Livestock farming eco-efficiency analysis: A systematic literature review of frontier approaches for sustainability

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UMR SMART
Structures et marchés agricoles, ressources et territoires

Plan

1- Introduction

2- Materials and methods

3- Results

4- Conclusion

1- Introduction

General context

- Agriculture faces multiple challenges : Food security, climate change, and resource conservation

- Sustainable agriculture : Application of sustainable development principles

  - Economic Sustainability: Agricultural productivity and farmers' income
  - Environmental Sustainability: Environmental externalities, natural resource, biodiversity with ecological limits
  - Social Sustainability: Equity and quality of life for all stakeholders, integrating societal needs and values

- Expansion of economic efficiency assessment to both environmental and social efficiency : Eco-efficiency

Research question

- Various frontier approaches exist for eco-efficiency assessment of agriculture

- Weak vs. Strong Sustainability paradigms
  - Weak sustainability (Hartwick, 1977; Solow, 1974)
    - Substitutability of natural resources
    - Managing natural resources to support economic growth
  - Strong sustainability (Costanza, 1991; Daly, 1991)
    - Non substitutability of natural resources
    - Necessity of preserving critical natural resources

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- How these approaches have been developed and how they can be categorized under either the weak or strong sustainability paradigms?

Literature review

- Systematic literature reviews on eco-efficiency in agriculture

(Kyrgiakos et al., 2023; Staniszewski and Matuszczak, 2023; Streimikis and Saraji, 2022; Suzigan et al., 2020).

  - Suzigan et al. (2020): Analyzed 90 articles from 1992 to 2018, identifying key methods for evaluating eco-efficiency
  - Staniszewski and Matuszczak (2023) analyzed 200 articles on environment-adjusted agricultural efficiency

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- Research Gaps

  - No existing studies specifically examine eco-efficiency in livestock farming
  - No classification of eco-efficiency assessment approaches according to weak or strong sustainability paradigms

Livestock farming

- Livestock farming plays a crucial role in supporting agriculture sustainability

- Major natural resource consumer contributing to :
  - GHG emissions, water pollution, soil degradation, and biodiversity loss
  - Represents 14.5% of global GHG emissions
  - Contributes to biodiversity loss by using around 30% of global ,land for grazing and forage, which alters habitats

- Grass-fed livestock can maintain grasslands, support species diversity, and serve as carbon sinks

Objectives and Main Contributions

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  - Identify research trends in the assessment of eco-efficiency in livestock farming
  - Propose a classification of the main frontier approaches for eco-efficiency assessment based on the weak and strong sustainability paradigms

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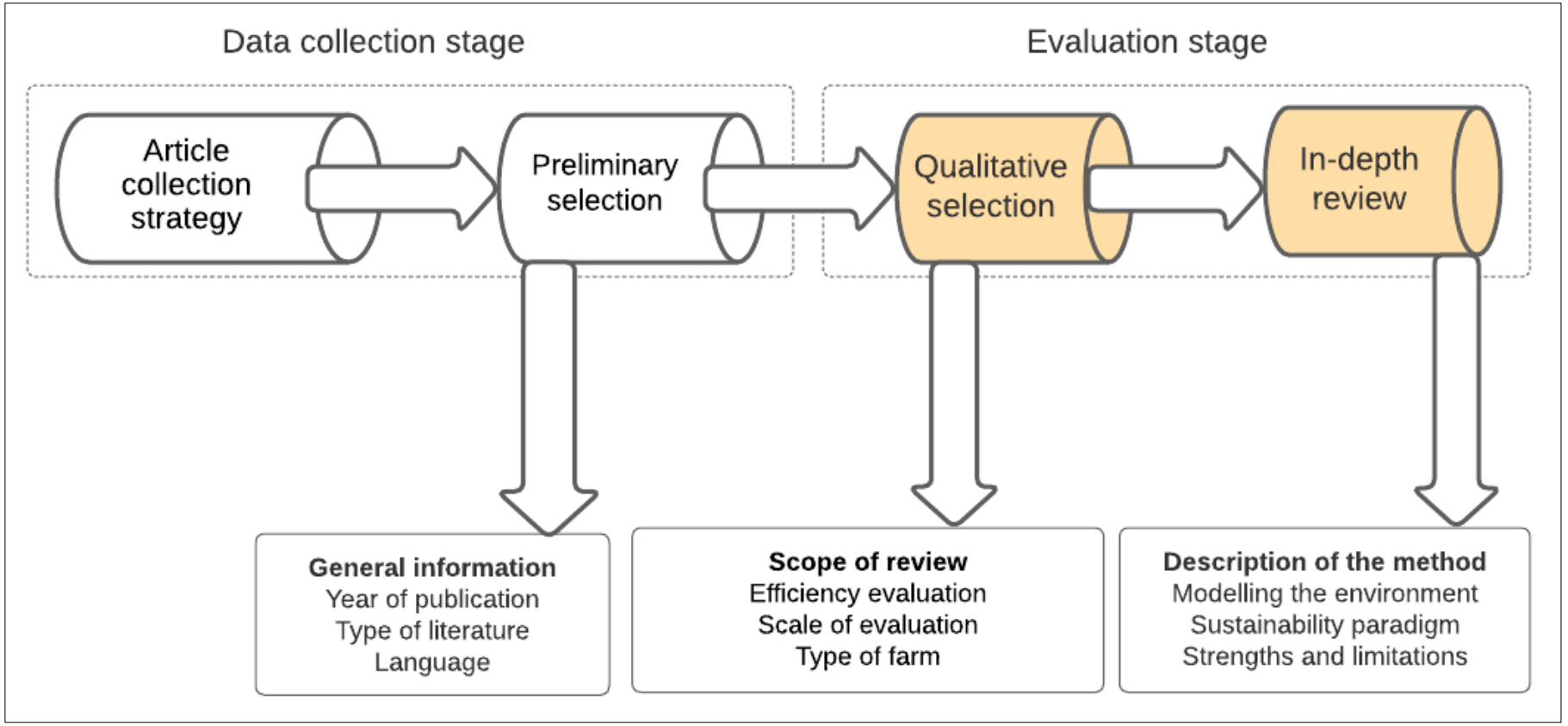
- Main Contributions
  - Provide a critical assessment of existing eco-efficiency approaches within the context of livestock
  - Offer insights on how these approaches align with the economic and environmental sustainability goals

2- Materials and methods

Literature Review Process

- Methodological framework of Lampridi et al. (2019)
- Principles of the PRISMA method (Page et al., 2021)

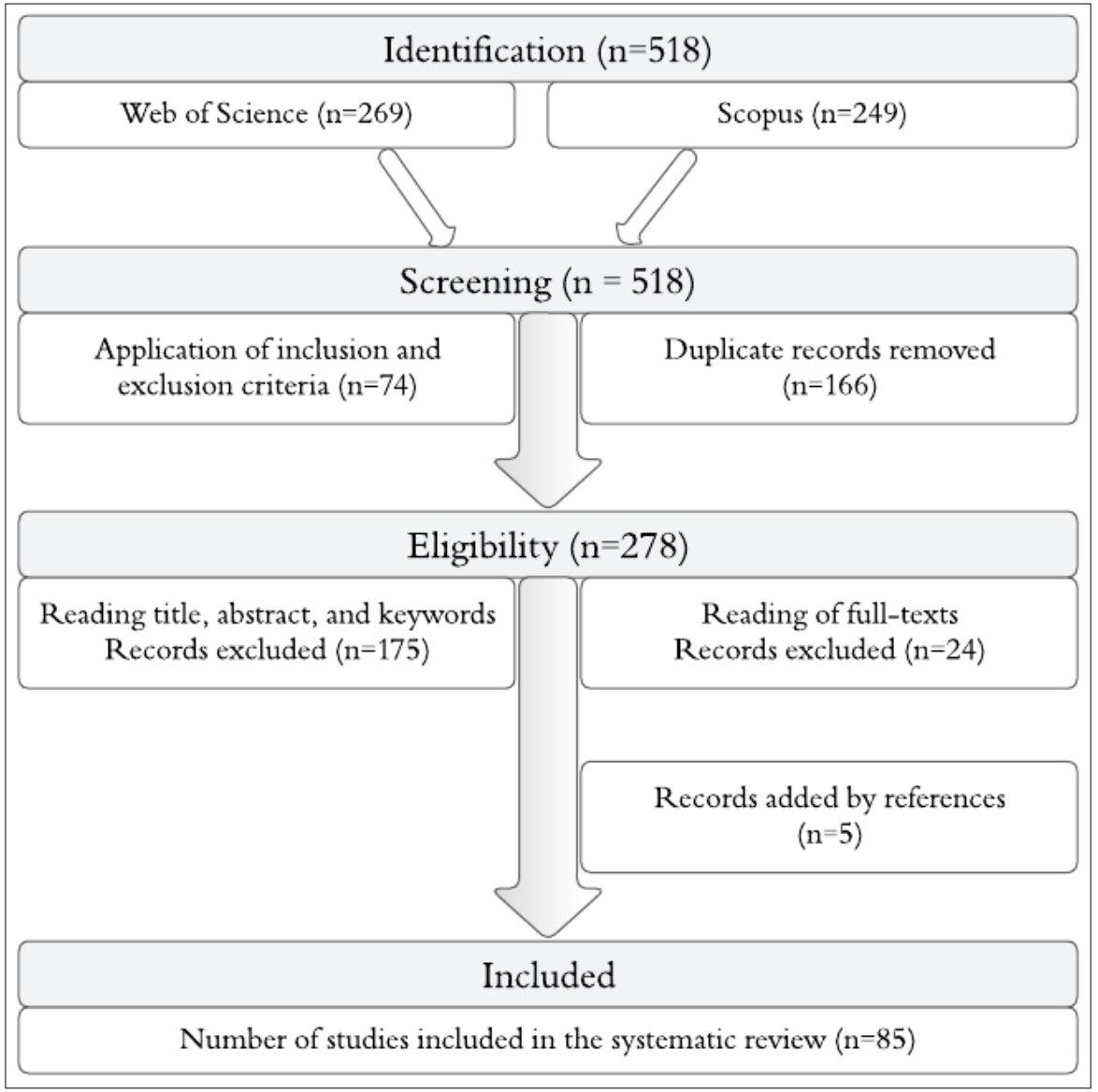
Literature Review Process



Article collection

Parameters	Inputs
Web of science and Scopus query search	(“agriculture” OR “agricultural” OR “farm*") AND ("livestock" OR "husbandry" OR "dairy" OR “poultry” OR “cattle” OR “sheep” OR “pig” OR "beef" OR "milk") AND ("eco-efficiency" OR "environmental efficiency" OR "ecological efficiency" OR "environmental inefficiency" OR "bad output*" OR "undesirable output*" OR "Environmental output*" OR "Environmental good*")
Year	1990 - 2023
Documents types	Articles or book chapters
Language	English

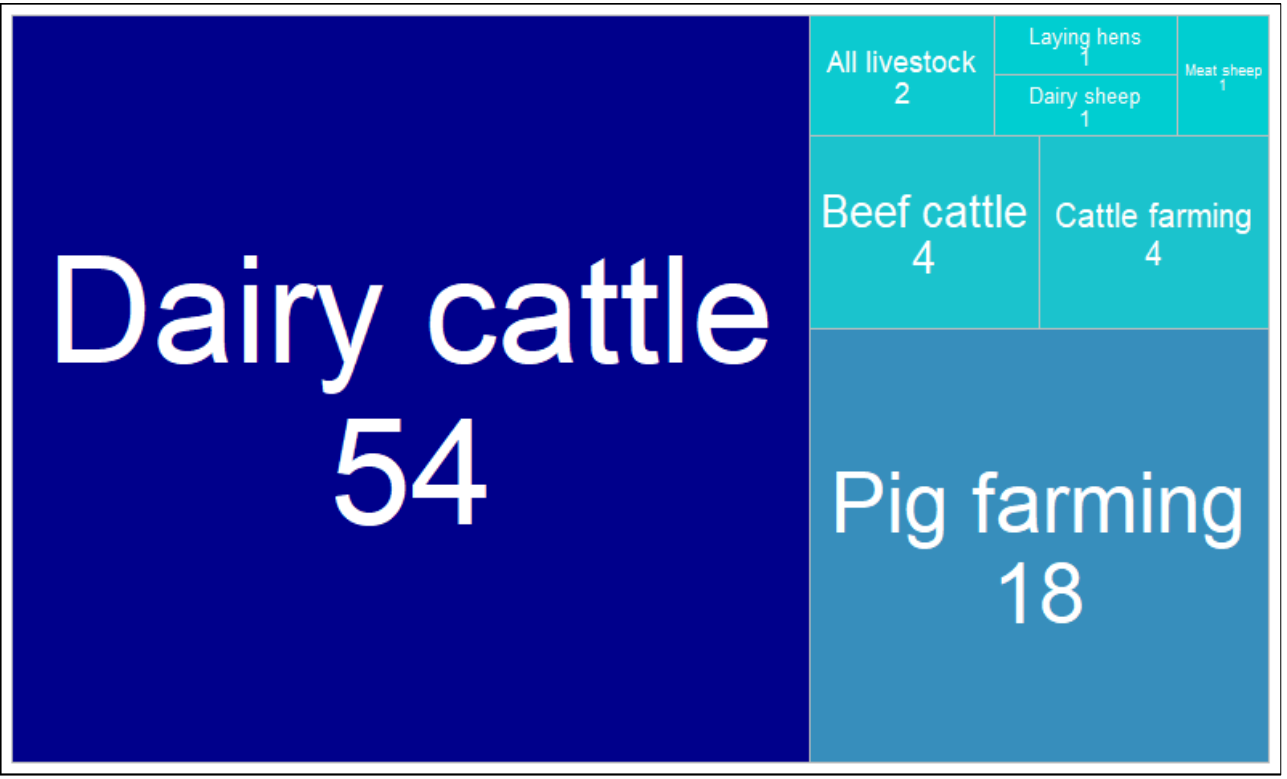
Diagram illustrating the PRISMA method for article selection



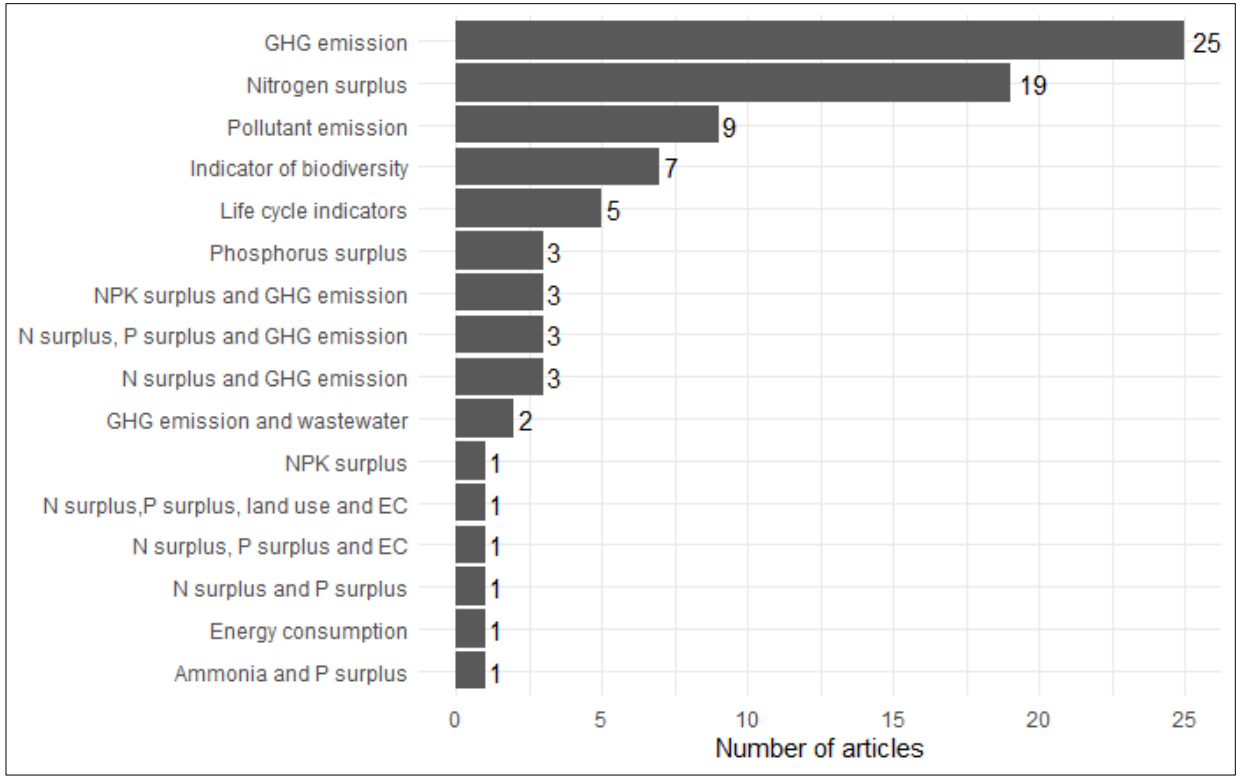
3- Results

General information and descriptive statistics

Number of articles by type of production/livestock

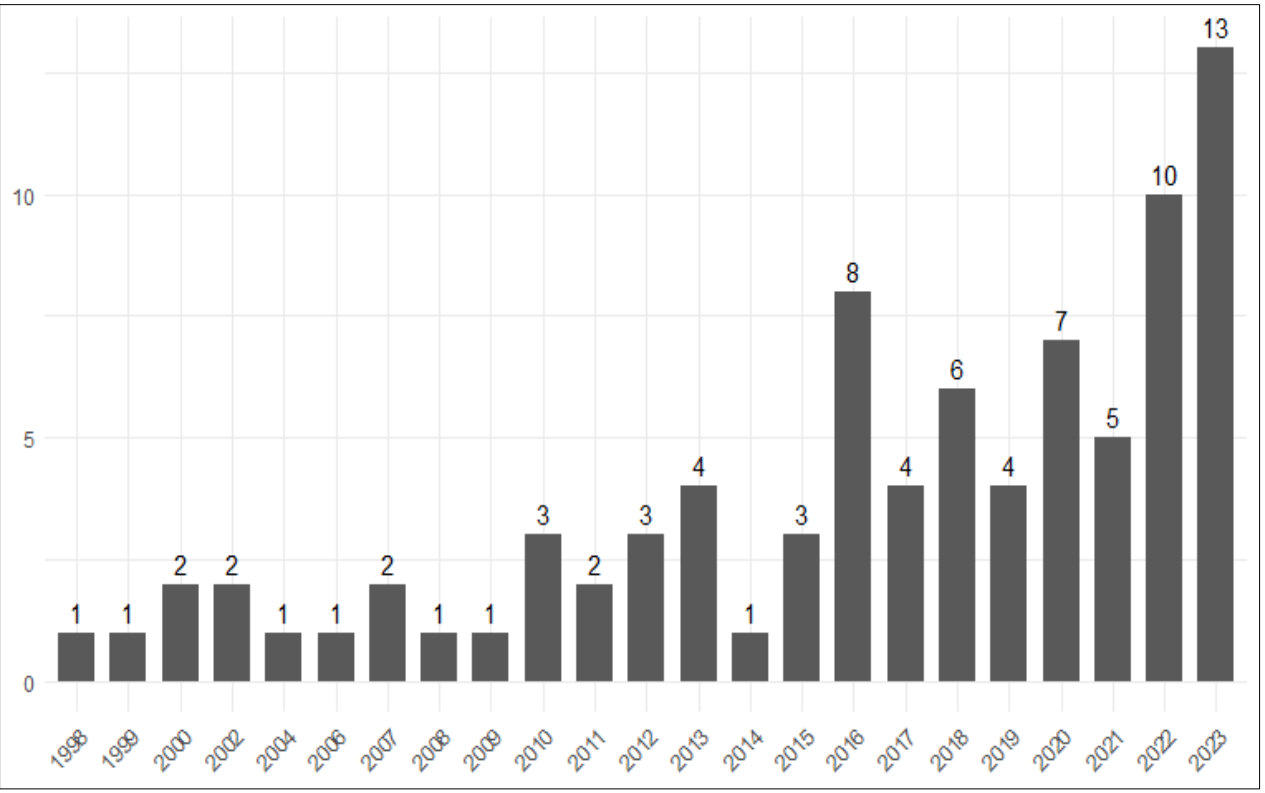


Number of articles by environmental indicator addressed

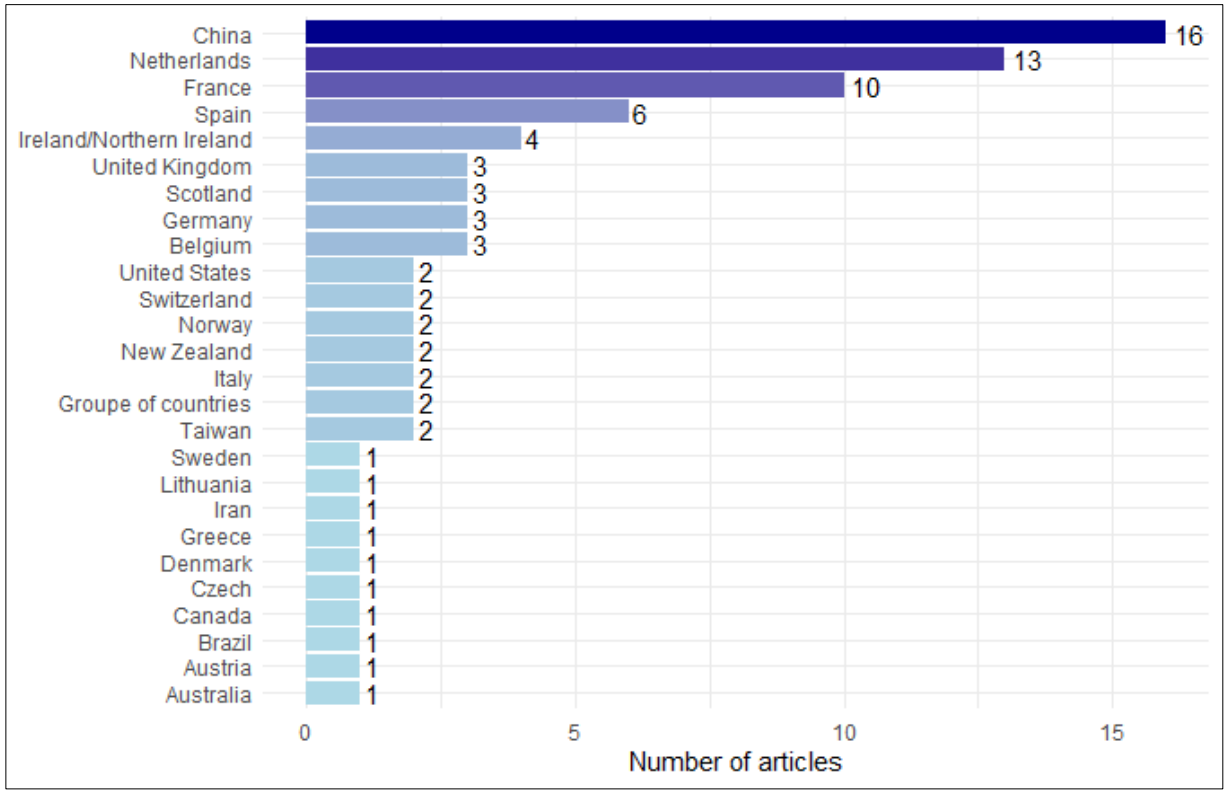


General information and descriptive statistics

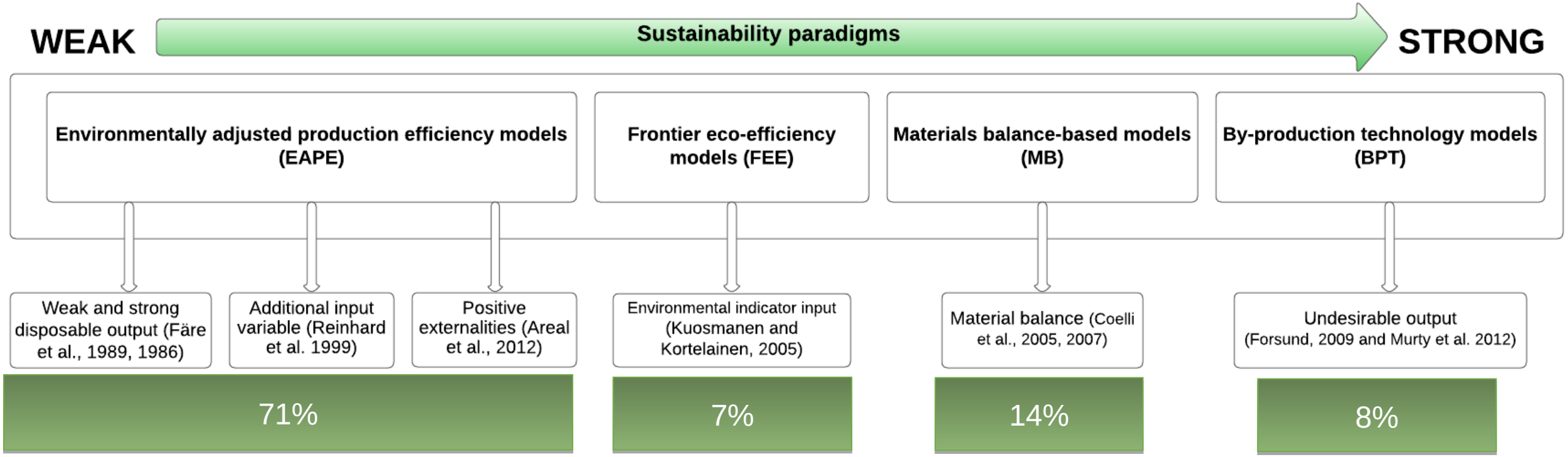
Number of articles published per year



Number of articles by country

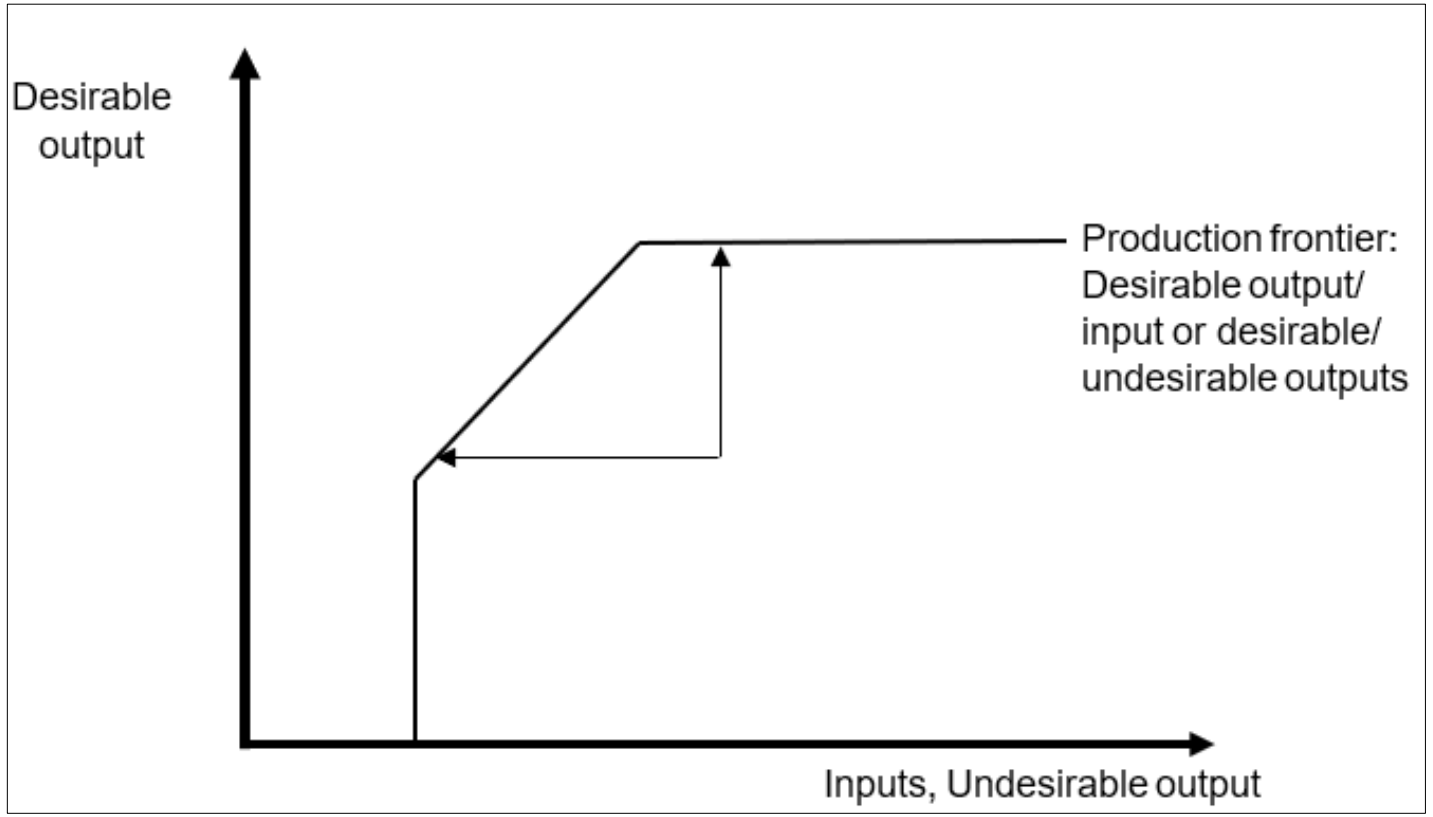


Main approaches for assessing the eco-efficiency of livestock farming



Main approaches for assessing the eco-efficiency of livestock farming

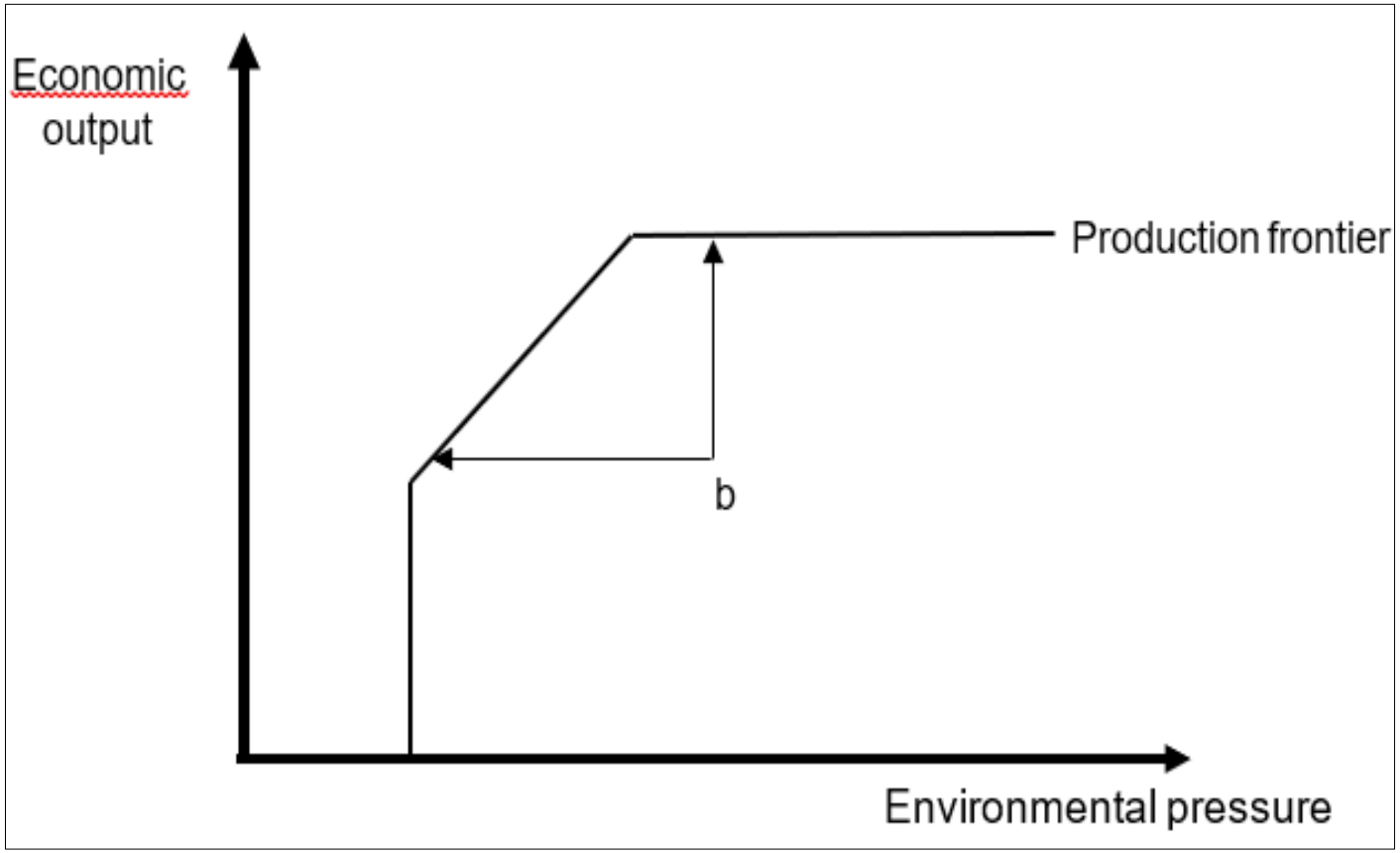
- Environmentally adjusted production efficiency (EAPE) models



- Non-compliance with Thermodynamic Laws
- Neglect of Material Balance Principle
- Abstract Pollution Variables
- Weak Sustainability Focus

Main approaches for assessing the eco-efficiency of livestock farming

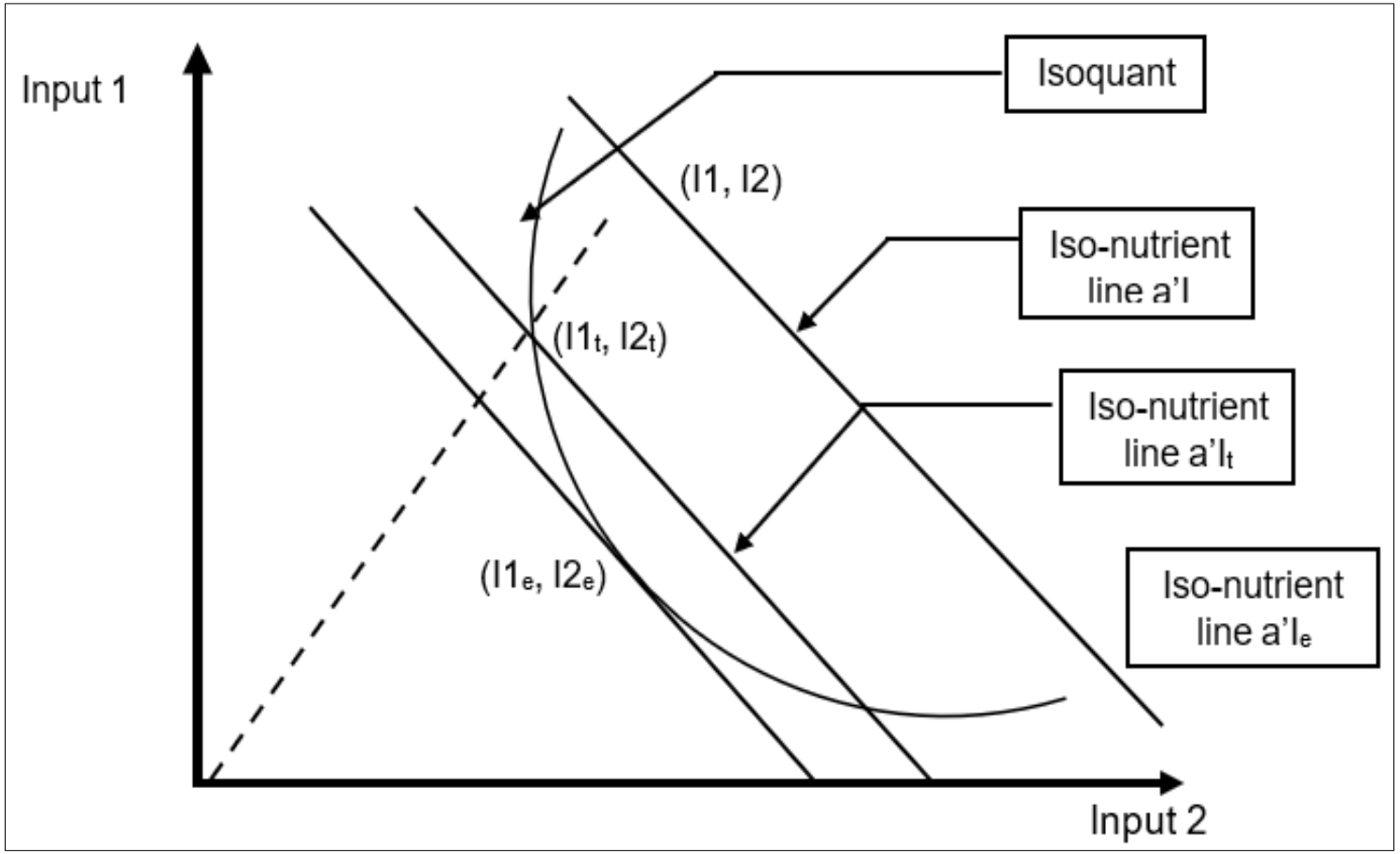
- Frontier eco-efficiency (FEE) models



- Incomplete production process
- Oversimplification
- Weak sustainability alignment

Main approaches for assessing the eco-efficiency of livestock farming

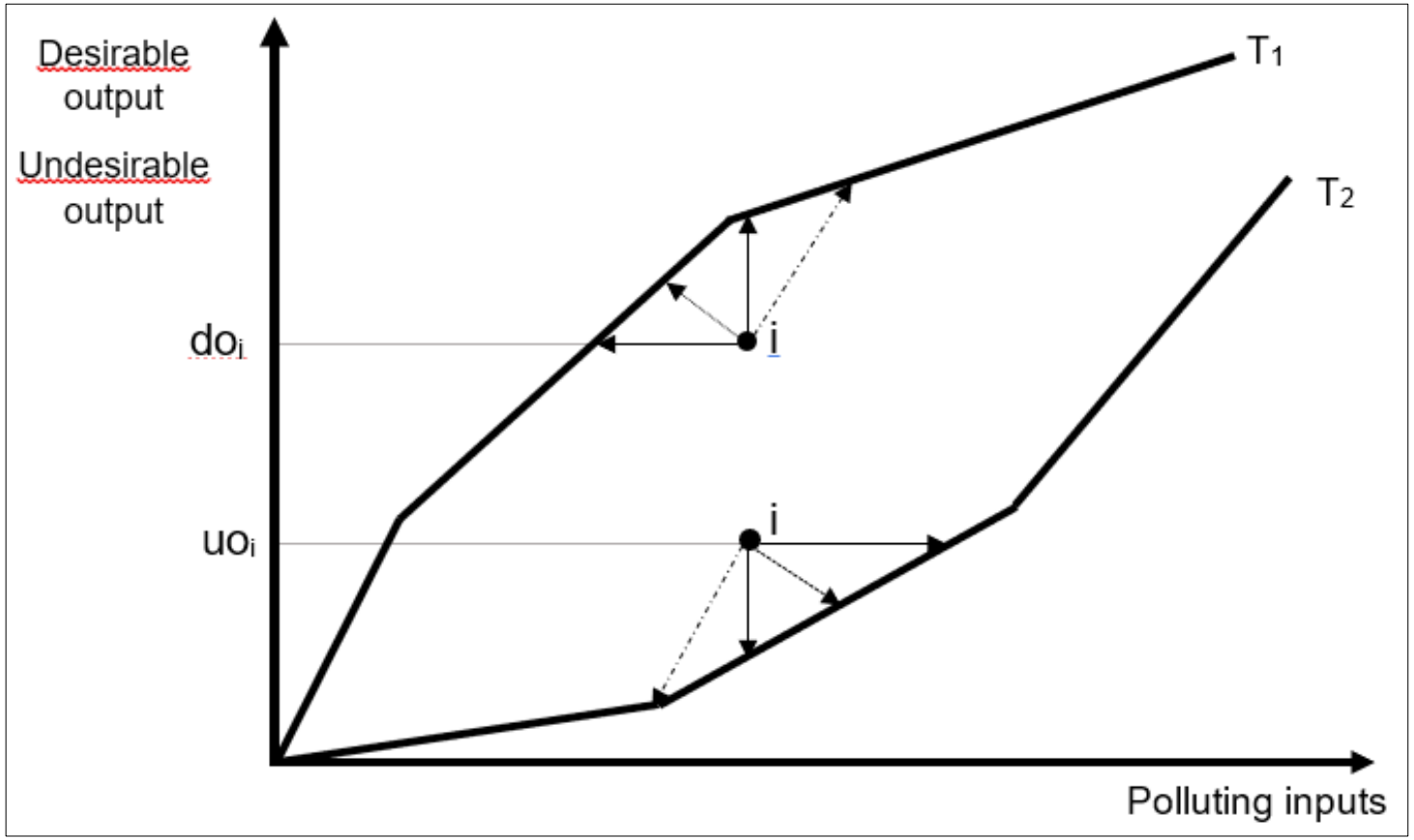
- Materials balance-based (MB) models



- Limited effectiveness for extensive livestock
- Data accuracy challenges
- Measurement difficulties
- Sustainability limitations

Main approaches for assessing the eco-efficiency of livestock farming

- By-production technology (BPT) models



- Pre-definition of inputs
- Subjectivity in input selection
- Independence of sub-technologies
- Sustainability challenges

Eco-efficiency frontier approaches

- Sophisticated tools: Provide advanced tools to balance economic and environmental considerations
- Economic-centered perspective : View the environment through the lens of economic efficiency
- Limited support for sustainability : Does not fully support the agricultural sector’s sustainability goals
- Environment as the primary context : Recognizing the environment as the primary context for production is key
- Embracing strong sustainability : Ensuring farming practices operate within ecological limits

Conclusion

Main results

- Identify research trends in the assessment of eco-efficiency
  - Most research primarily focuses on dairy cattle and pig farming
  - GHG emissions Nitrogen pollution are the main environmental indicators considered
  - Limited attention has been given to biodiversity indicators
  - Very few studies (2%) address positive environmental outputs

- Propose a classification based on the weak and strong sustainability paradigms
  - Frontiers models fail to fully align with the paradigm of strong sustainability
  - Focus on improving production efficiency while reducing environmental impacts
  - By-production technology (BPT) models offer a more coherent and realistic assessment of eco-efficiency

Perspectives for future research

- Investigation of policy recommendations : Influence of different environmental modeling approaches on policy recommendations requires further investigation

- Need for attention on positive outputs: Future research should place more emphasis on positive environmental outputs

- Need for attention on multiple impacts: Future research should address multiple environmental impacts (e.g., climate vs. biodiversity)

- Neglected social dimension : Future studies should incorporate social aspects

Thank You!
Des questions?

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