KU LEUVEN

PROteINSECT
INSECTS AS SUSTAINABLE SOURCES OF PROTEIN

WORK PACKAGE 4

Life Cycle Sustainability Assessment (LCSA)

Grant Agreement No. 312084
THEME: KBBE. 2012.2.3-05
Insects as novel sources of proteins-SICA
April 2016

TEAM WORK PACKAGE 4|

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With strong support of…

PROteINSECT
INSECTS AS SUSTAINABLE SOURCES OF PROTEIN

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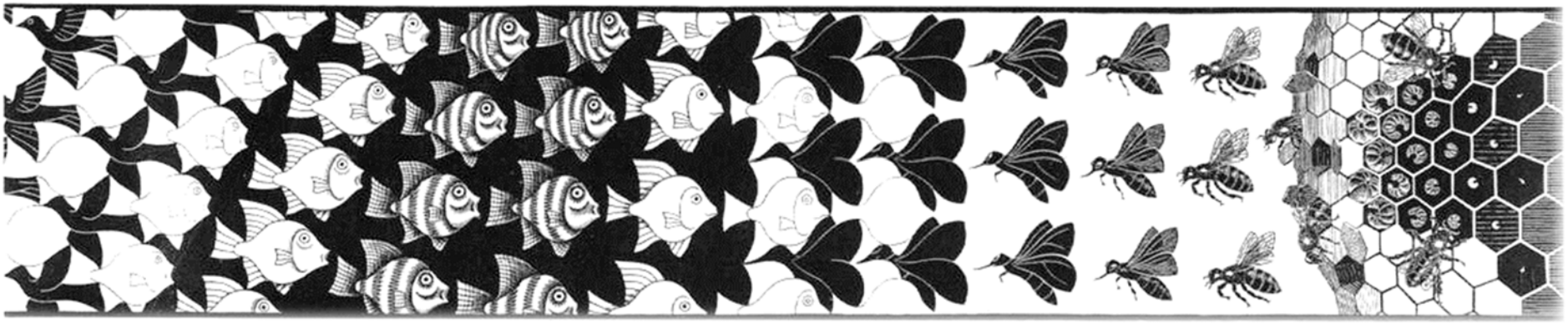
INTRODUCTION| *Objectives*

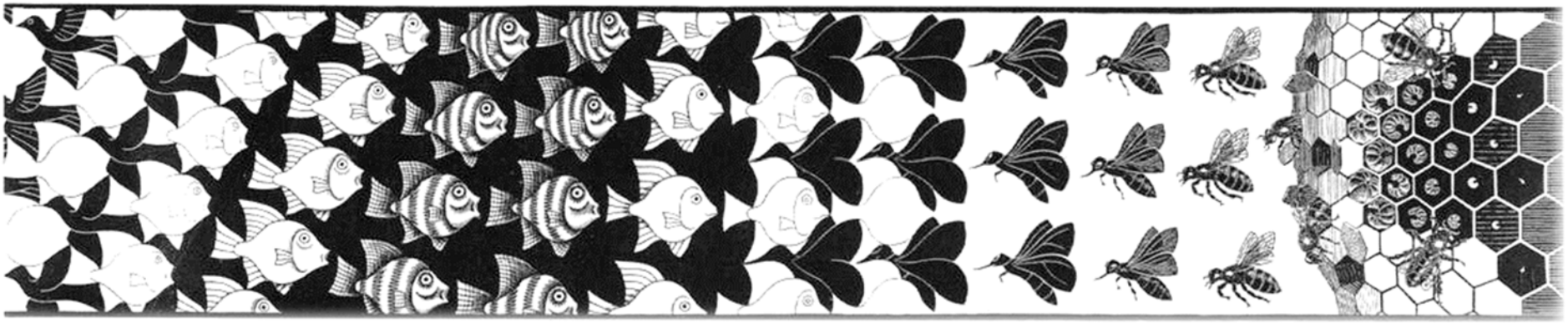


…by Escher

OBJECTIVES

- Align our R&D activities towards agreed sustainability goals
- Ex-ante life cycle sustainability assessment of insect-derived animal feeds in different geographical regions
- Compare the insect product performance with conventional protein feeds
- Develop optimization pathways towards more sustainable insect production systems

SUSTAINABILITY | *Concept*



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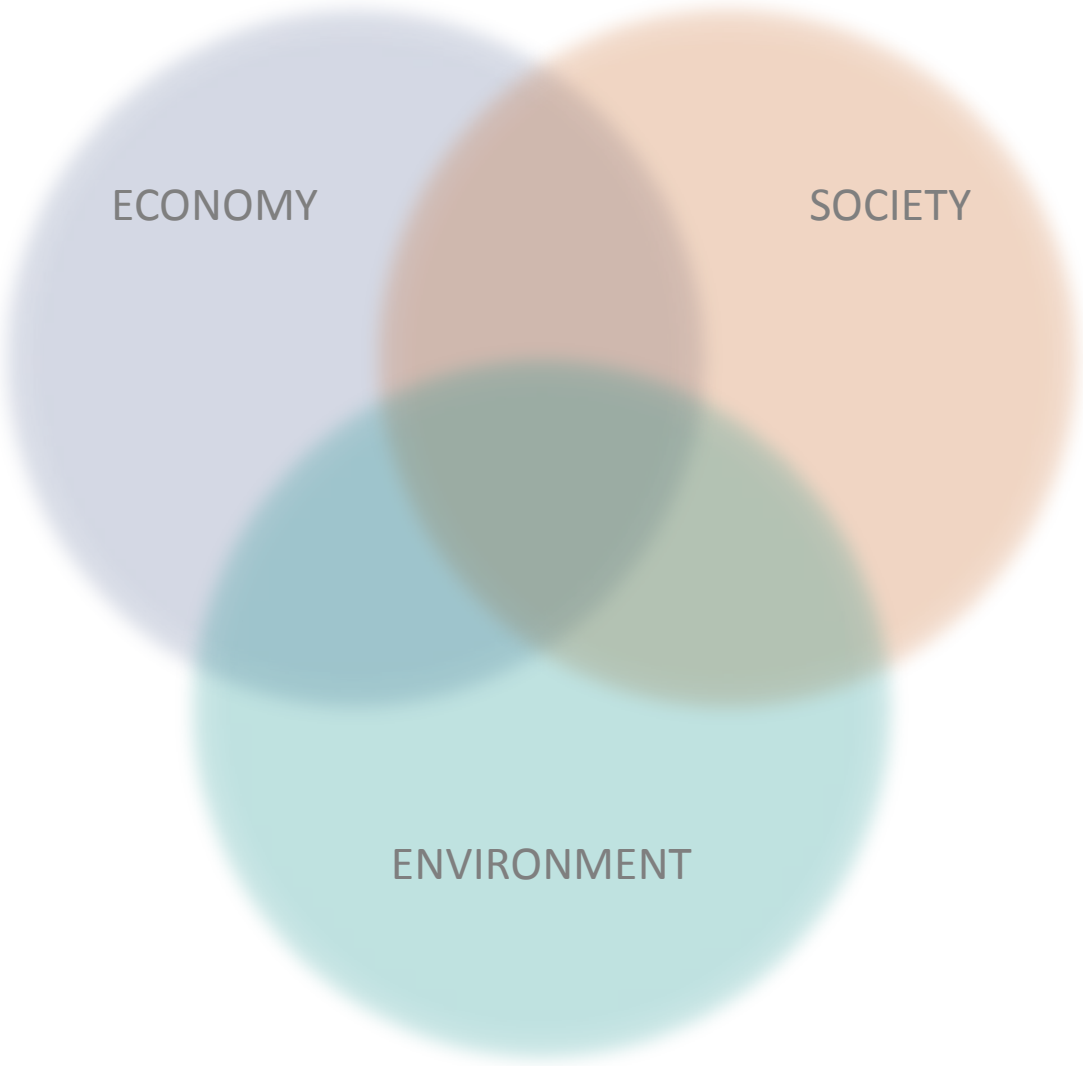
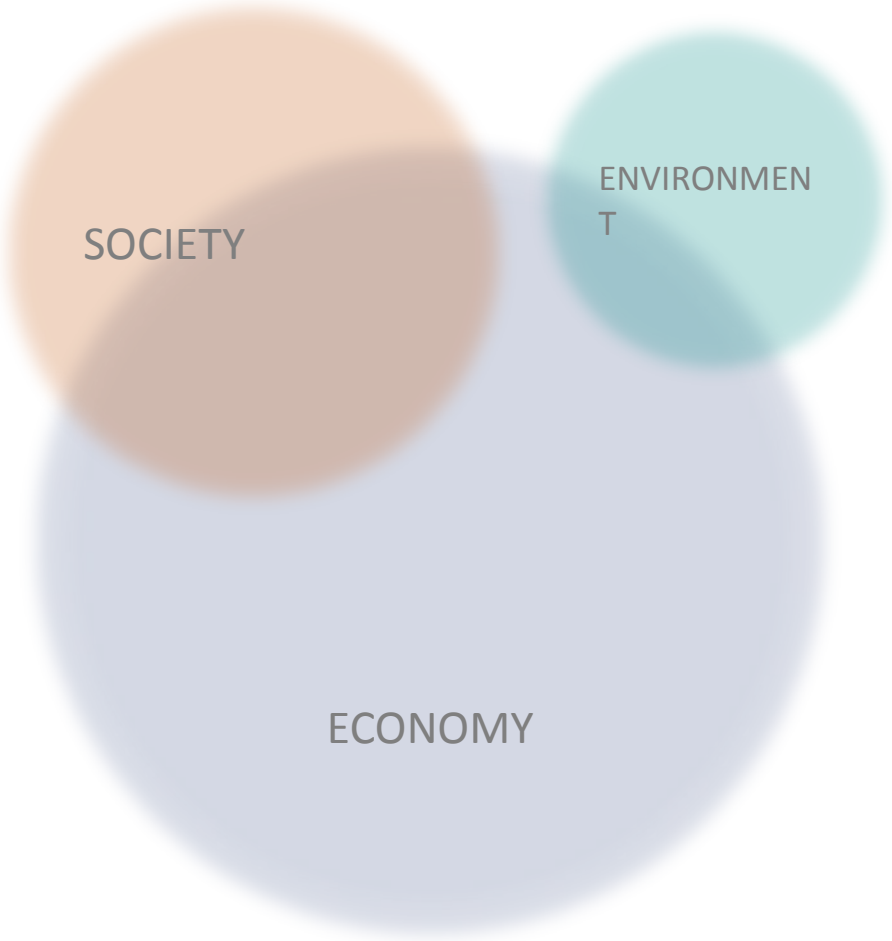
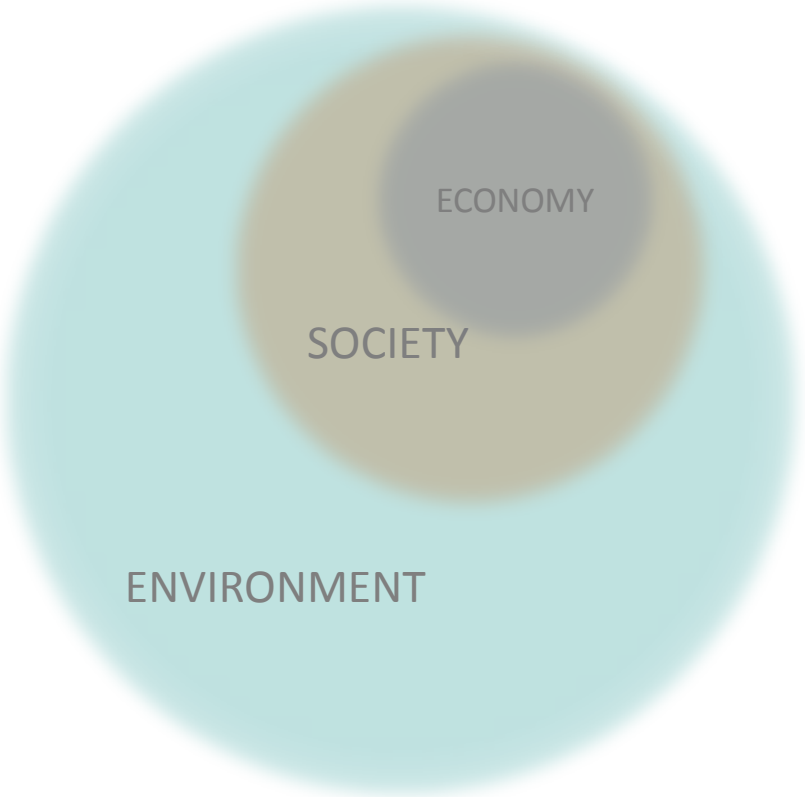


Sustainability| Conventional 3-pillar model

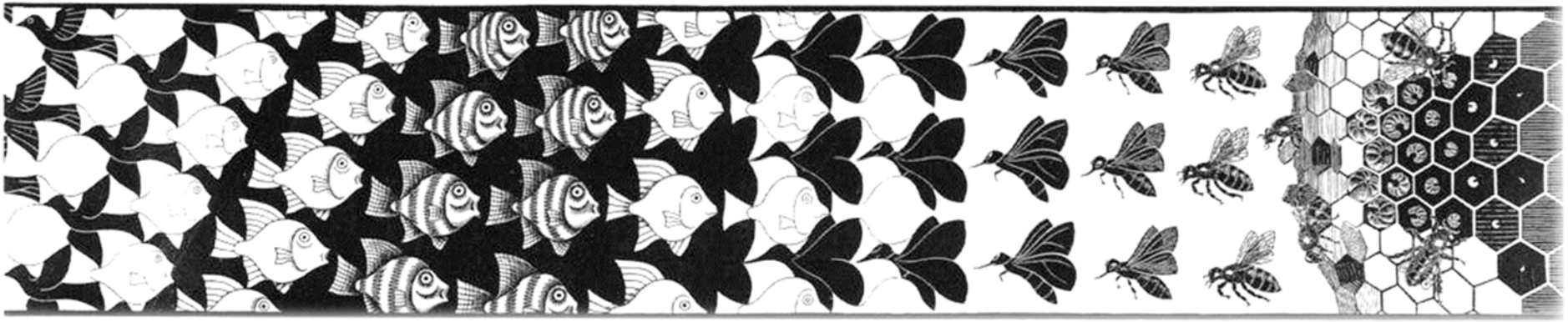


Weak sustainability | “Mickey Mouse”



Strong sustainability| Nested model

METHODOLOGY | *Implementing sustainability criteria in product development*



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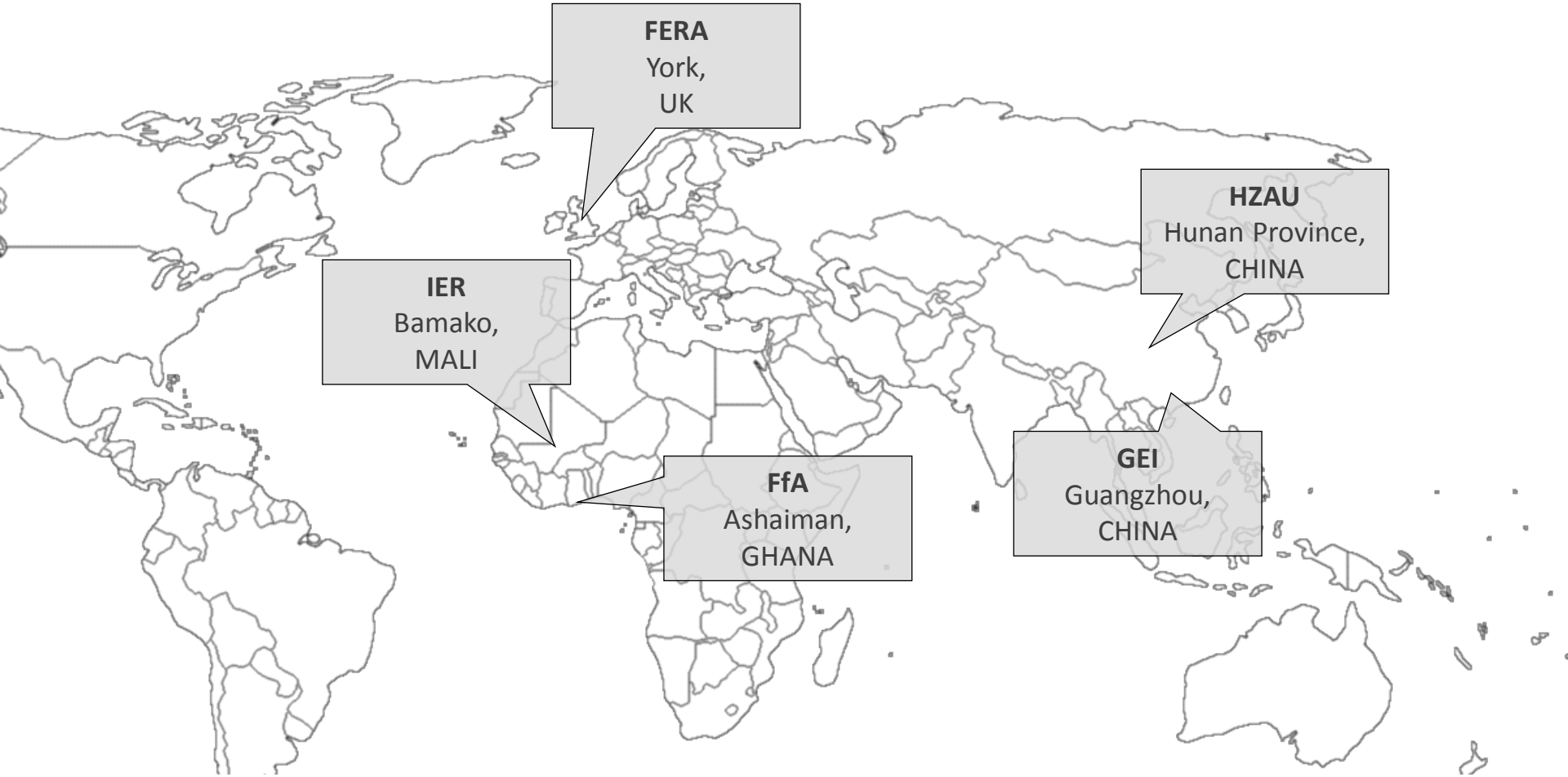
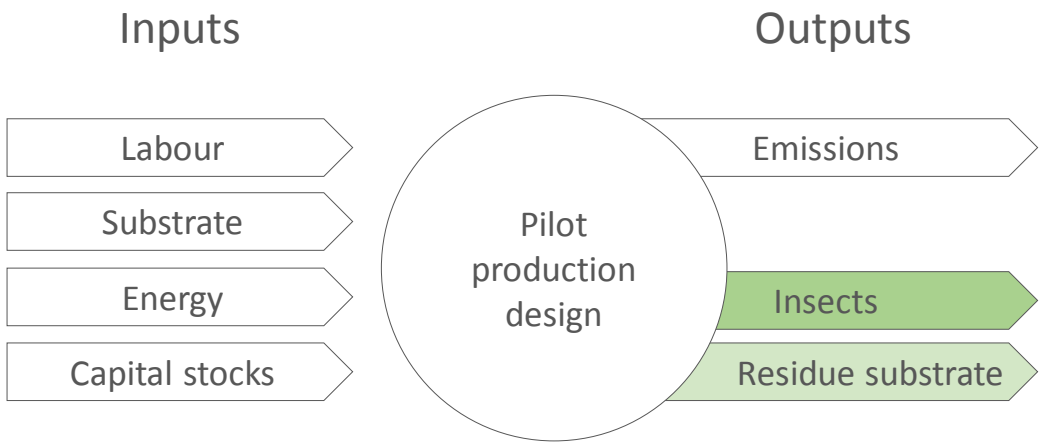
1. Survey of pilot-scale production systems



1. Survey of experimental trials and data gathering
2. Establish Life Cycle inventories of pilot-scale production systems



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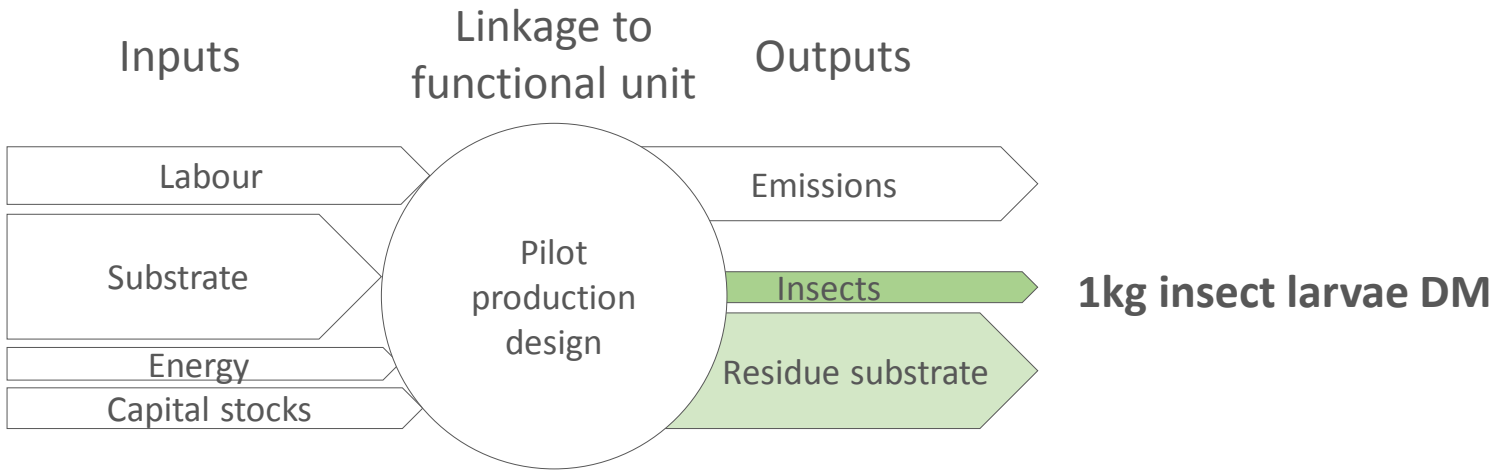
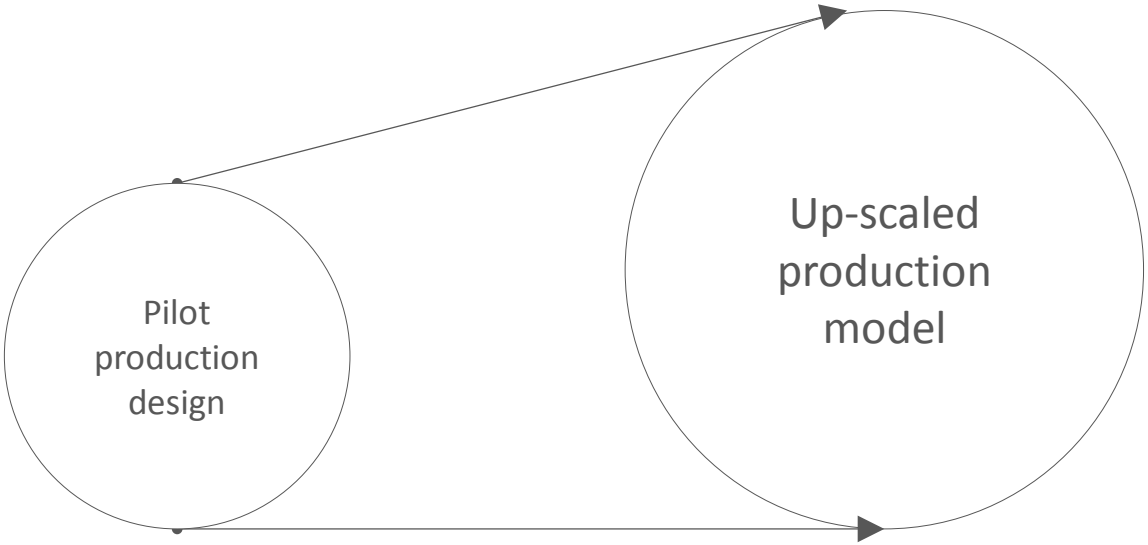


1. Survey of experimental trials and data gathering
2. Establish Life Cycle inventories of production trials
3. Modelling of up-scaled system versions

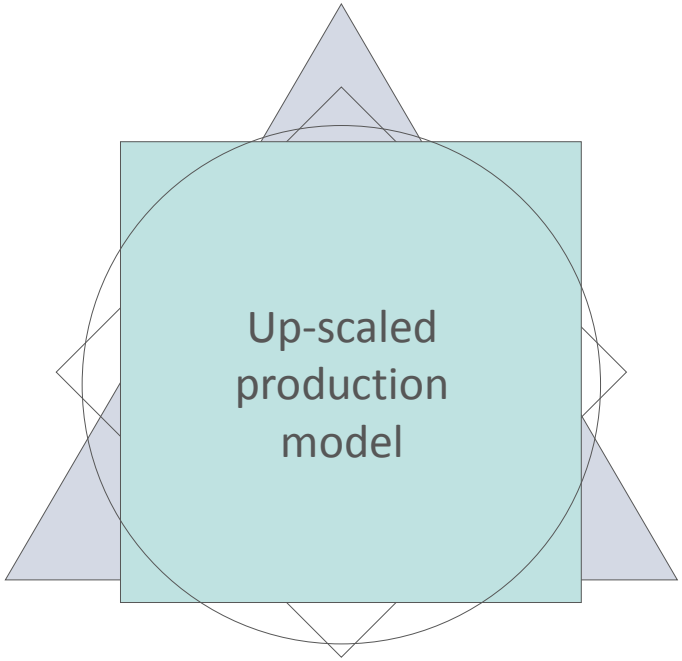


1. Survey of experimental trials and data gathering
2. Establish Life Cycle inventories of production trials
3. Modelling of up-scaled system versions
4. Characterization

Economic characterization

Societal characterization

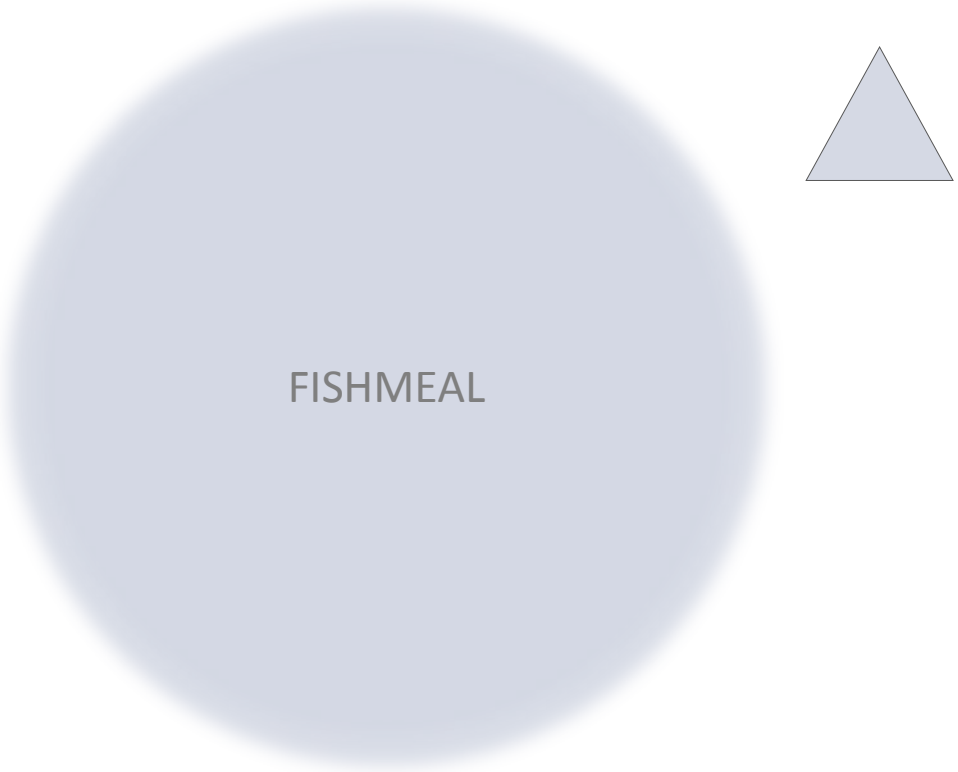
Environmental characterization



1. Survey of experimental trials and data gathering
2. Establish Life Cycle inventories of production trials
3. Modelling of up-scaled system versions
4. Characterization
5. Ex-ante sustainability assessment (benchmarking against fishmeal)

   Economic performance

   Production costs | market price



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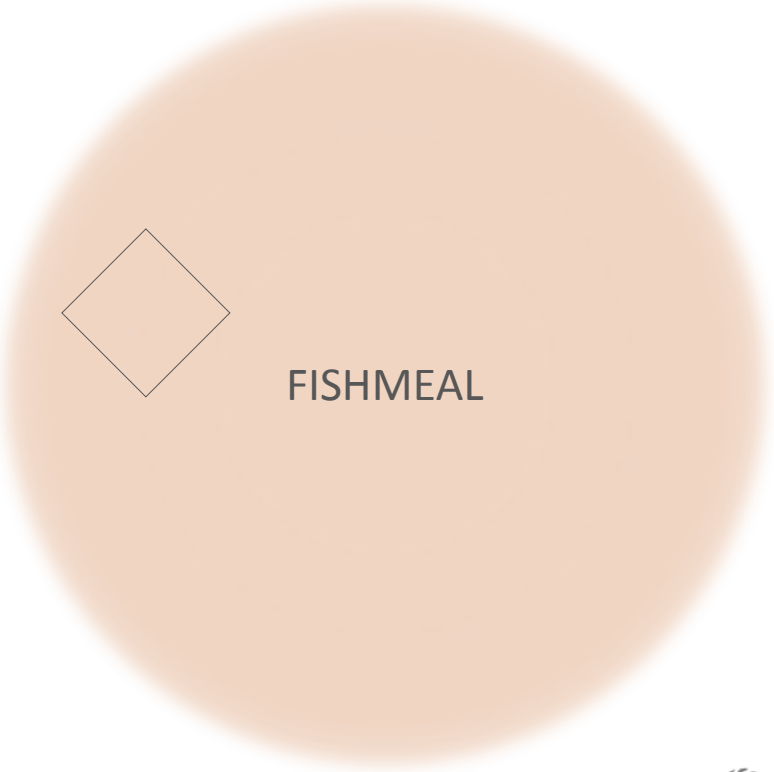
   Societal performance

   (i) Economic strain of labour inputs

   (ii) Local welfare benefits



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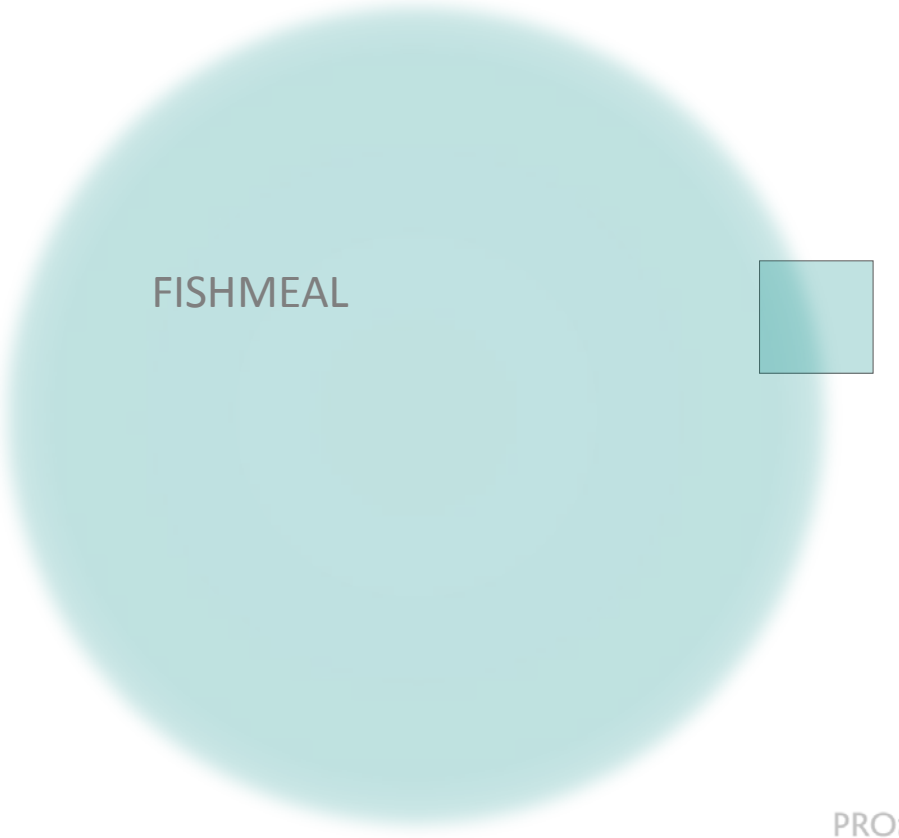
   Environmental performance

   ReCiPe methodology | SimaPro®



ReCiPe METHOD | Impact categories assessed at midpoint level

IMPACT CATEGORY	ABBR.	CHARACTERIZATION FACTOR	UNIT
climate change	CC	global warming potential	kg (CO_2 to air)
ozone depletion	OD	ozone depletion potential	kg (CFC-11 to air)
terrestrial acidification	TA	terrestrial acidification potential	kg (SO_2 to air)
freshwater eutrophication	FE	freshwater eutrophication potential	kg (P to freshwater)
marine eutrophication	ME	marine eutrophication potential	kg (N to freshwater)
human toxicity	HT	human toxicity potential	kg (14DCB to urban air)
photochemical oxidant formation	POF	photochemical oxidant formation potential	kg (NMVOC to air)
particulate matter formation	PMF	particulate matter formation potential	kg (PM_{10} to air)
terrestrial ecotoxicity	TET	terrestrial ecotoxicity potential	kg (14DCB to industrial soil)
freshwater ecotoxicity	FET	freshwater ecotoxicity potential	kg (14DCB to freshwater)
marine ecotoxicity	MET	marine ecotoxicity potential	kg (14-DCB to marine water)
ionising radiation	IR	ionising radiation potential	kg (U^{235} to air)
agricultural land occupation	ALO	agricultural land occupation potential	m^2×yr (agricultural land)
urban land occupation	ULO	urban land occupation potential	m^2×yr (urban land)
natural land transformation	NLT	natural land transformation potential	m^2 (natural land)
water depletion	WD	water depletion potential	m^3 (water)
mineral resource depletion	MRD	mineral depletion potential	kg (Fe)
fossil resource depletion	FD	fossil depletion potential	kg (oil)

1. Survey of experimental trials and data gathering
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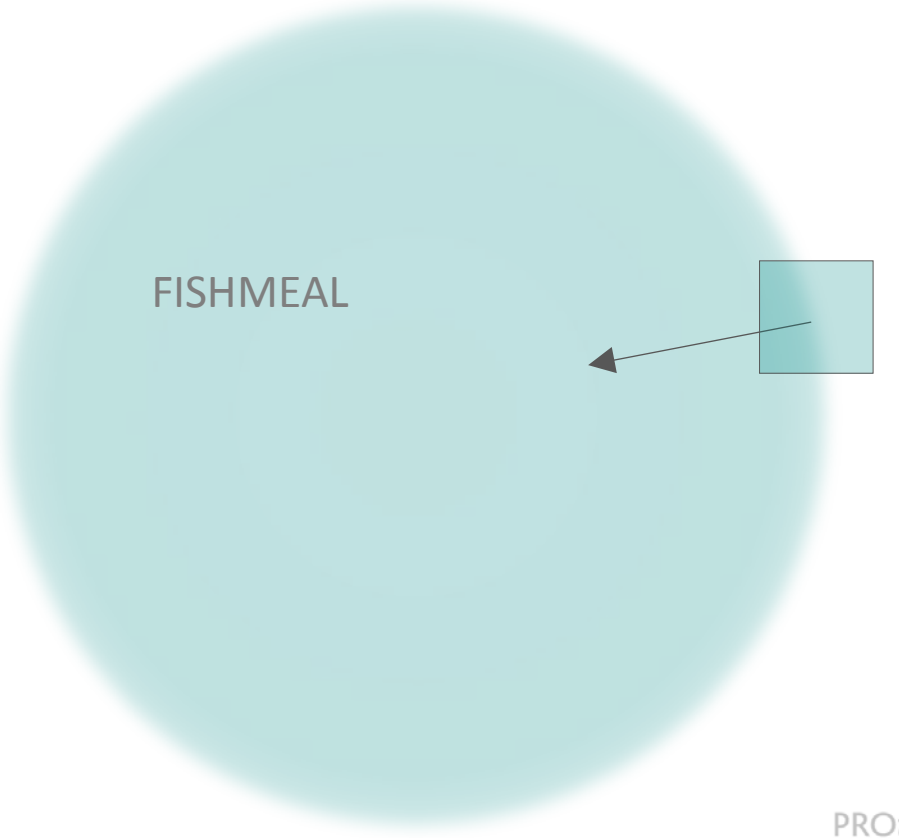
5. Ex-ante sustainability assessment (benchmarking against fishmeal)
6. Developing optimization pathways



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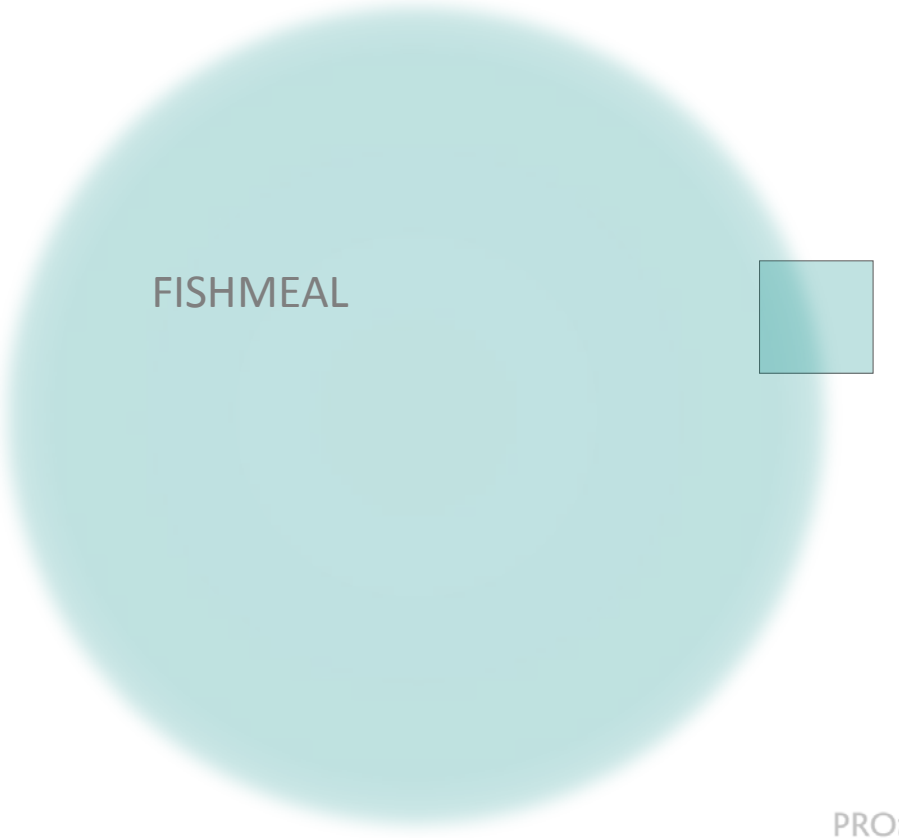
→ Implement optimization pathways



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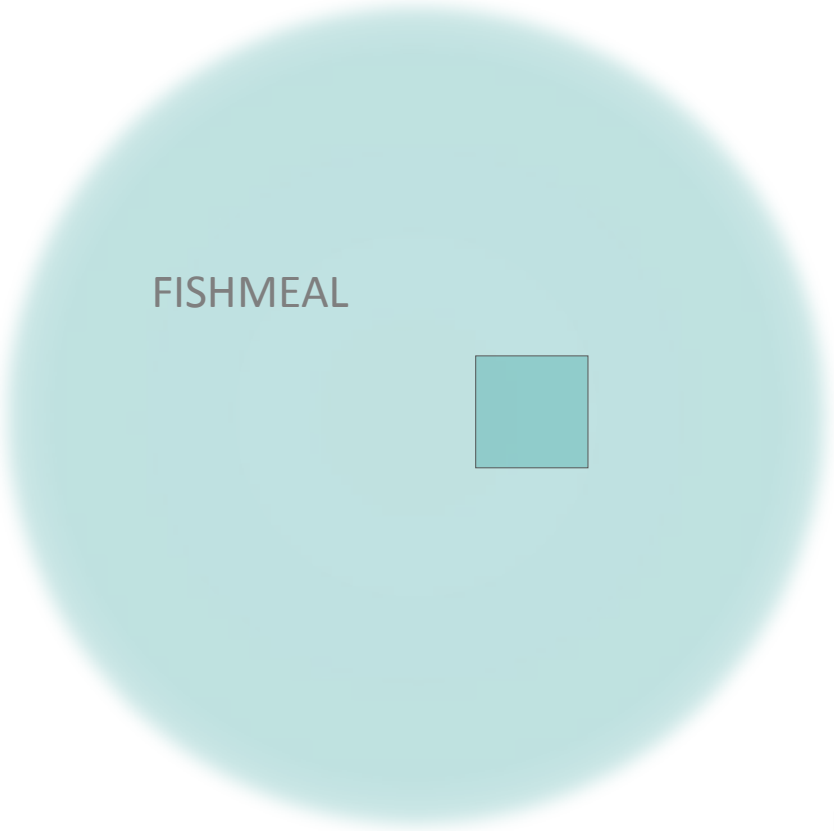
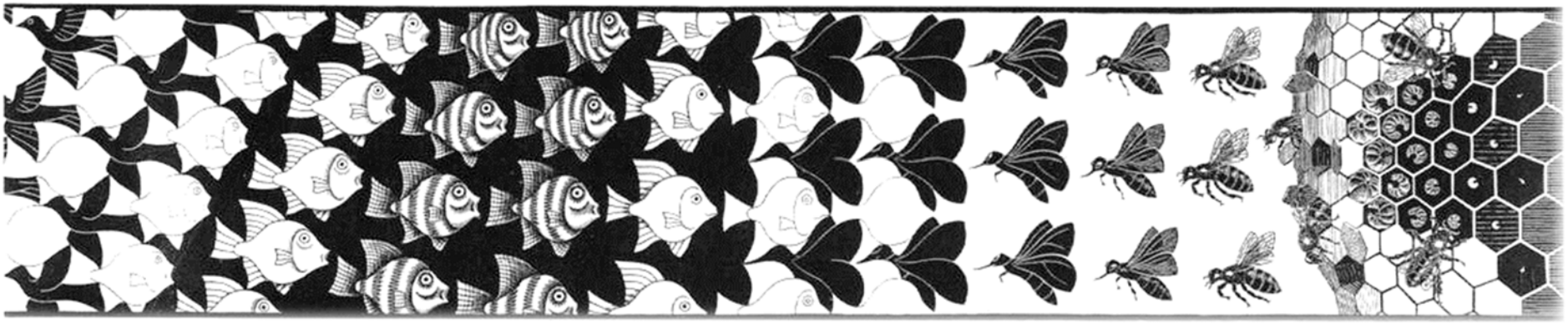
∞ Rerun assessments



RESULTS | Socioeconomic and environmental performance of insect based feeds compared to fishmeal



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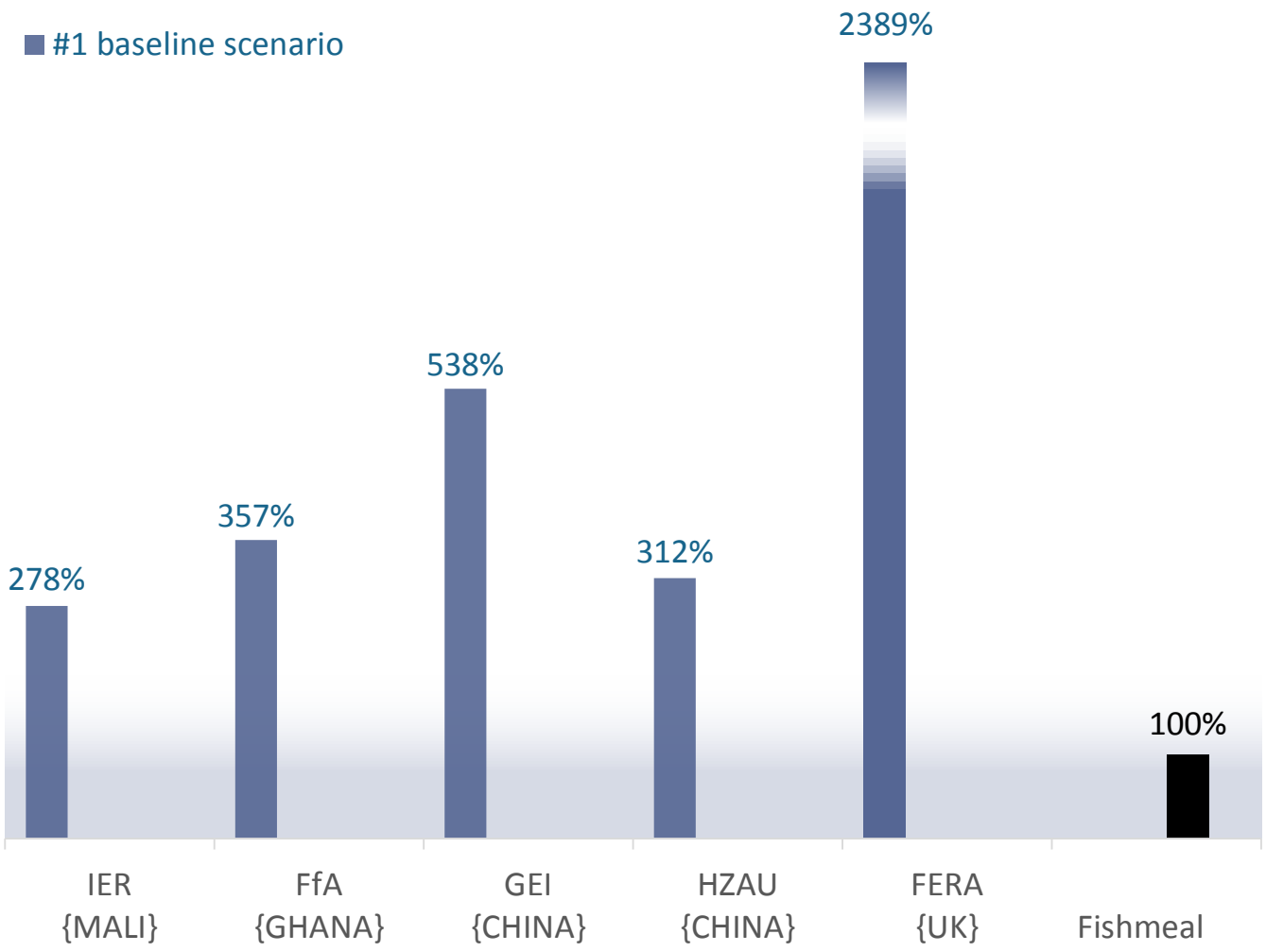
ECONOMIC PERFORMANCE |

Estimated production costs in percentage to the market price of fishmeal



ECONOMY

ECONOMIC PERFORMANCE |

#2 OPTIMIZATION PATHWAYS

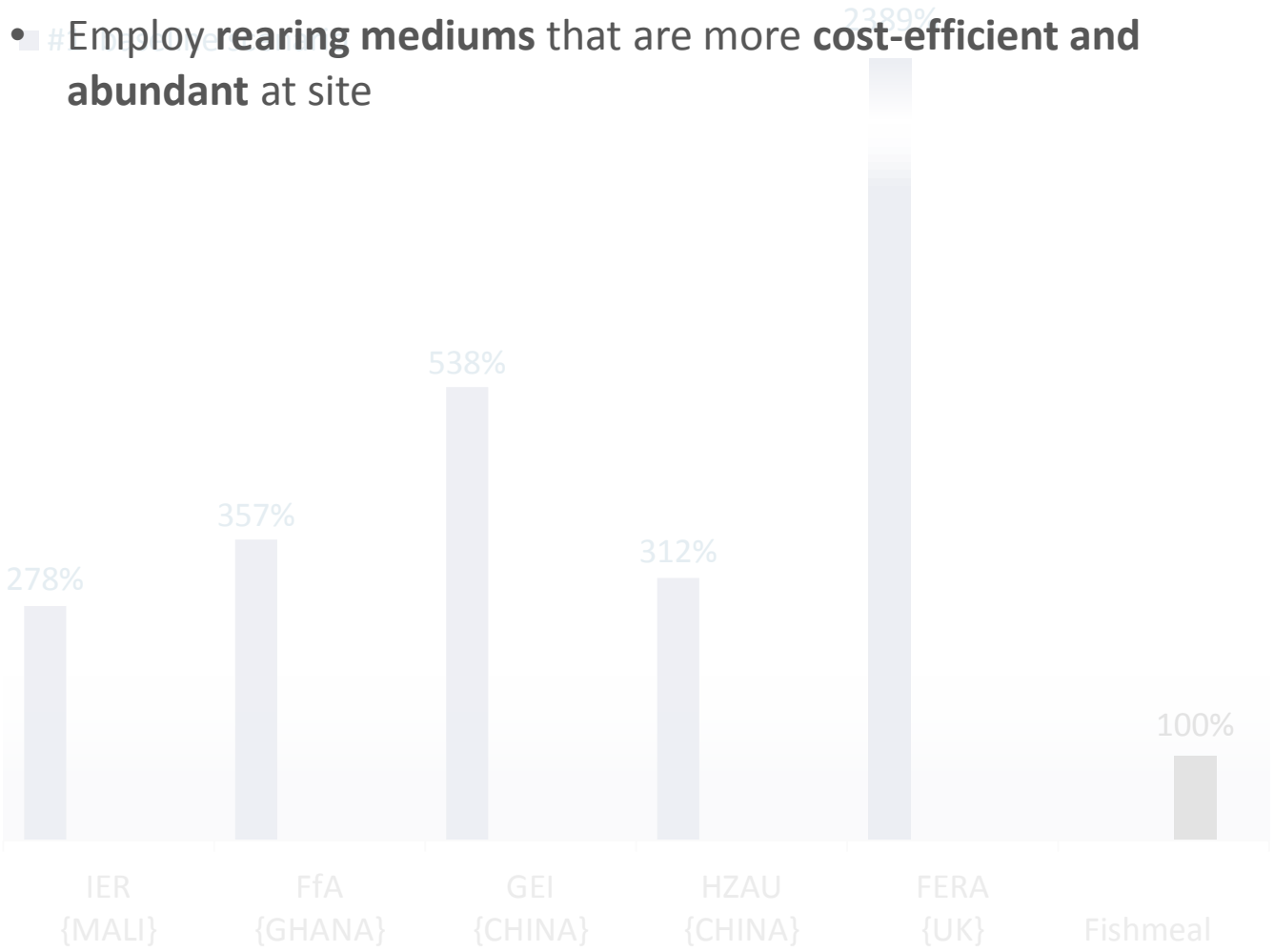
Estimated production costs in percentage to the market price of fishmeal

- Assume production in **close proximity to substrate** providing facilities

ECONOMY

#2 OPTIMIZATION PATHWAYS

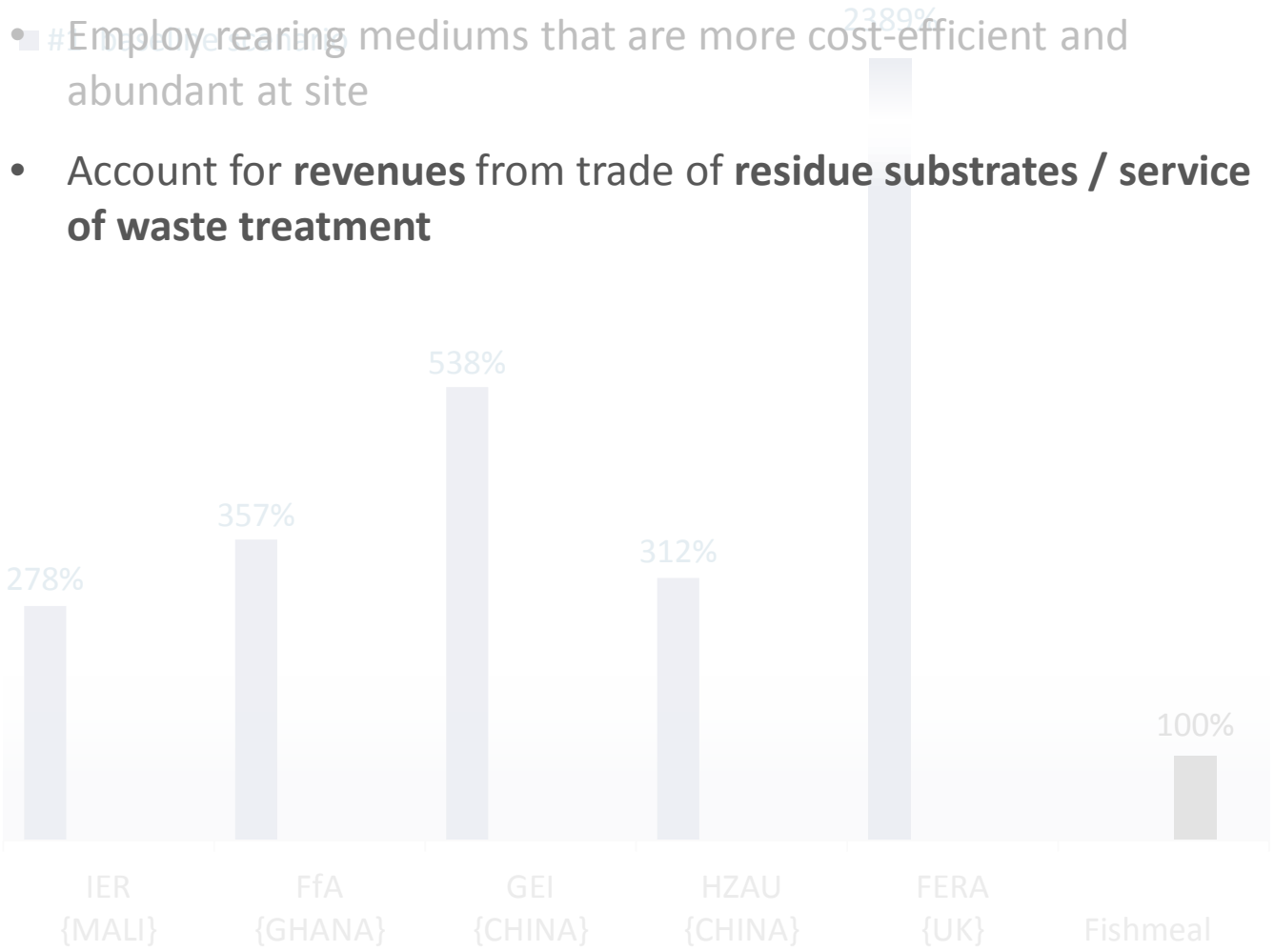
- Assume production in close proximity to substrate providing facilities
- Employ **rearing mediums** that are more **cost-efficient and abundant** at site



ECONOMY

#2 OPTIMIZATION PATHWAYS

- Assume production in close proximity to substrate providing facilities
- Employ rearing mediums that are more cost-efficient and abundant at site
- Account for **revenues** from trade of **residue substrates / service of waste treatment**



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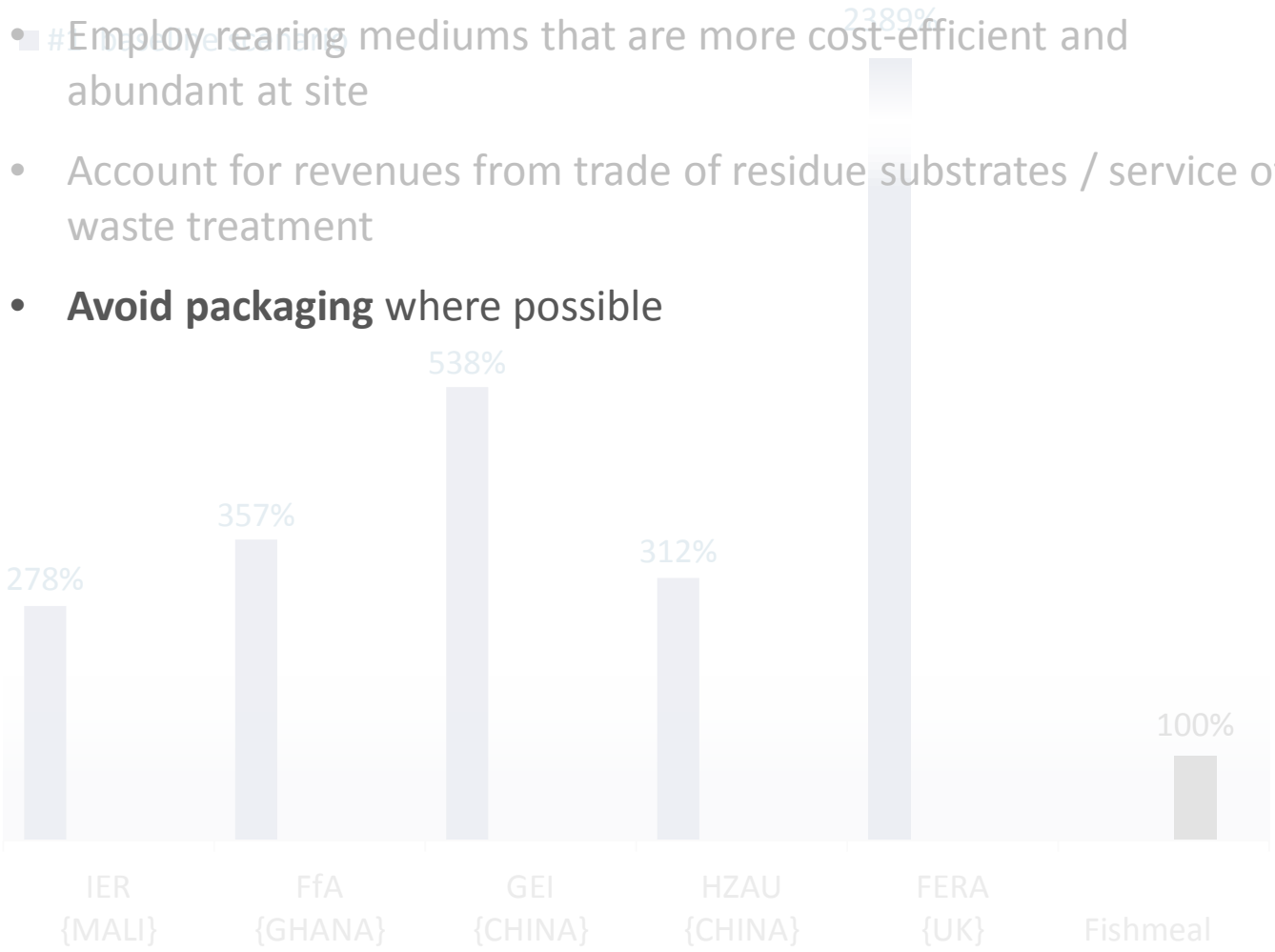
ECONOMY

ECONOMIC PERFORMANCE |

Estimated production costs in percentage to the market price of fishmeal

#2 OPTIMIZATION PATHWAYS

- Assume production in close proximity to substrate providing facilities
- Employ rearing mediums that are more cost-efficient and abundant at site
- Account for revenues from trade of residue substrates / service of waste treatment
- **Avoid packaging** where possible



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ECONOMY

#2 OPTIMIZATION PATHWAYS

- Assume production in close proximity to substrate providing facilities
- Employ rearing mediums that are more cost-efficient and abundant at site
- Account for revenues from trade of residue substrates / service of waste treatment
- Avoid packaging where possible
- Change source of electrical energy to **grid-tied solar panels**

ECONOMY

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- Assume production in close proximity to substrate providing facilities
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- Change source of electrical energy to grid-tied solar panels
- Imply the use of **longer-lasting construction** materials

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ECONOMY

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- Assume production in close proximity to substrate providing facilities
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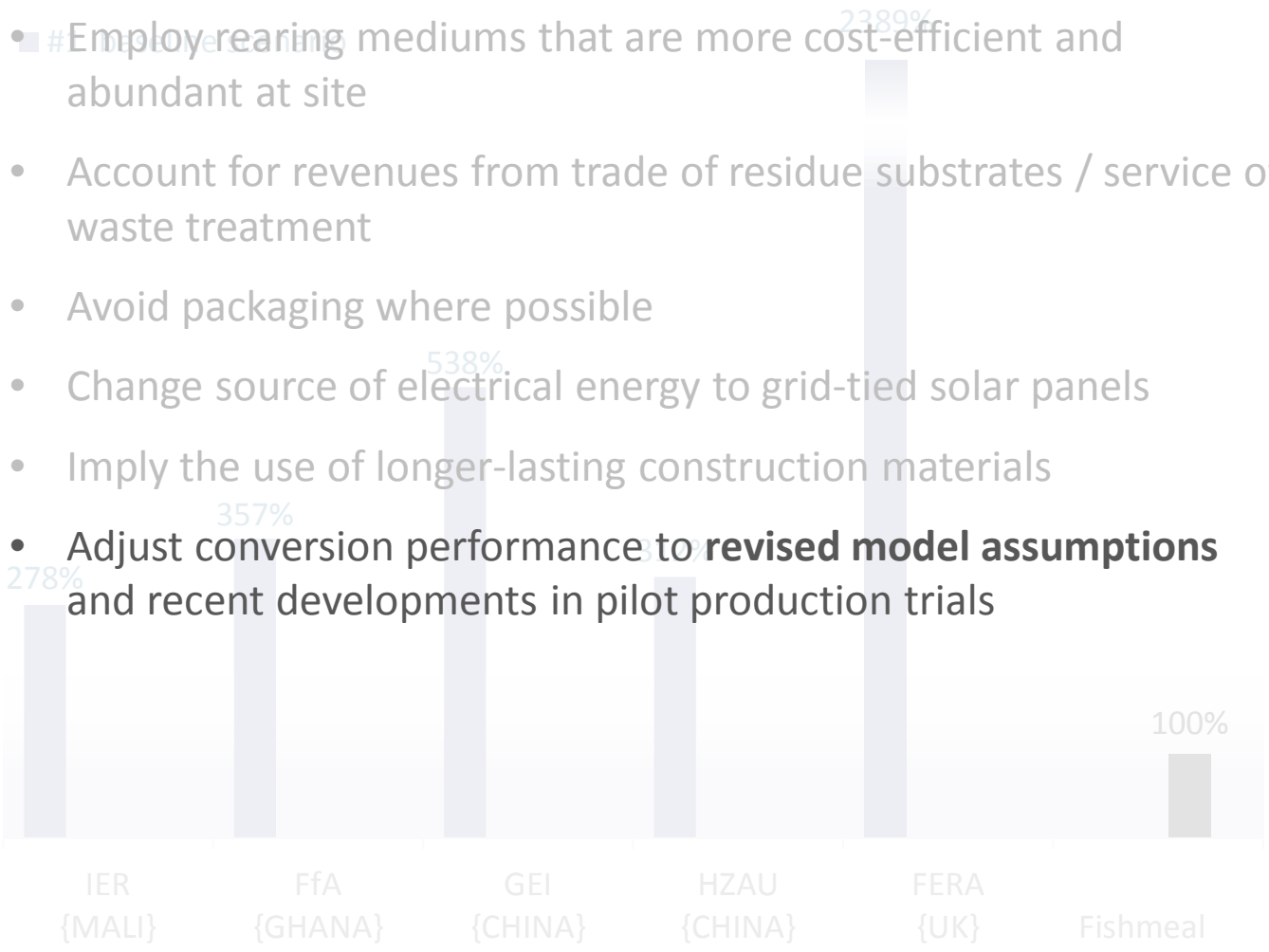
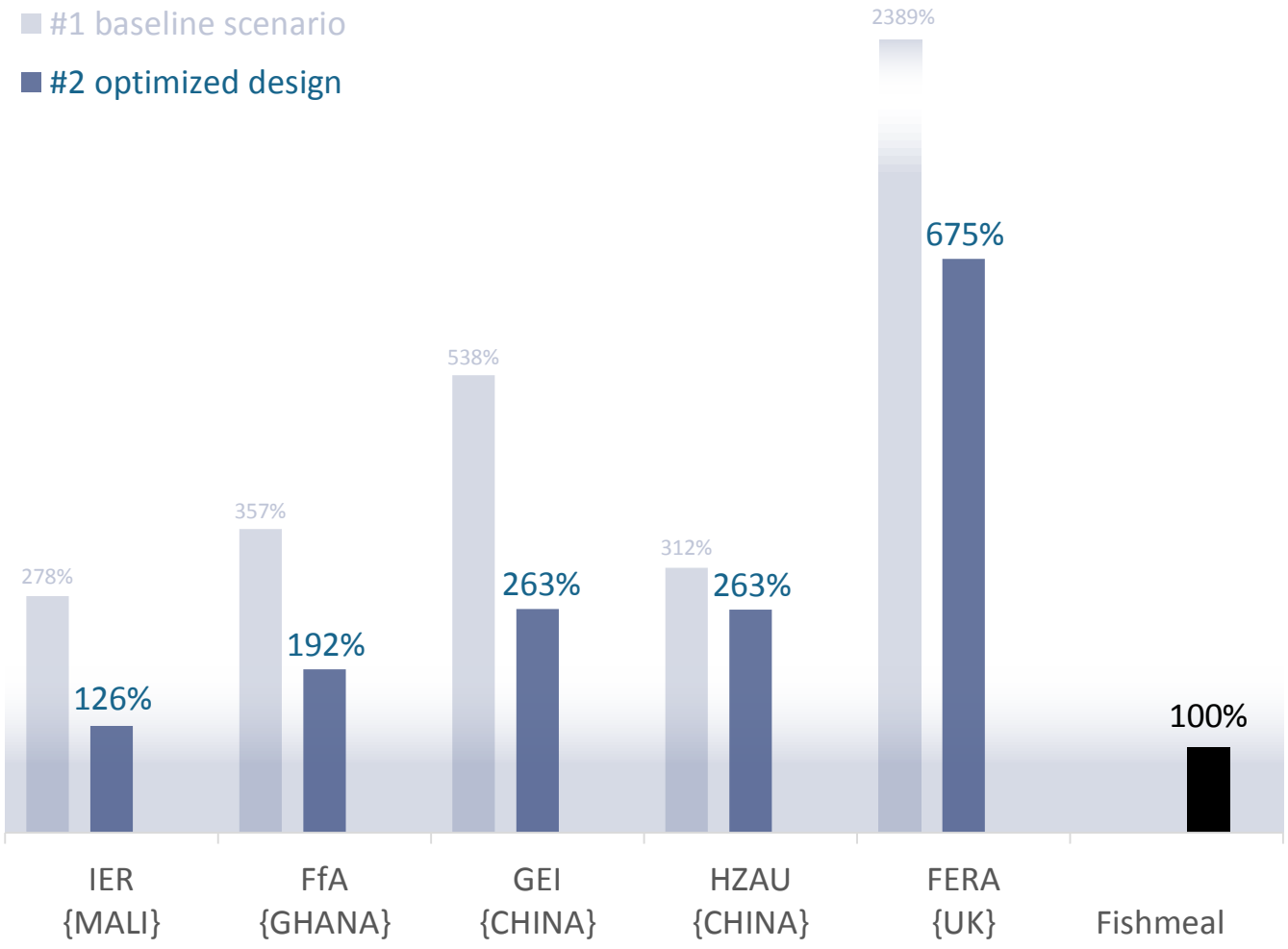
- Avoid packaging where possible
- Change source of electrical energy to grid-tied solar panels
- Imply the use of longer-lasting construction materials
- Adjust conversion performance to **revised model assumptions** and recent developments in pilot production trials



ECONOMY

ECONOMIC PERFORMANCE |

Estimated production costs in percentage to the market price of fishmeal

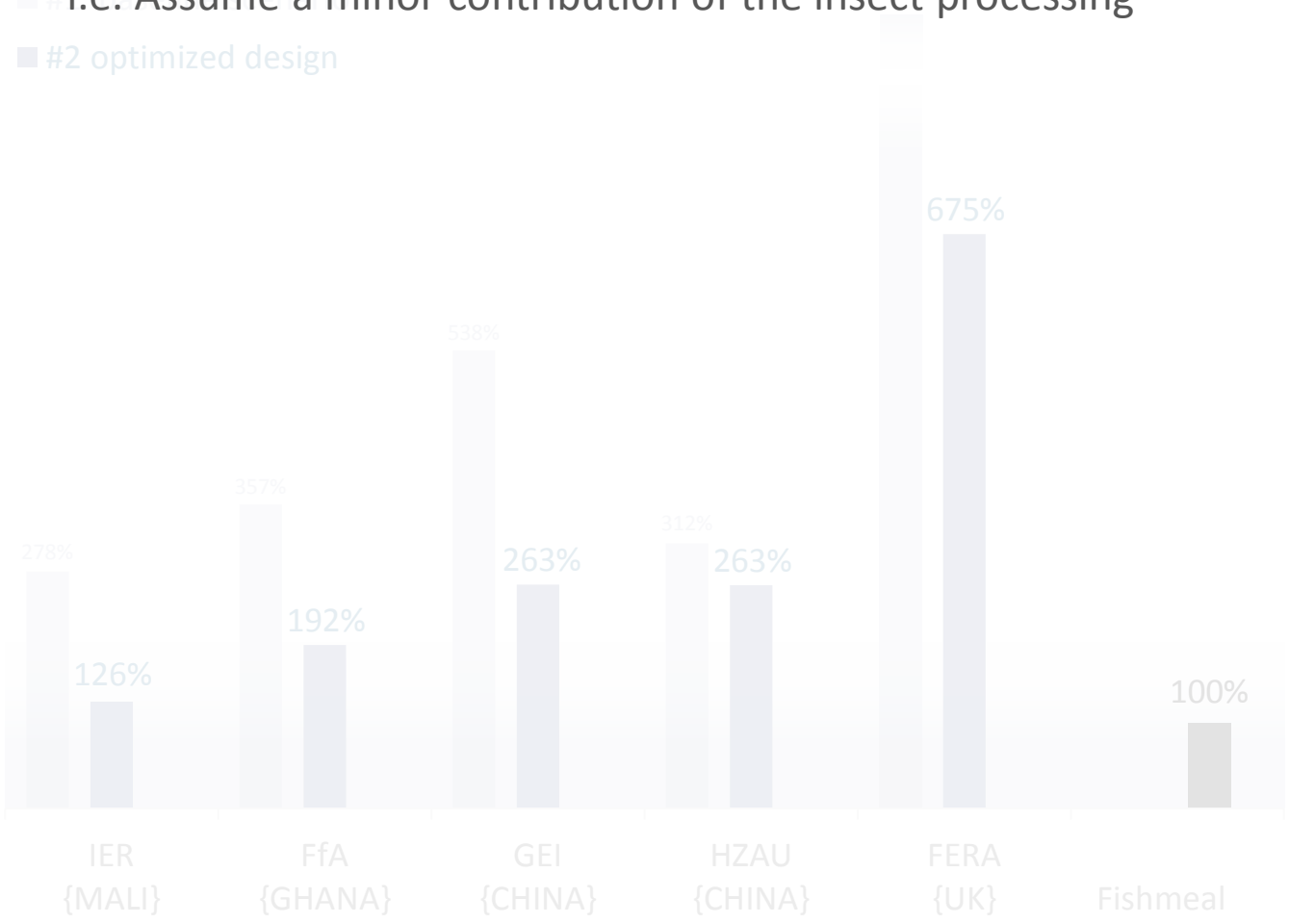


ECONOMY

#3 OPTIMIZATION PATHWAYS

- Correct for incoherence in scale between insect production units and processing units

i.e. Assume a minor contribution of the insect processing



ECONOMY

ECONOMIC PERFORMANCE |

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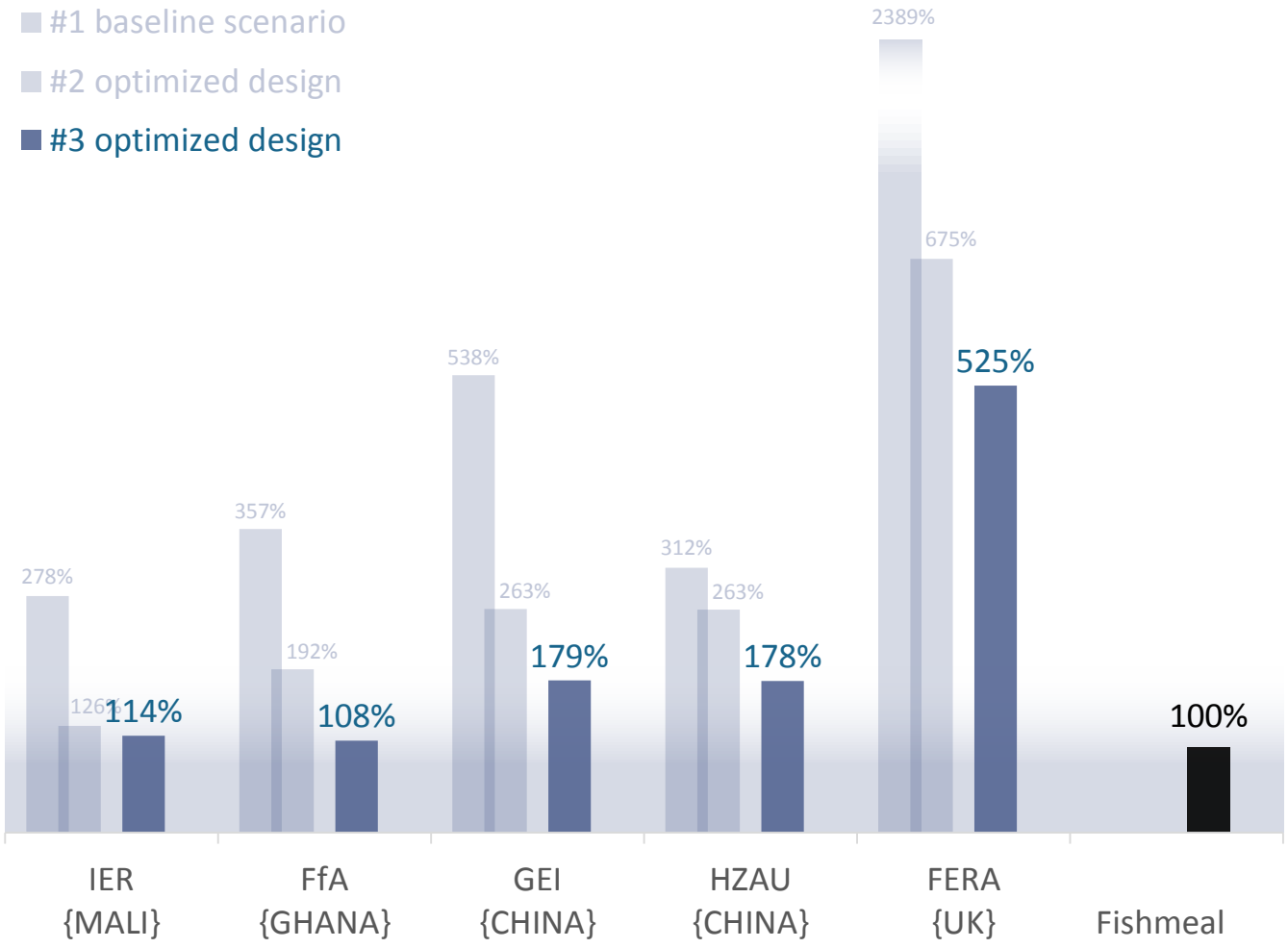
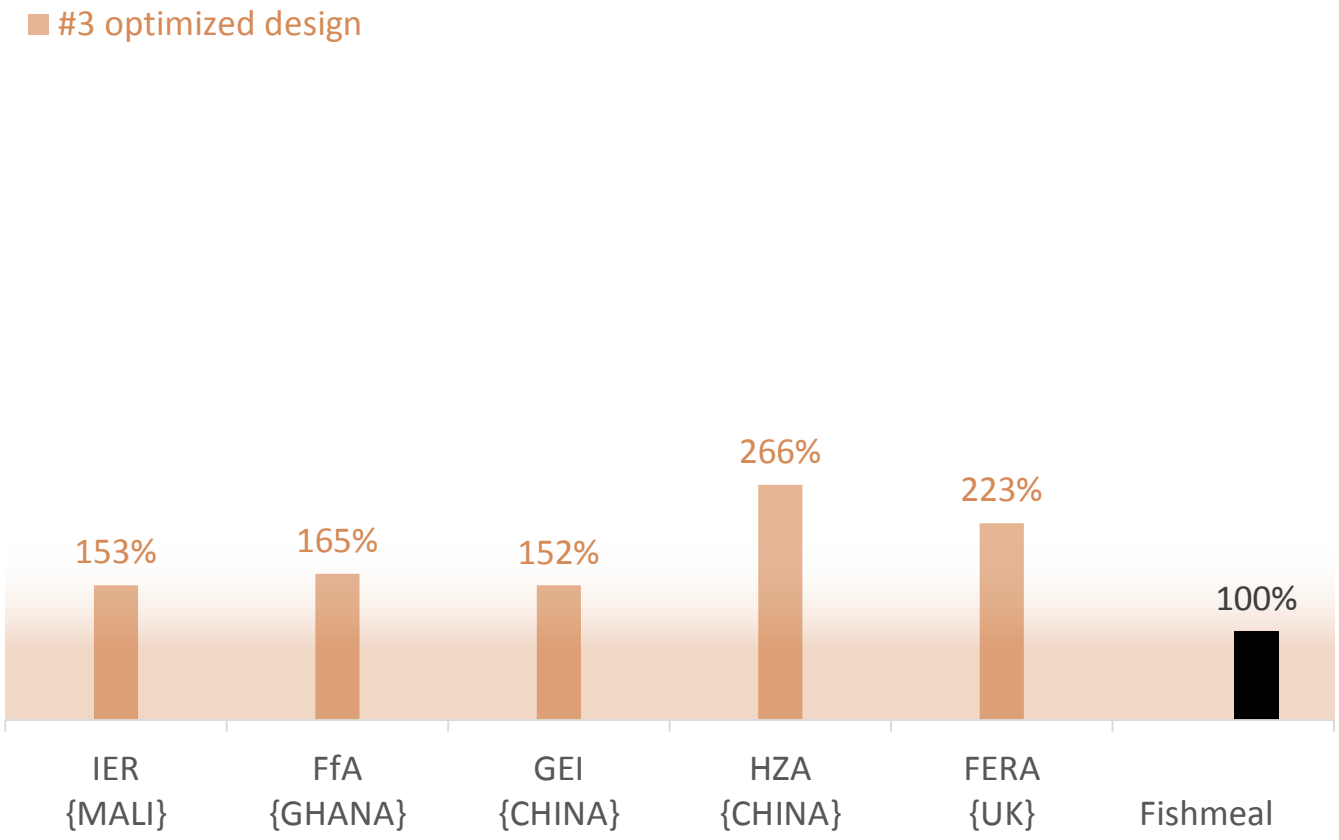


SOCIETY

SOCIETAL PERFORMANCE |

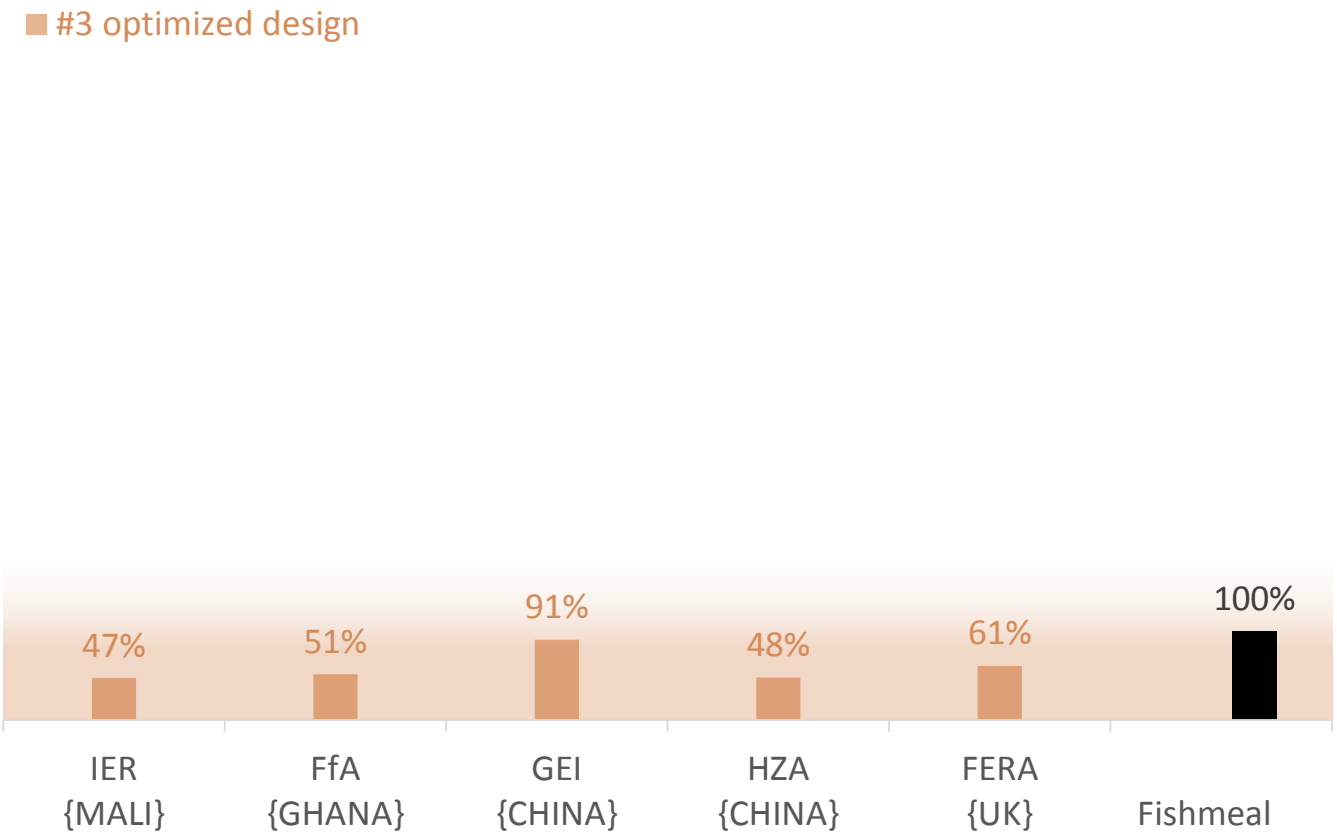
Estimated economic strain of labour inputs in percentage to fishmeal



SOCIETY

SOCIETAL PERFORMANCE |

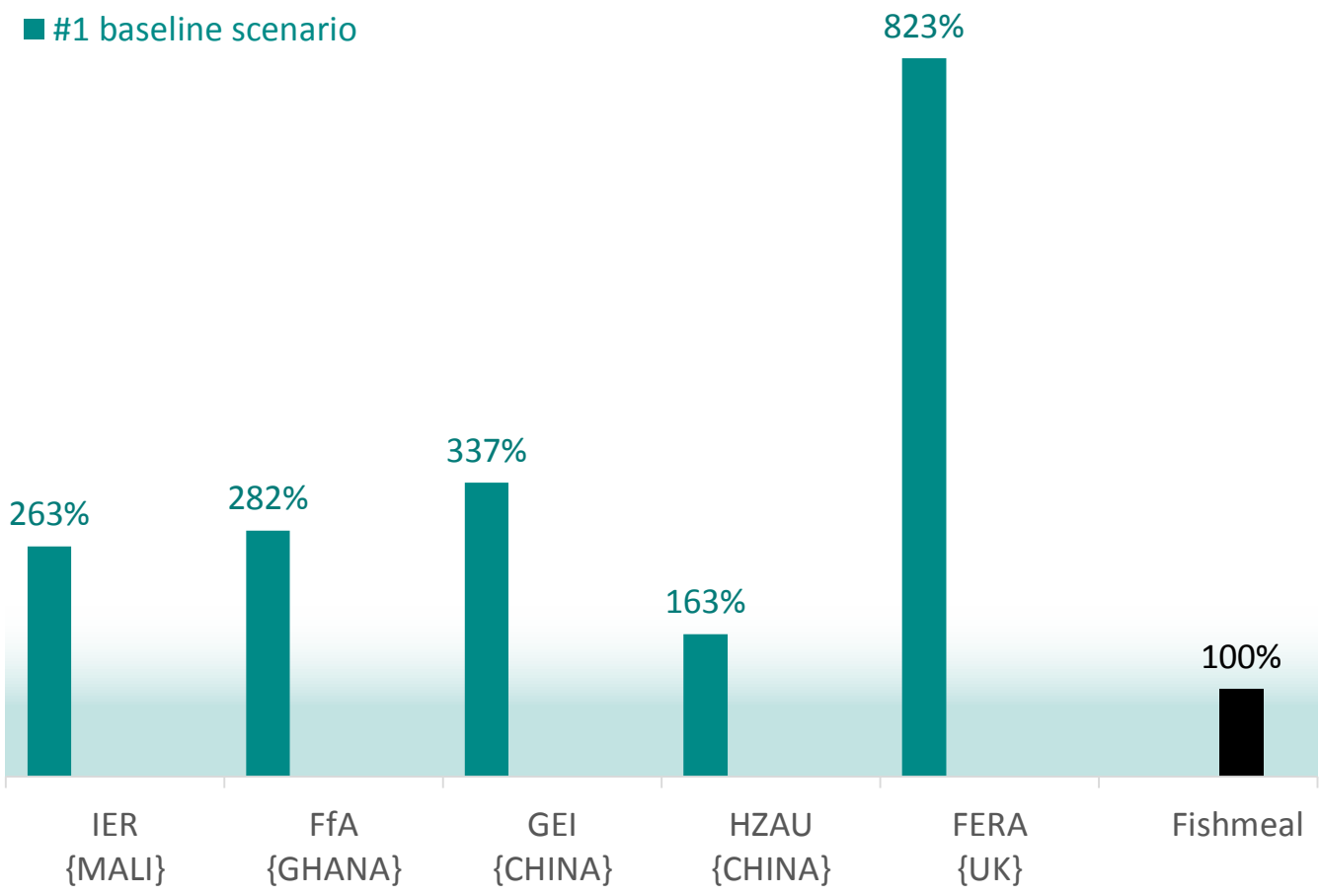
Estimated local welfare benefits in percentage to fishmeal



ENVIRONMENT

ENVIRONMENTAL PERFORMANCE |

Estimated environmental impact in percentage to fishmeal



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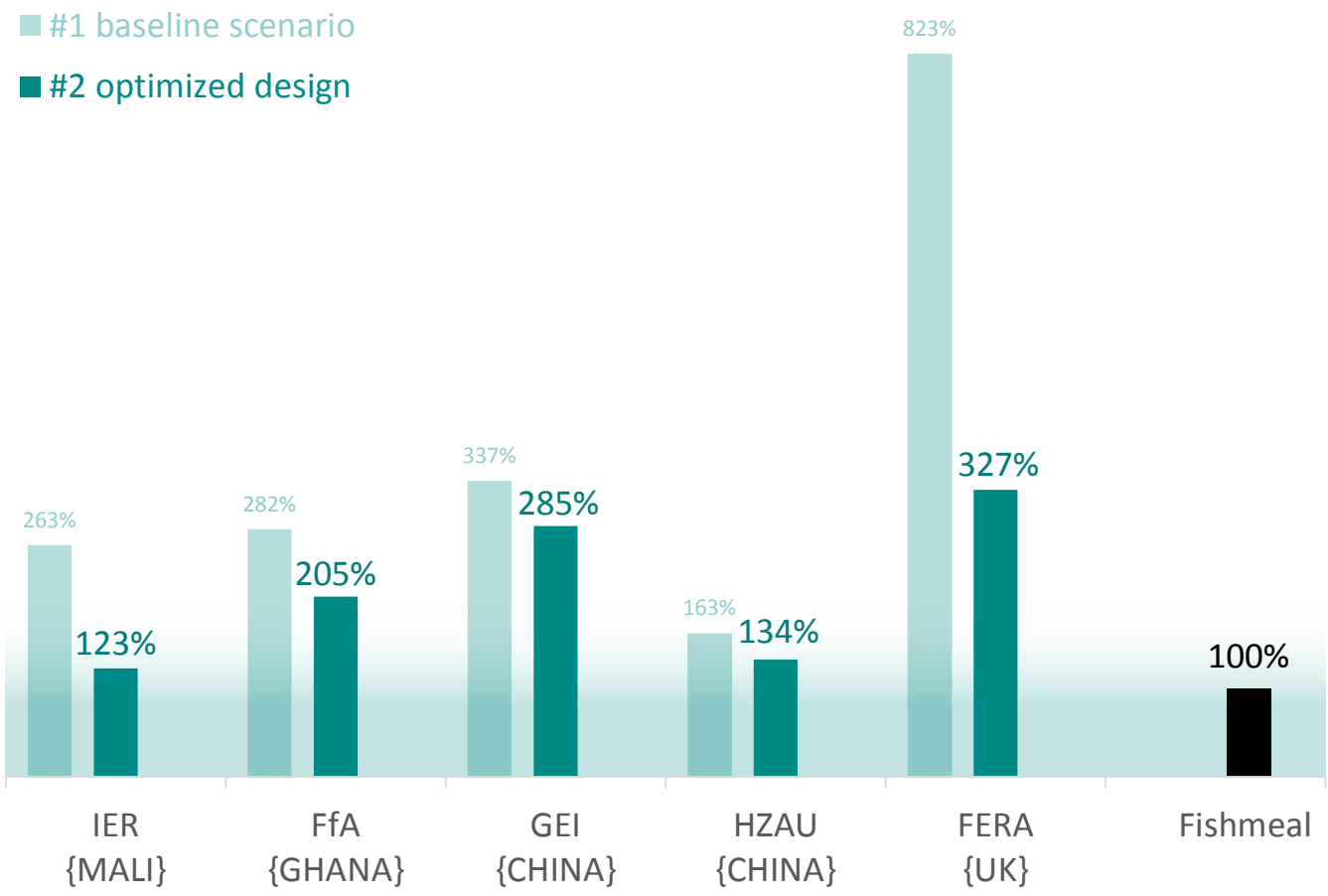

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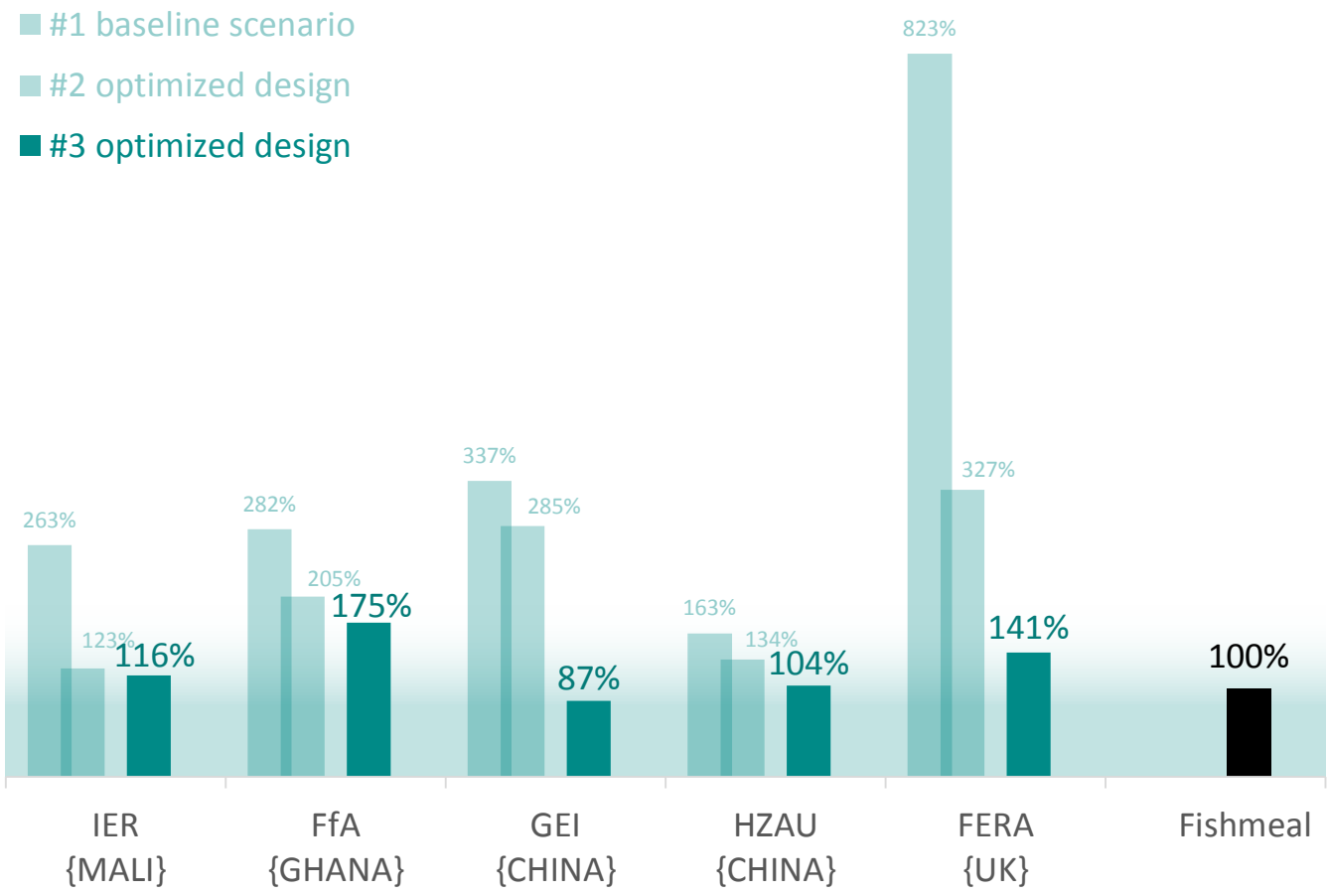

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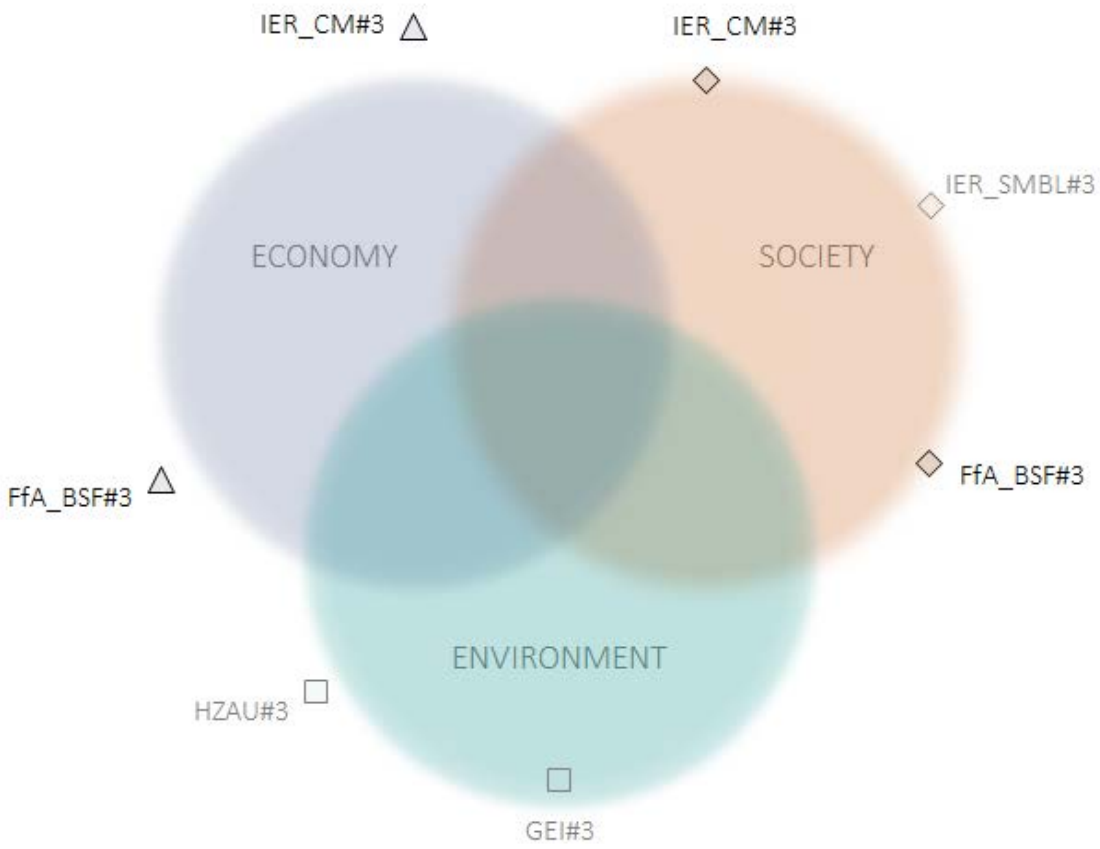
SUSTAINABILITY PERFORMANCE|

In percentage to fishmeal according to the '3-pillar model '



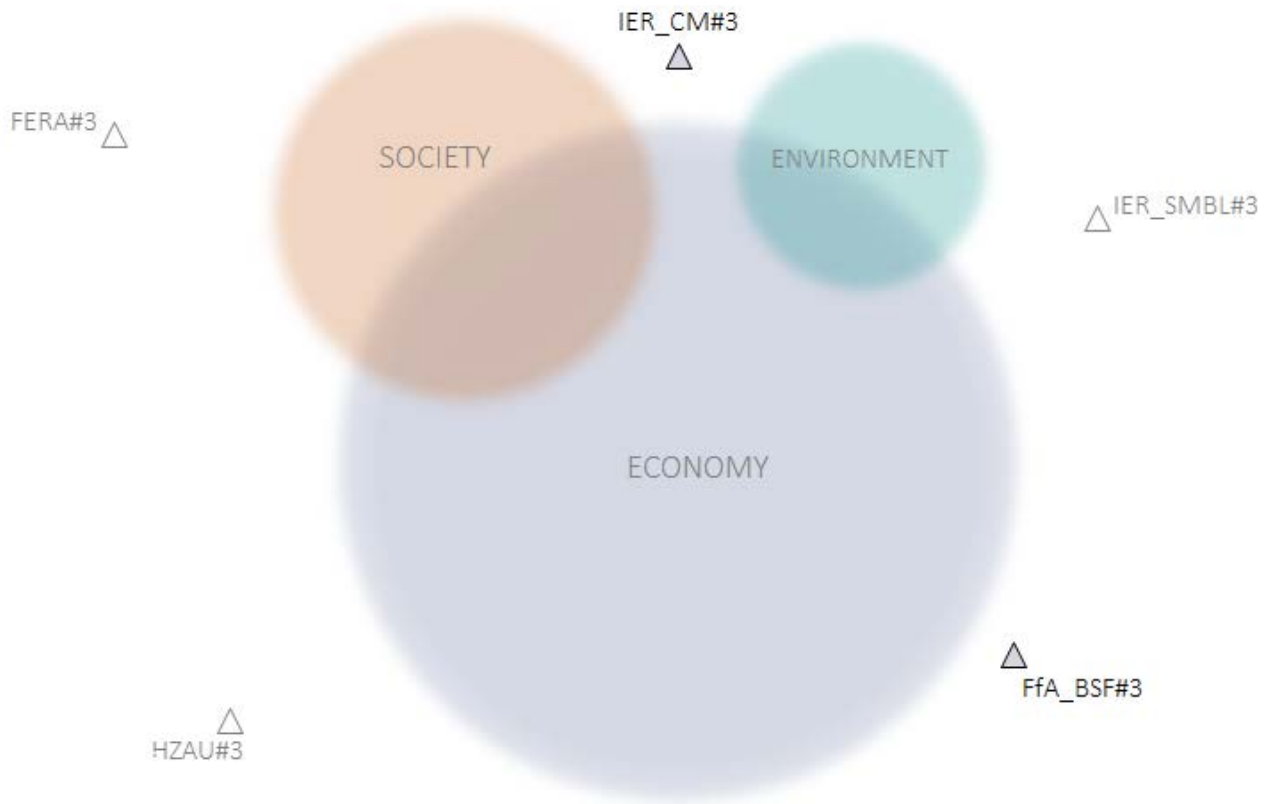
□ Environmental performance of insect based feeds

◇ Societal performance of insect based feeds

△ Economic preformance of insect based feeds

SUSTAINABILITY PERFORMANCE|

In percentage to fishmeal according to the 'Mickey Mouse model'



□ Environmental performance of insect based feeds

◇ Societal performance of insect based feeds

△ Economic preformance of insect based feeds

SUSTAINABILITY PERFORMANCE|

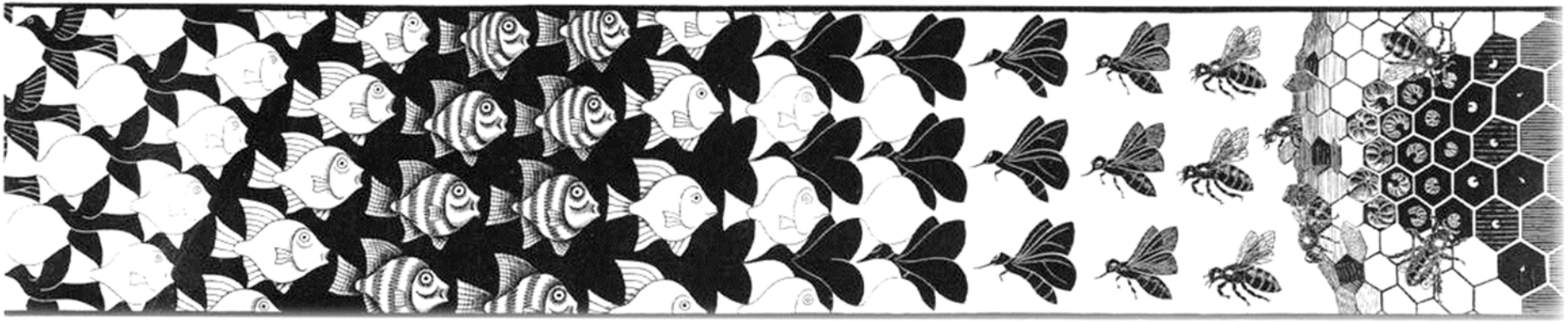
In percentage to fishmeal according to the 'Nested model'

□ Environmental performance of insect based feeds

◇ Societal performance of insect based feeds

△ Economic preformance of insect based feeds

CONCLUSIONS |recommendations for implementation and future R&D



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IMPLEMENTATION

- Depending on the geographical context and scale of production, the **sustainability** performance of **current production designs** was found **comparable** to the one of **fishmeal**
- Important **performance-critical site conditions** are prevalent **wage level**, **climate**, **substrate availability**, **energy mix of national grid**
- Use true **waste streams** (no economic value) or **substrates** that are **not** yet **valorized in other value chains.**
- Where possible, we recommend a direct **integration** in **substrate providing facilities**

RESEARCH AND DEVELOPMENT

- Perform experimental trials to detect **direct GHG emissions**
- Investigate **ileal digestibility** (functional unit) to allow for a **more accurate comparison** with conventional feeds
- Further explore **geographical suitability**