70th Annual Meeting of the
European Federation of Animal Science
City of Ghent (Belgium), 26 - 30 Aug 2019

LARSyS Laboratory of Robotics and Engineering Systems

MARETEC MARINE ENVIRONMENT & TECHNOLOGY CENTER

The role of pasture type and fattening in the lifecycle impacts of Portuguese meat production

Tiago G. Morais[1], Ricardo F. M. Teixeira[1], Manuel P. Santos[1], Tatiana Valada[2] and Tiago Domingos[1]

[1] Instituto Superior Técnico - University of Lisbon, Portugal; [2] Terraprima Lda

FCT Fundação para a Ciência e a Tecnologia MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E ENSINO SUPERIOR

Animal Future

TÉCNICO LISBOA

Reference situation for pastures in Portugal

1990:
~1 Mha of unproductive semi-natural pastures

"Semi-natural"

Spontaneous pastures or long crop-pasture rotations

Shrub encroachment

Frequent tillage

Degradation of agri-forestry *Montado* ecosystems

Sown Biodiverse Pastures (SBP)
A biodiversity engineering innovation

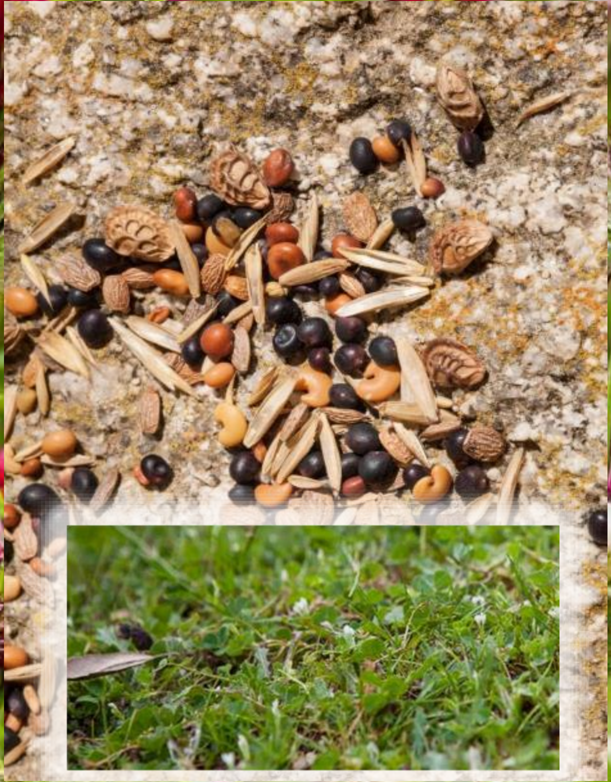
Permanent, as they are self-reseeding and can be maintained for at least 10 years (in some cases 25 years)

Sown, because high-yield native species are introduced into the pasture

Biodiverse, because up to 20 species or varieties of plant seeds are used

Rich in legumes, because many species are legumes that sequester nitrogen from the atmosphere and avoid the use of additional fertilizer

Sown Biodiverse Pastures (SBP)
A biodiversity engineering innovation



Permanent, as they are self-reseeding and can be maintained for at least 10 years (in some cases 25 years)

Sown, because high-yield native species are introduced into the pasture

Biodiverse, because uo to 20 species or varieties of plant seeds are used

Rich in legumes, because many species are legumes that sequester nitrogen from the atmosphere and avoid the use of additional fertilizer

Each hectare of SBP

- Avoids the use of approximately 0.5 hectares of farm land
(Higher yield -> Less concentrate feed consumption)

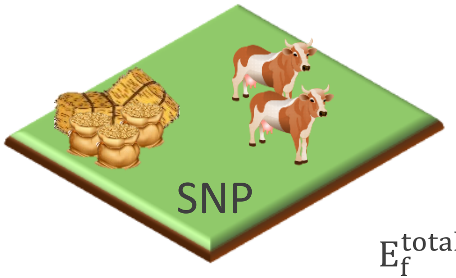
- **Sequesters 6.5 t CO_2/yr in the soil**
(Higher yield -> More carbon inputs into soil;
No mobilization -> Less organic matter mineralization)

Goal of the work (1/2)

To assess the effects of beef produced in SBP on greenhouse gas emissions from beef production using a *consequential* approach

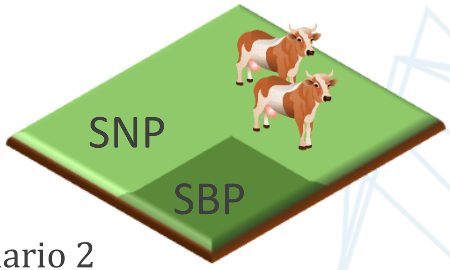
Scenario 1

Semi-natural pasture (SNP) + concentrate feed



Scenario 2

SBP + SNP



$$E_f^{total} - E_i^{total} = \text{Scenario 1} - \text{Scenario 2}$$

Morais, T.G. et al. 2018. The Effects on Greenhouse Gas Emissions of Ecological Intensification of Meat Production with Rainfed Sown Biodiverse Pastures. Sustainability 10, 4184

Assumptions

Assumptions required for the comparison:

(1) nutritional equivalence between initial and final situations in terms of:

- Crude protein
- Crude fibre
- Neutral detergent fibre
- Gross energy

(2) area invariance

(3) stocking rate invariance

Scenario 1

Semi-natural pasture (SNP) + concentrate feed

Scenario 2

SBP + SNP

$$E_f^{total} - E_i^{total} = \text{Scenario 1} - \text{Scenario 2}$$

Morais, T.G. et al. 2018. The Effects on Greenhouse Gas Emissions of Ecological Intensification of Meat Production with Rainfed Sown Biodiverse Pastures. Sustainability 10, 4184

Calculation

$$\frac{E_f^{total} - E_i^{total}}{A_f^{SBP}} = \{E\}^{SBP} - \{E\}^{SNP} - \left(\frac{\varepsilon - 1}{\varepsilon}\right)\frac{\{NFU\}^{SBP}}{\langle NFU\rangle^{feed}}\langle E\rangle^{feed}$$

$$\begin{cases} \{E\}^{SNP} = \{E\}_{op}^{SNP} \\ \{E\}^{SBP} = \{E\}_{op}^{SBP} + \{E\}_{N2O}^{SBP} - \{E\}_{CO2}^{SBP} \end{cases}$$

Materials, energy, equipment – quantified using Life Cycle Assessment (LCA)

E_i^{total} and E_f^{total} are the total environmental impact in the initial and final scenarios

A_f^{SBP} is the area of SBP installed

$\{E\}^{SBP}$ and $\{E\}^{SNP}$ are the impacts of management operations on SBP and SNP

$\{E\}_{N2O}^{SBP}$ is the amount of nitrous oxide (N_2O) emitted in SBP

$\{E\}_{CO2}^{SBP}$ is the amount of carbon dioxide (CO_2) sequestered in SBP

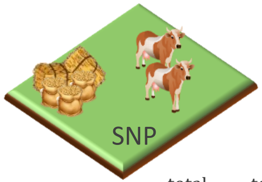
$\{NFU\}^{SBP}$ is the Nutritional Forage Unit (NFU) of SBP per unit of area

$\langle NFU\rangle^{feed}$ is the NFU of commercial feed per unit of mass

$\langle I\rangle^{feed}$ is the life cycle environmental impact of commercial feed

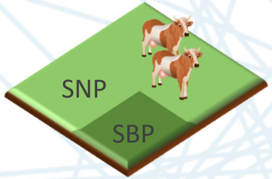
Scenario 1

Semi-natural pasture (SNP) + concentrate feed



Scenario 2

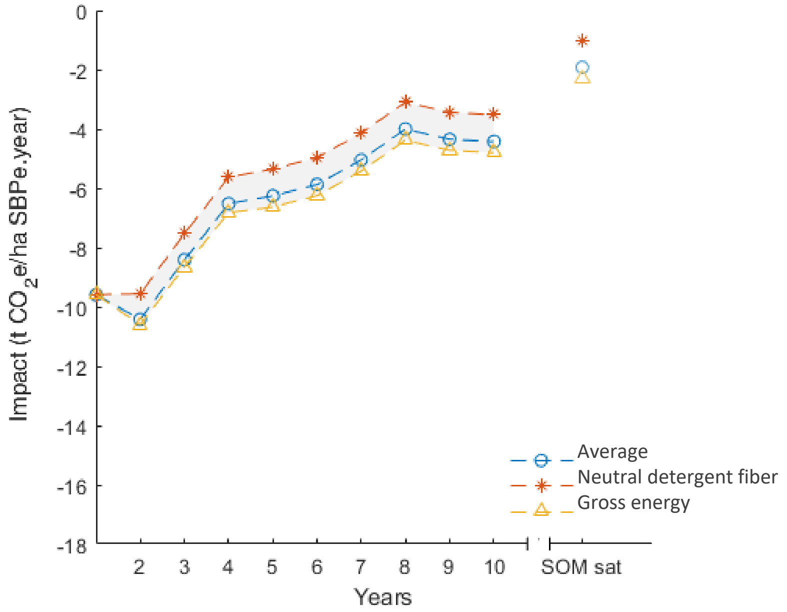
SBP + SNP



$$E_f^{total} - E_i^{total} = \text{Scenario 1} - \text{Scenario 2}$$

Morais, T.G. et al. 2018. The Effects on Greenhouse Gas Emissions of Ecological Intensification of Meat Production with Rainfed Sown Biodiverse Pastures. Sustainability 10, 4184

Contribution for climate change



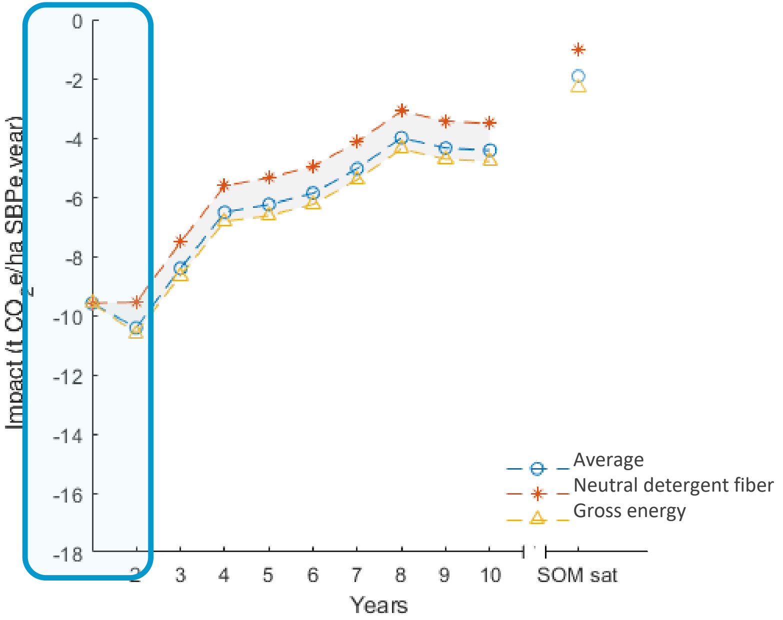
Morais, T.G. et al. 2018. The Effects on Greenhouse Gas Emissions of Ecological Intensification of Meat Production with Rainfed Sown Biodiverse Pastures. Sustainability 10, 4184

LARSyS
Laboratory of Robotics and Engineering Systems

MARETEC

Contribution for climate change

Result always negative – SBP have lower emissions than the alternative



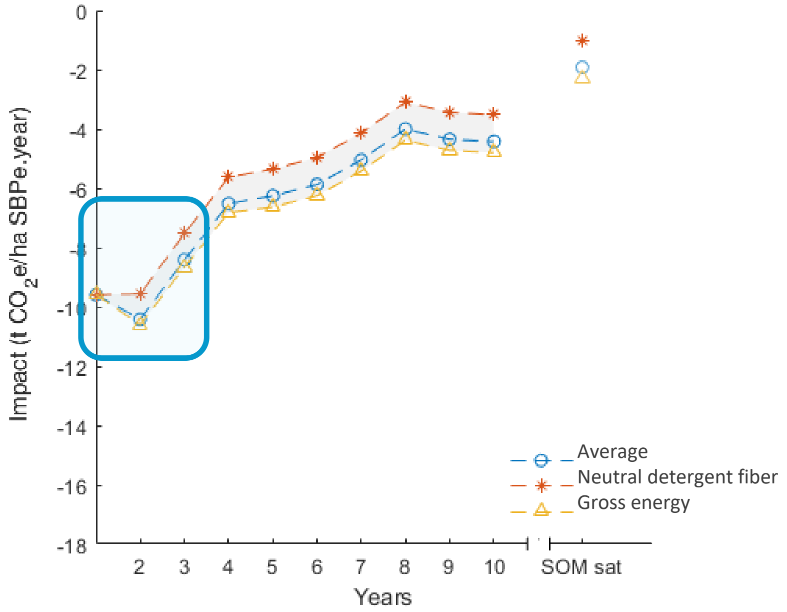
Morais, T.G. et al. 2018. The Effects on Greenhouse Gas Emissions of Ecological Intensification of Meat Production with Rainfed Sown Biodiverse Pastures. Sustainability 10, 4184

TÉCNICO LISBOA

Contribution for climate change

Result always negative – SBP have lower emissions than the alternative

Initial carbon sequestration is especially high, despite the emissions due to SBP installation

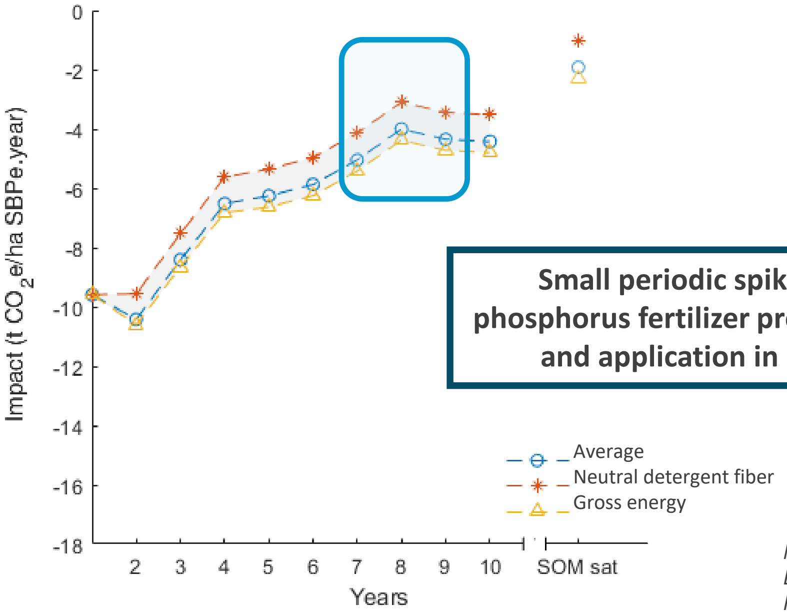


Morais, T.G. et al. 2018. The Effects on Greenhouse Gas Emissions of Ecological Intensification of Meat Production with Rainfed Sown Biodiverse Pastures. Sustainability 10, 4184

Contribution for climate change

Result always negative – SBP have lower emissions than the alternative

Initial carbon sequestration is especially high, despite the emissions due to SBP installation



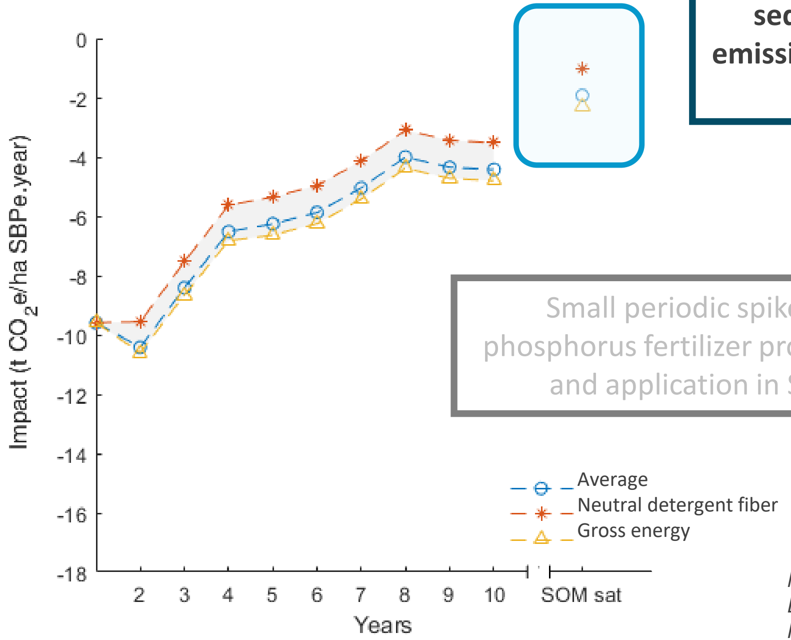
Small periodic spikes – phosphorus fertilizer production and application in SBP

Morais, T.G. et al. 2018. The Effects on Greenhouse Gas Emissions of Ecological Intensification of Meat Production with Rainfed Sown Biodiverse Pastures. Sustainability 10, 4184

Contribution for climate change

Result always negative – SBP have lower emissions than the alternative

Initial carbon sequestration is especially high, despite the emissions due to SBP installation

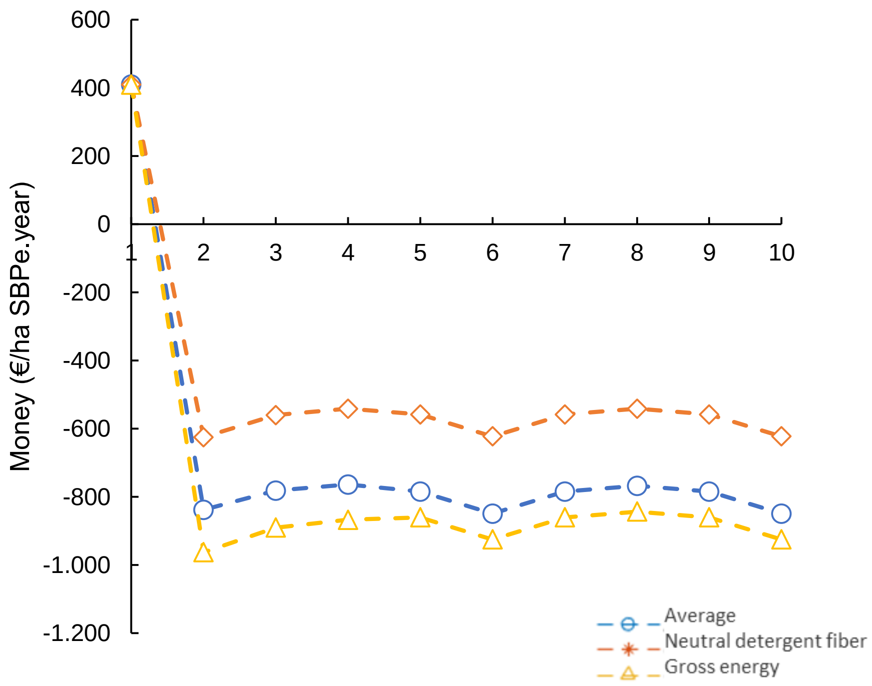


After the 10th year, even as carbon sequestration stops, SBP save emissions due to avoided emissions during feed production

Small periodic spikes – phosphorus fertilizer production and application in SBP

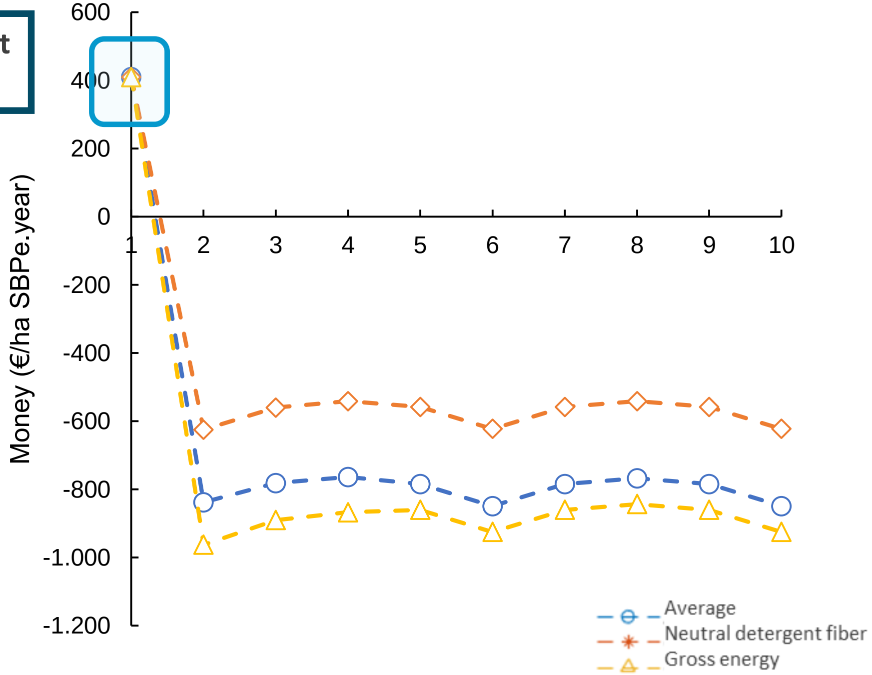
Morais, T.G. et al. 2018. The Effects on Greenhouse Gas Emissions of Ecological Intensification of Meat Production with Rainfed Sown Biodiverse Pastures. Sustainability 10, 4184

Economic assessment

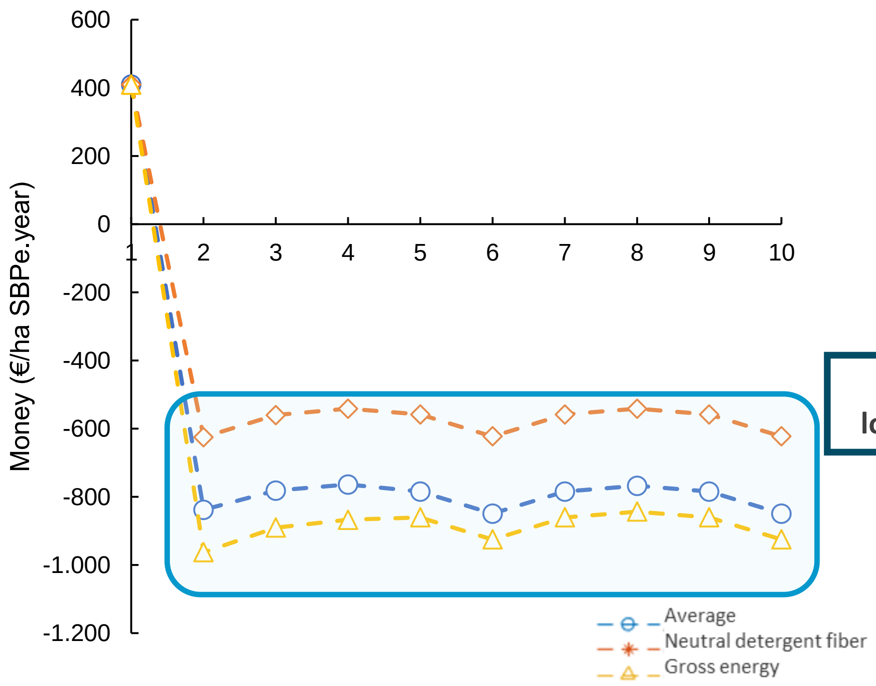


Economic assessment

SBP installation has a higher cost than the initial scenario

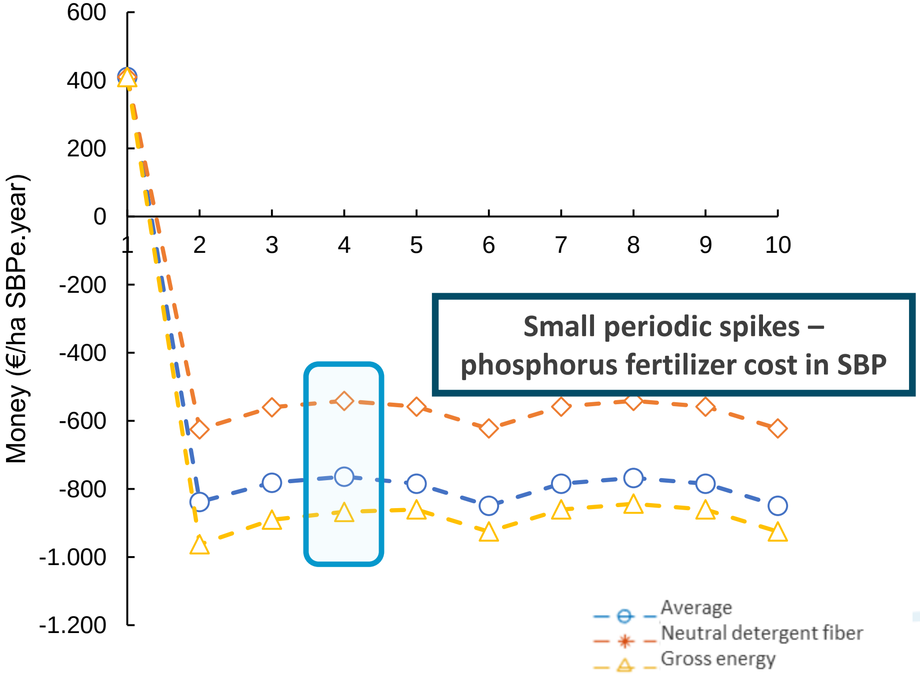


Economic assessment



From second year, SBP have lower cost than the alternative

Economic assessment



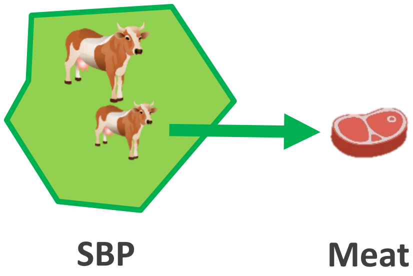
Goal of the work (2/2)

To identify the main environmental and economic trade-offs involved at two different animal ages at slaughter (without considering SOM accumulation)

Scenario 1

SBP (grazing)

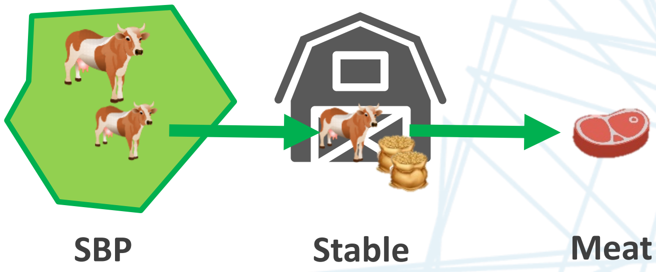
Age at slaughter between 9 and 12 months



Scenario 2

SBP + Concentrate feed (housing)

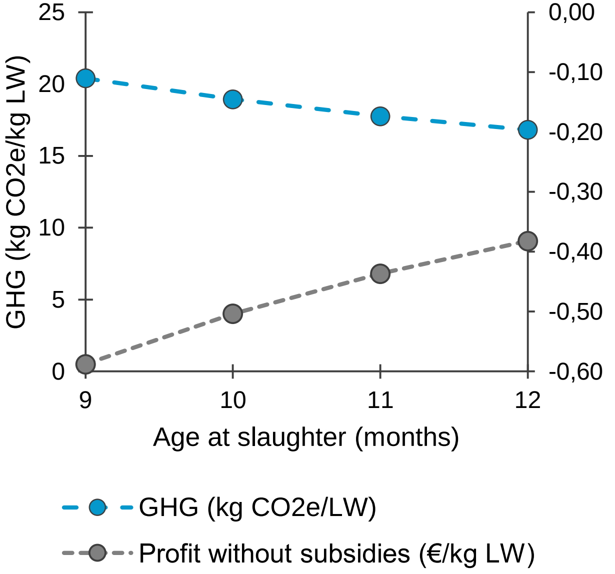
Age at slaughter between 13 and 18 months



Environmental and economic trade-offs

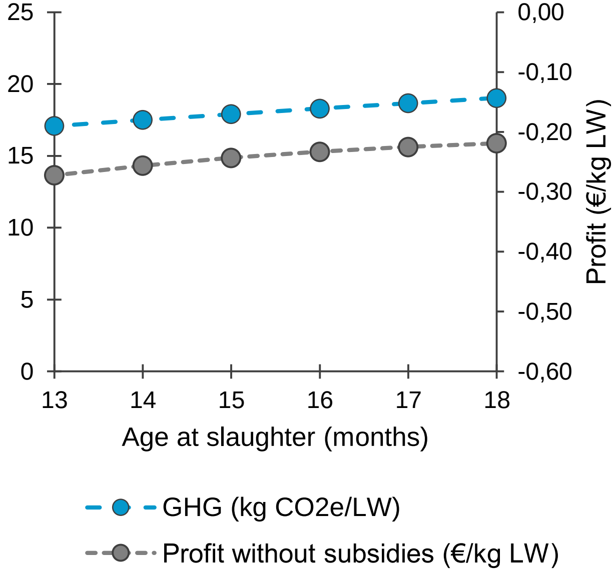
Scenario 1

SBP (grazing)



Scenario 2

SBP + concentrate feed (housing)

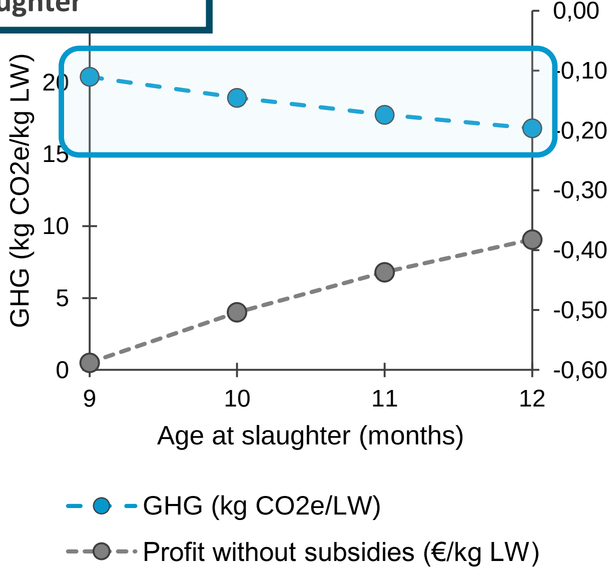


Environmental and economic trade-offs

Scenario 1

SBP (grazing)

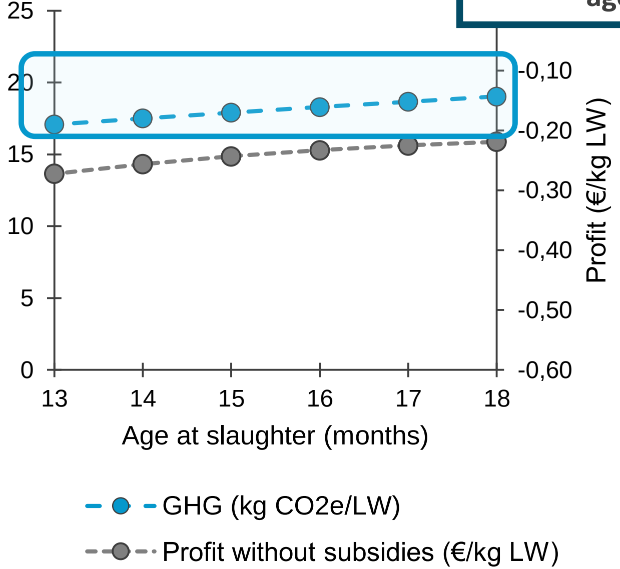
GHG emissions decrease with age at slaughter



Scenario 2

SBP + concentrate feed (hous

GHG emissions increase with age at slaughter



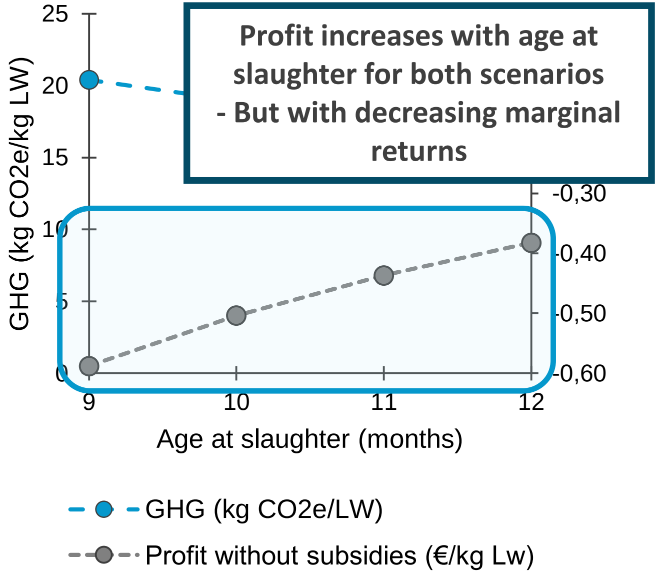
LARSyS Laboratory of Robotics and Engineering Systems

MARETEC

Environmental and economic trade-offs

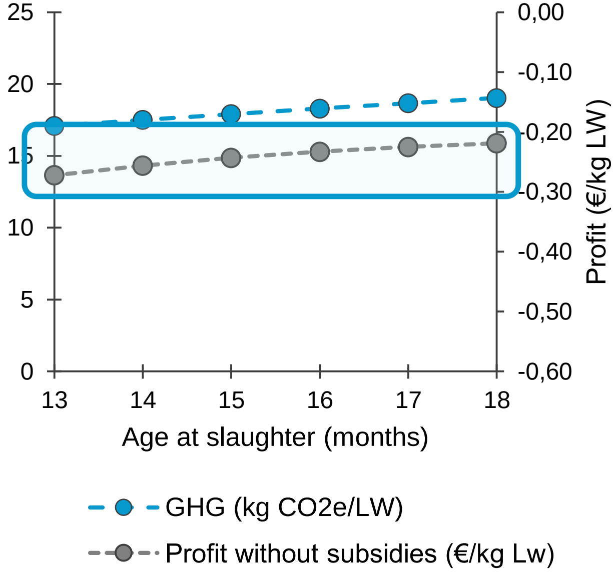
Scenario 1

SBP (grazing)



Scenario 2

SBP + concentrate feed (housing)



TÉC LISBOA

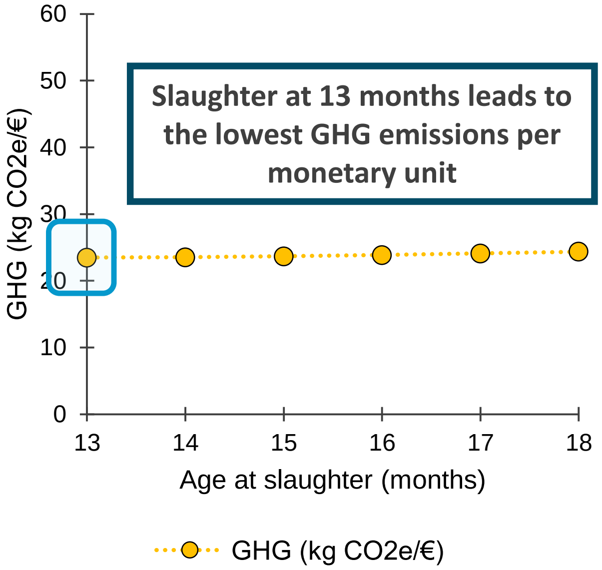
Environmental and economic trade-offs

Scenario 1

SBP (grazing)

Scenario 2

SBP + concentrate feed (housing)



LARSyS
Laboratory of Robotics and Engineering Systems

MARETEC

Conclusions

Concentrate replacement **avoids the emission of about 3 t CO_2eq/ha** even for mature SBP after soil carbon saturation, even considering that SBP require more energy use and fertilizers

Considering the overall emissions from beef production, **SBP can avoid 25% emissions from beef** production per kg of live animal weight

Slaughter at 13 months leads to the lowest GHG emissions per monetary unit; 12 months is the age that leads to the lowest emissions per kg of live animal weight and 18 months is the age with highest profit

TÉCNICO LISBOA

70th Annual Meeting of the
European Federation of Animal Science
City of Ghent (Belgium), 26 - 30 Aug 2019

This work was supported by FCT/MCTES (PIDDAC) through project UID/EEA/50009/2019.

Tiago G. Morais by grant SFRH/BD/115407/2016 and Ricardo F.M. Teixeira was supported by grant SFRH/BPD/111730/2015 from Fundação para a Ciência e Tecnologia. Manuel P. dos Santos was supported by grant BL 263/2018 (IST-ID) and SFRH/BD/147158/2019 from Fundação para a Ciência e Tecnologia.

The work was also supported by the following projects:

- "Animal Future - Steering Animal Production Systems towards Sustainable Future", funded by the Fundação para a Ciência e Tecnologia (SusAn/0001/2016).
- Project ModelMeat - Modelo de Optimização de Ambiente e Qualidade do Produto para Serviços de Apoio à Competitividade dos Agentes da Fileira da Produção Animal Extensiva is funded by Portugal 2020 (nr. 017630).