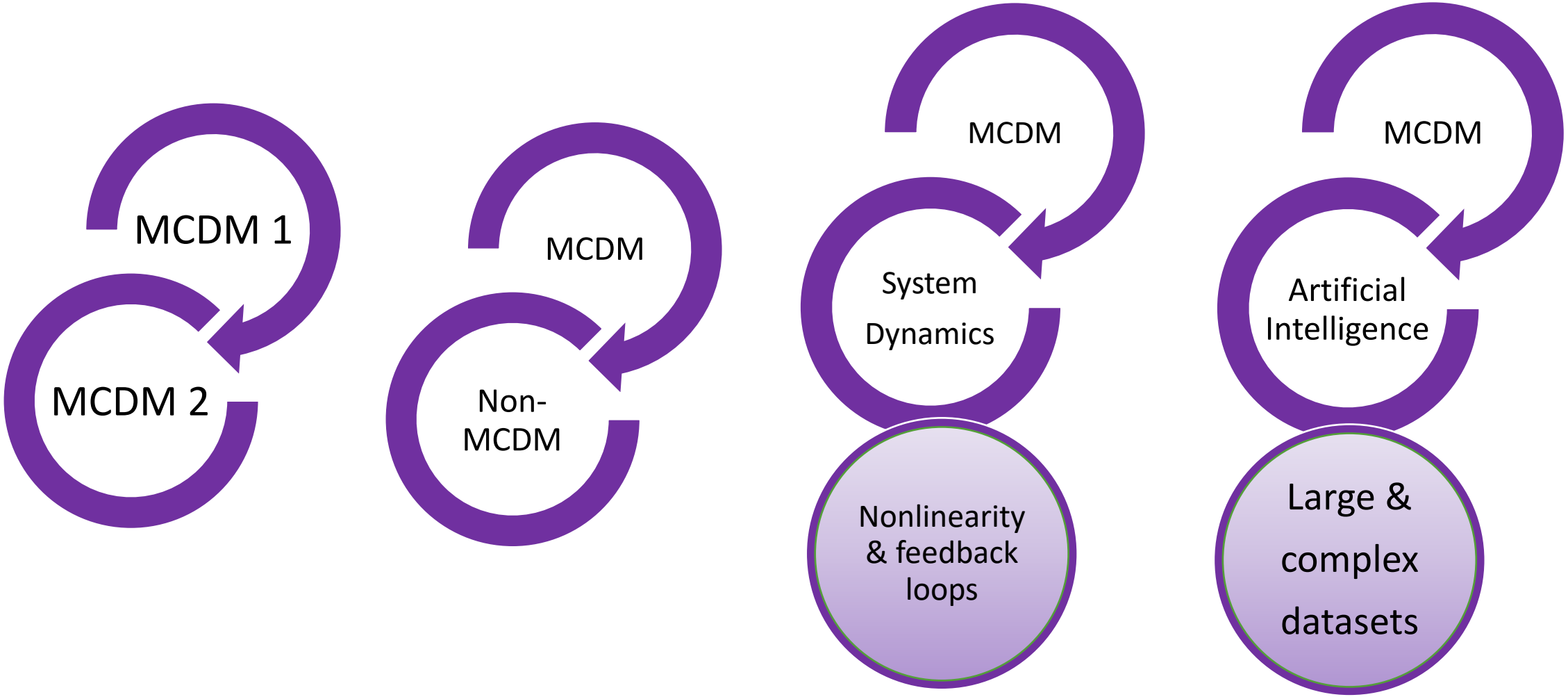
Biased decision-making



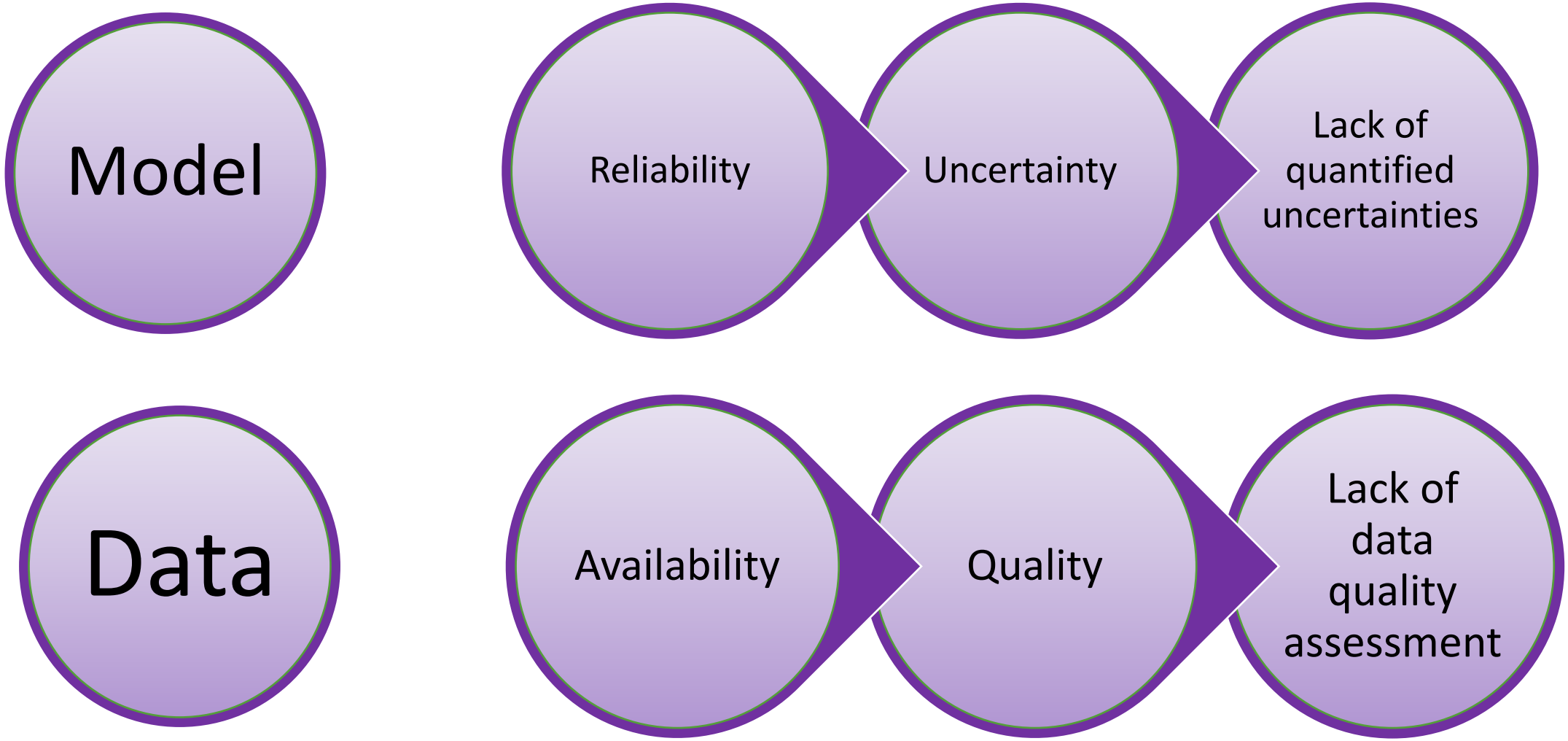
User-friendly tool



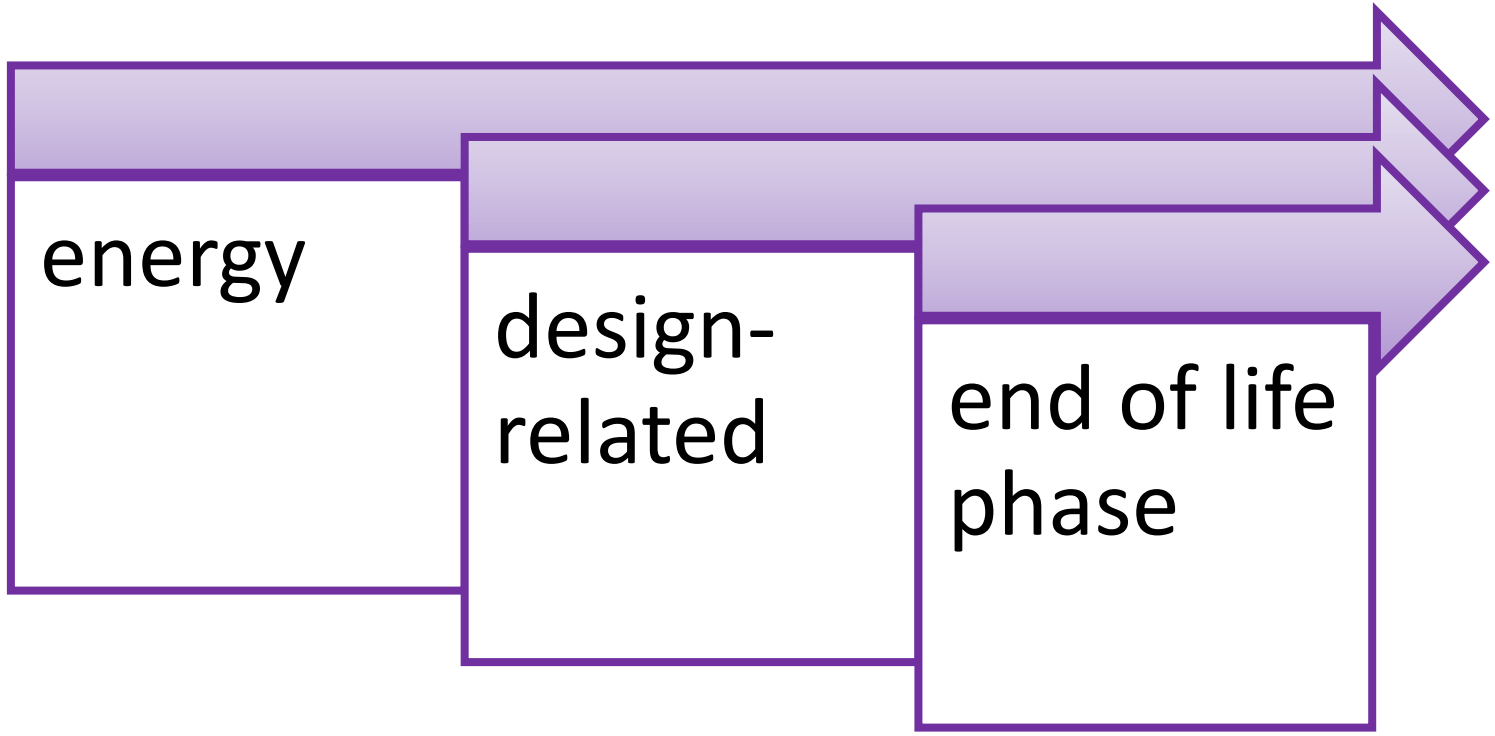
Future research trends in MCDM methods



Gaps in LCA methods



Future research trends in LCA context



Interdisciplinary nature of LCA and sustainability → pivotal role for LCA research across various industries

Gaps in ML methods in LCA

Data

- Detailed information
- High-quality data

Model accuracy

- Hybrid ML methods
- Advanced stochastic metaheuristics

Real-time application

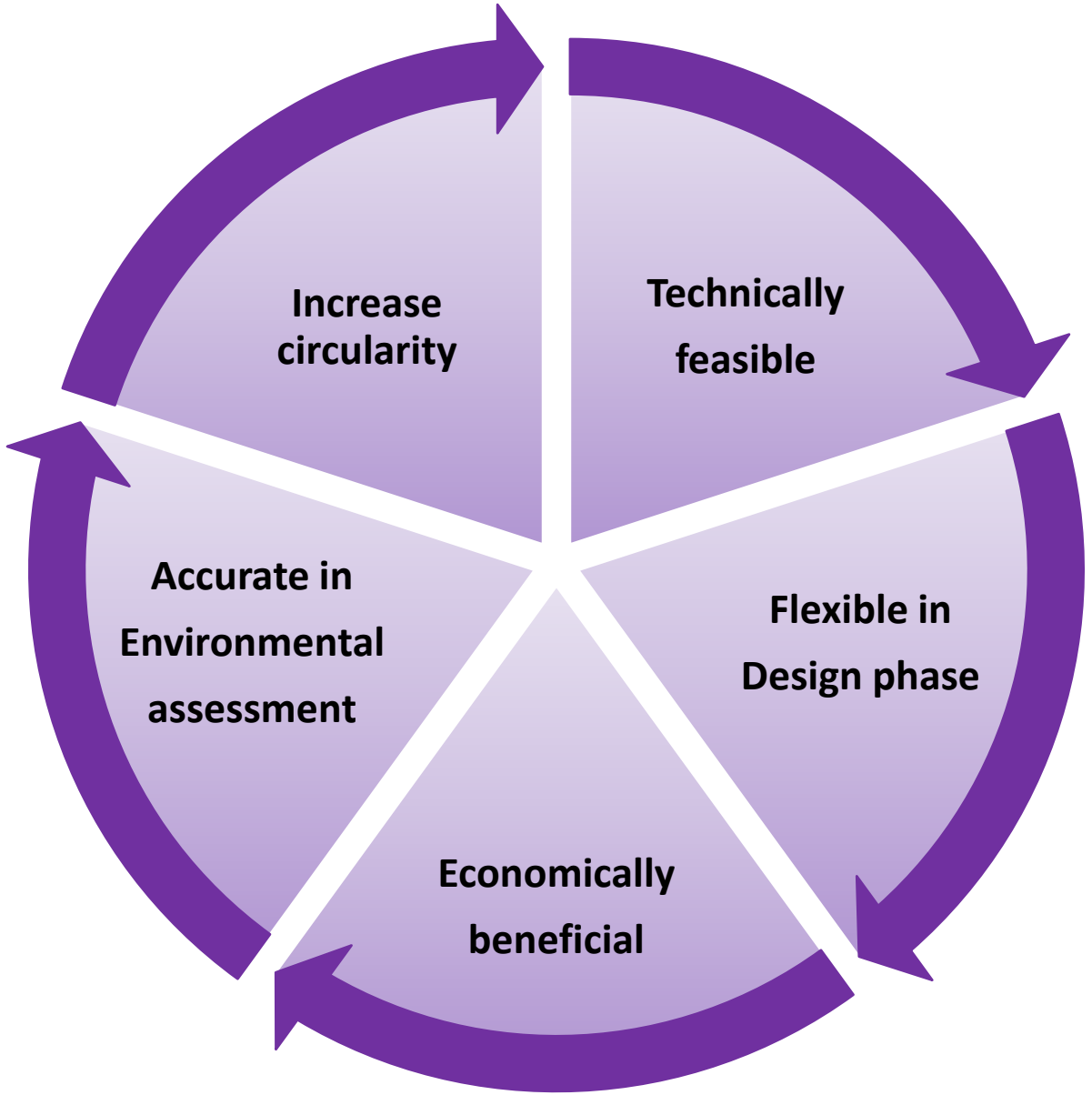
- Reduce computational cost
- Internet of things (IOT)

Future research trends in ML methods in LCA

ML algorithms could be applied in:

- screening and cleaning data for Life Cycle Inventory (LCI)
- Estimating flow data for unit processes
- improving the quality and quantity of data to determine carbon footprint

Future research trends in eco-design



Thanks for your attention