Using Life Cycle Assessment to Estimate Environmental Impacts from Correlated Genetic Traits in Pigs

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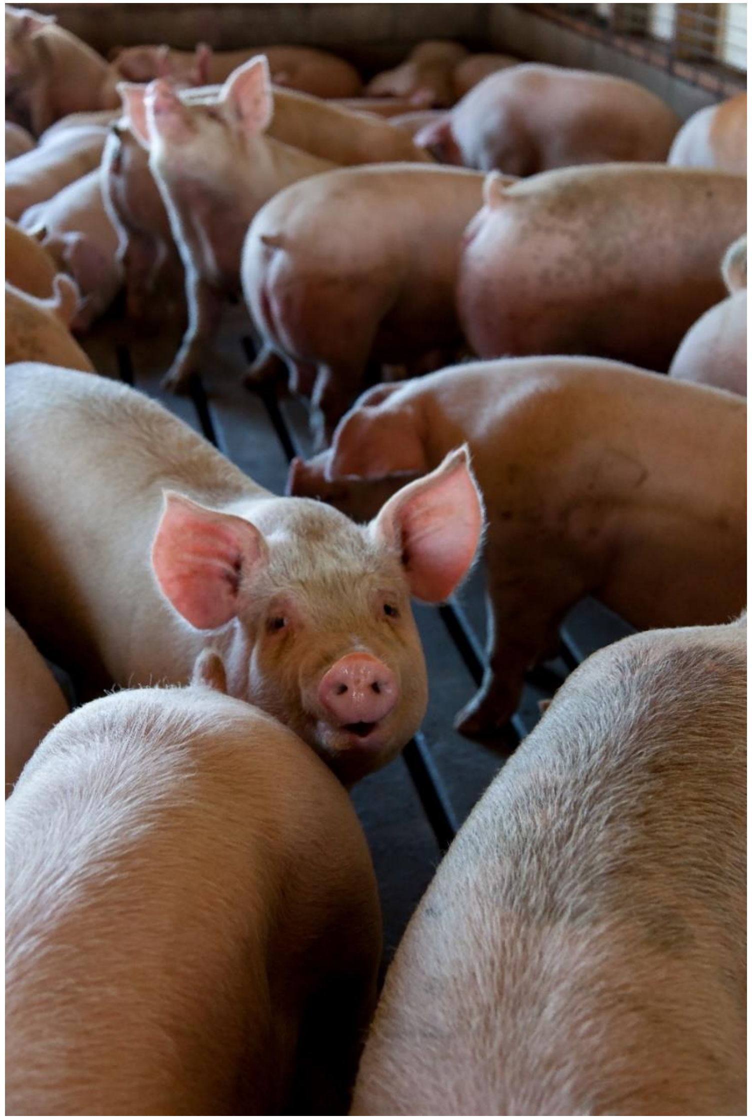
Pig breeding for lower environmental impacts

- Pork is the most consumed meat product globally
- Due to marked focus, pig producers are continually improving both management and pig genotypes
- It is not known which genetic traits are most influential on environmental impacts, and how important trait correlations are

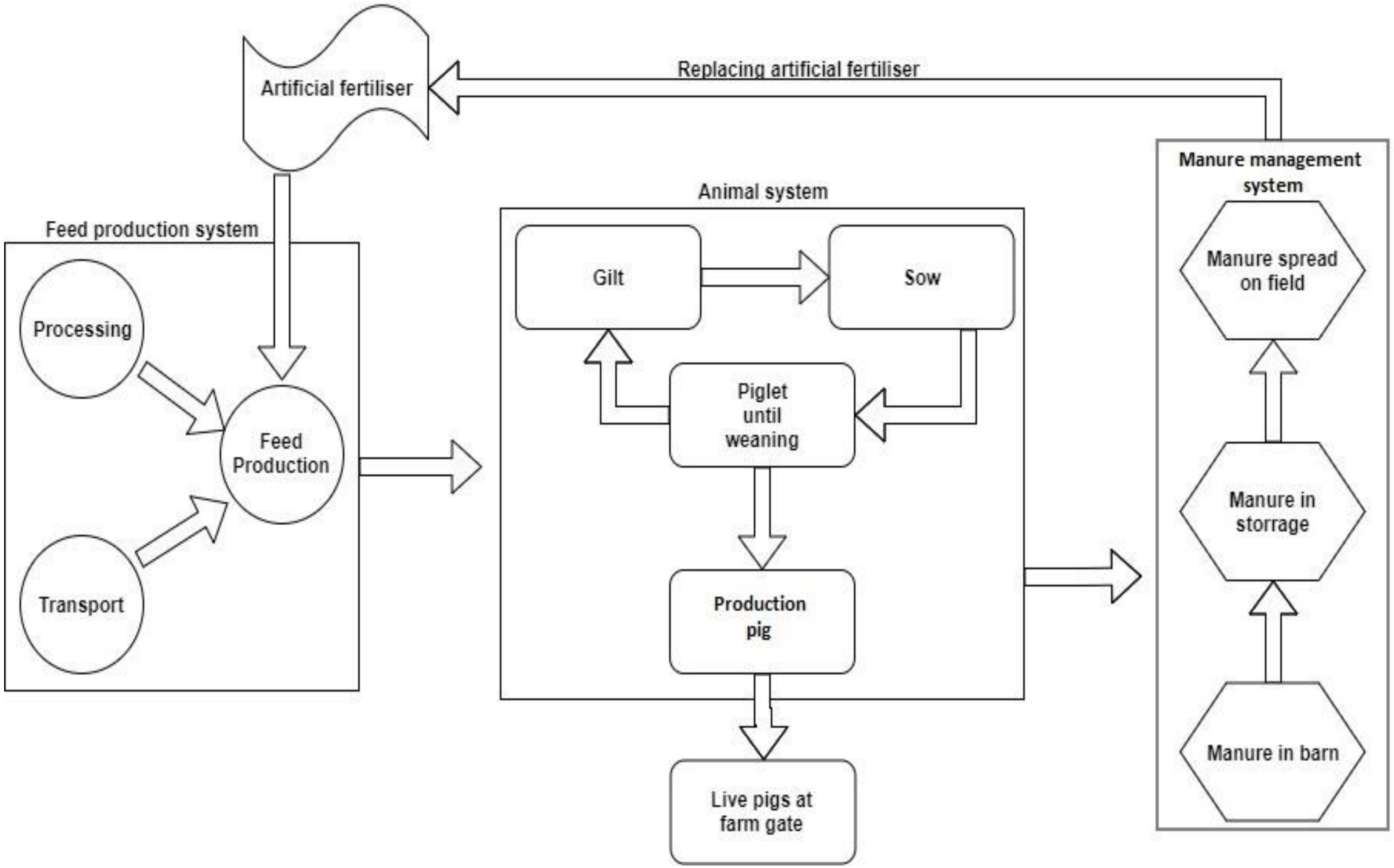
Aim: to investigate the environmental impacts of individual genetic traits in pigs and assess the influence of genetic correlations among these traits

Life Cycle Assessment methodology

- Environmental Life Cycle Assessment (LCA) is an accounting method quantifying environmental effects of a process:
  - Outputs are grouped in impact categories
  - Outputs are scaled to the functional unit
  - Can compare systems under similar assumptions



Pig production system model



- Danish integrated indoor system (including breeding and finisher unit)
- Boundary from cradle to farm gate
- Manure applied to fields replacing the use of artificial fertilizer
- Functional unit of 1 kg of live pig at slaughter age leaving the farm

Selected traits included in the model

Included traits are used in animal breeding, can be modelled in the given framework and has genetic variance and correlations reported in literature

- Growth-related traits:
  - **ADG30**: growth rate from wean to 30 kg
  - **ADG100**: growth rate from 30 kg to 100 kg
  - **AgeMature**: gilt age at first insemination
- Sow-related traits:
  - **BWLossLactation**: sow body weight loss during lactation
  - **LactationFeed**: feed intake during lactation
  - **LitterSize**: litter size across all parities
- Body composition and performance traits:
  - **BWMature**: gilt body weight at first insemination
  - **Maintenance**: daily use of energy depending on body weight
  - **ProtLip**: protein to lipid ratio
- Survival traits:
  - **AMPar**: average maximum parity of the sow before culling
  - **PostWMort**: mortality rate after weaning
  - **PreWMort**: mortality rate before weaning

Estimation of energy requirements

- *Energy intake as a function of energy demands from:*
  - *Energy maintenance*
  - *Protein gains*
  - *Lipid gains*
- $E_f \propto \left(a * BW^b + \left(\frac{\Delta Prot * E_{Pr}}{k_{Pr}} + \frac{\Delta Lip * E_L}{k_L} \right) \right)$

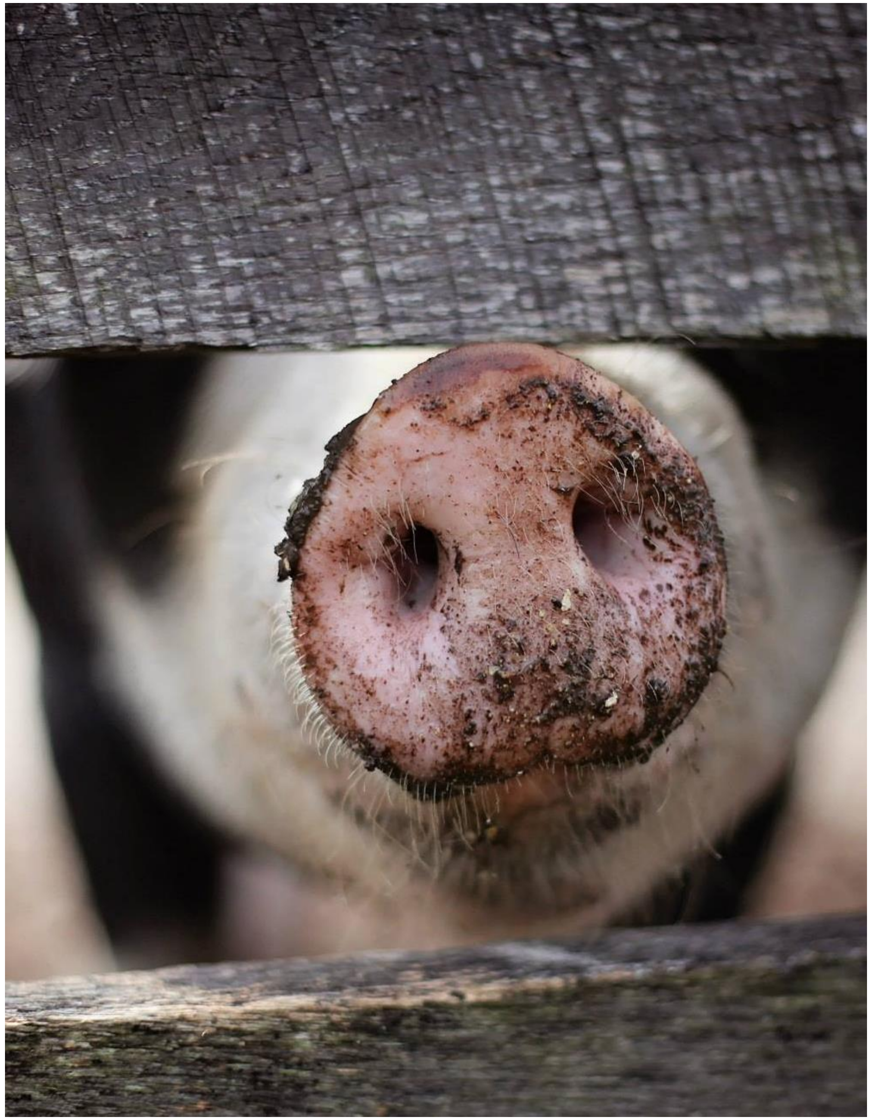
Modified from: https://www.wikihow.com/Feed-Pigs

Compiling the genetic trait correlation matrix

- Pig genetic traits are heavily correlated
- A correlation matrix was compiled using Fishers Z transformation of data from 22 studies which included:
  - Western commercial pig breeds
  - Published within last decade
  - Number of pigs included in study
  - Additive genetic correlation

Sensitivity analyses

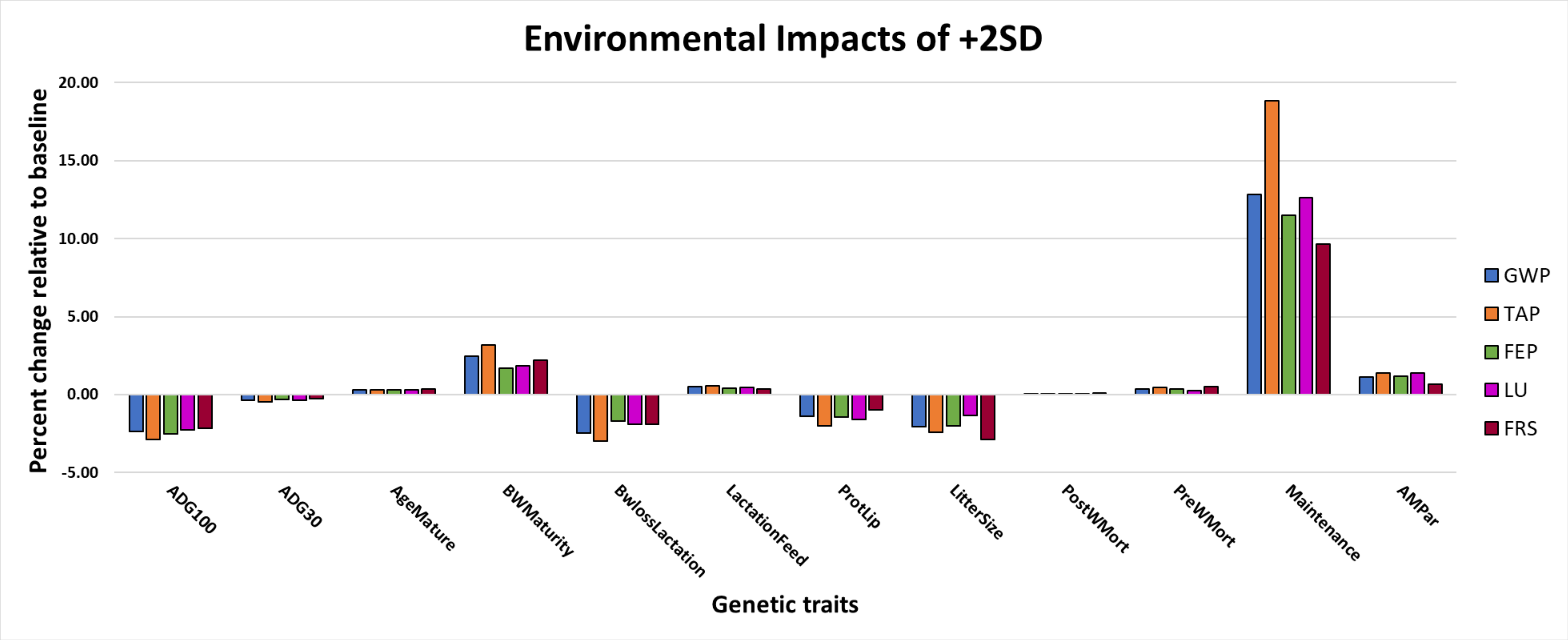
- Gradually increasing inclusion of correlations:
  - One at a time: each trait was varied independently one at a time
  - Clusters of traits: traits clustered according to Euclidian distance based on geometrical interpretation of correlations. All traits in each cluster was changed simultanously
  - Total, Uncorrelated and Correlated sensitivity index: Latin Hypercube sampling to determine degree of model variance explained by each trait alone and by interactions with other traits



Baseline outcomes of the model

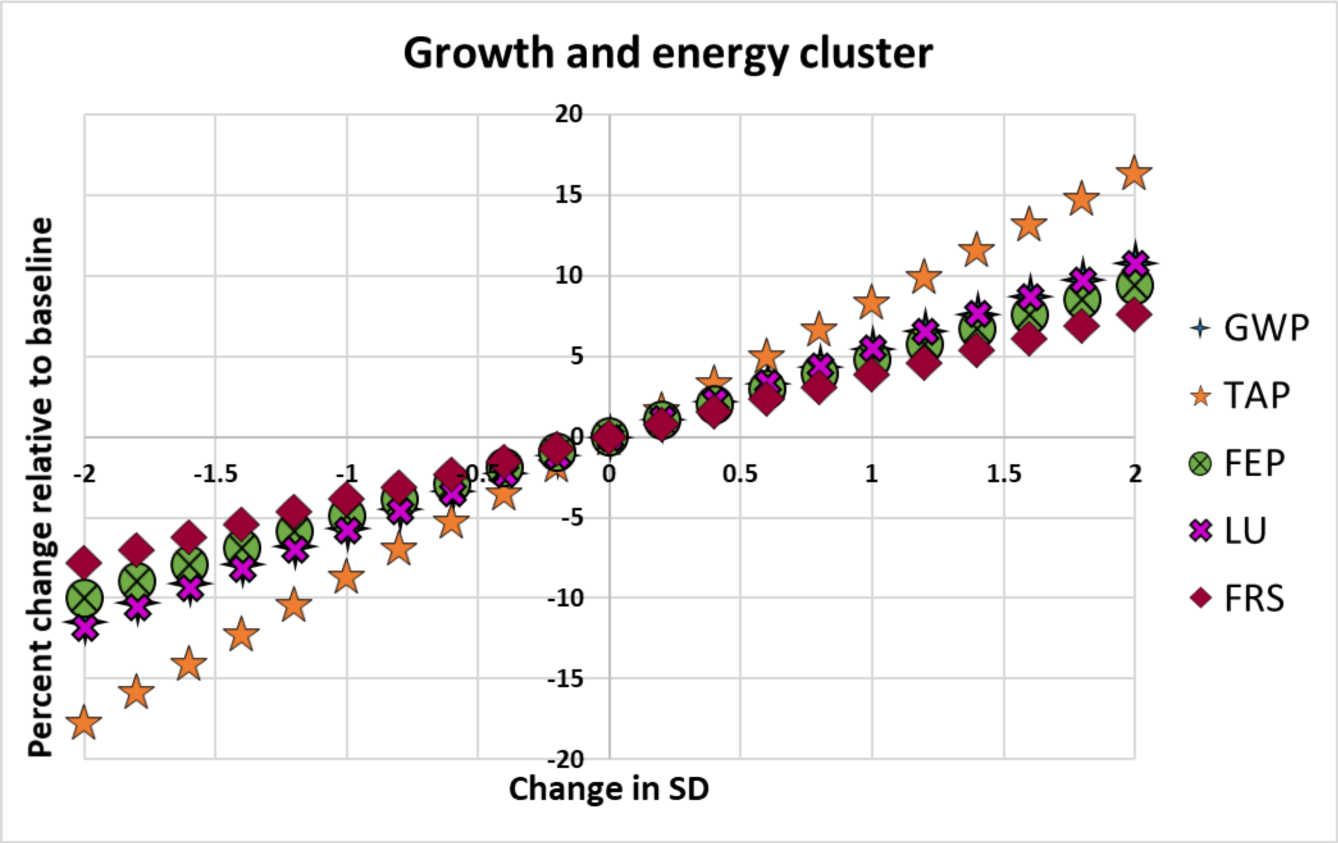
	Impact categories				
	Global Warming Potential (kg CO_2 eq)	Terrestrial Acidification Potential (kg SO_2 eq)	Freshwater Eutrophication Potential (kg P eq)	Land Use(m^2)	Fossil Resource Scarcity (kg oil eq)
Results: mean (SD)	4.18 (0.28)	$40.9*10^{-3}$ ($4.00*10^{-3}$)	$552*10^{-6}$ ($33.4*10^{-6}$)	4.12 (0.27)	0.202 (0.010)
	Partial contribution of Baseline System (%)				
- Gilt	2	2	3	3	3
- Sow	19	23	18	11	26
- Production pig	79	75	80	86	71

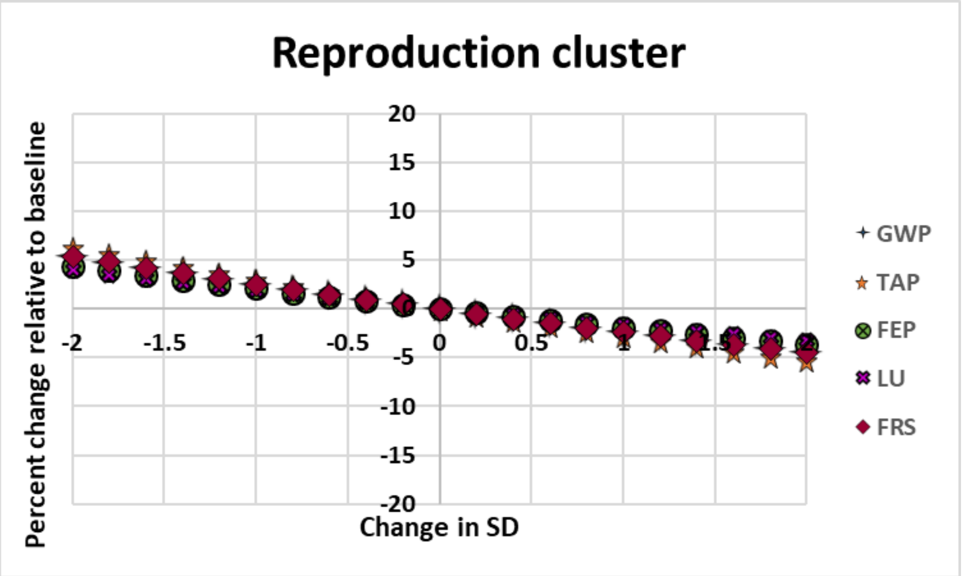
Results - one at a time sensitivity analysis

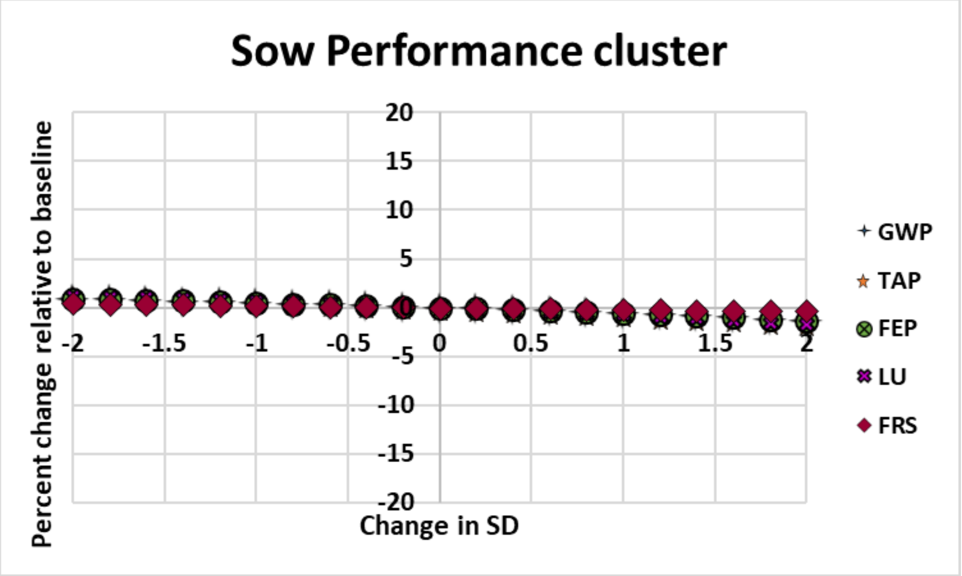


GWP: Global Warming Potential; TAP: Terrestrial Acidification Potential; FEP: Freshwater Eutrophication Potential; LU: Land Use; FRS: Fossil Resource Scarcity

Results - clusters of traits sensitivity analysis







GWP: Global Warming Potential; TAP: Terrestrial Acidification Potential; FEP: Freshwater Eutrophication Potential; LU: Land Use; Fossil Resource Scarcity

Results – sensitivity index

GWP: Global Warming Potential
TAP: Terrestrial Acidification Potential
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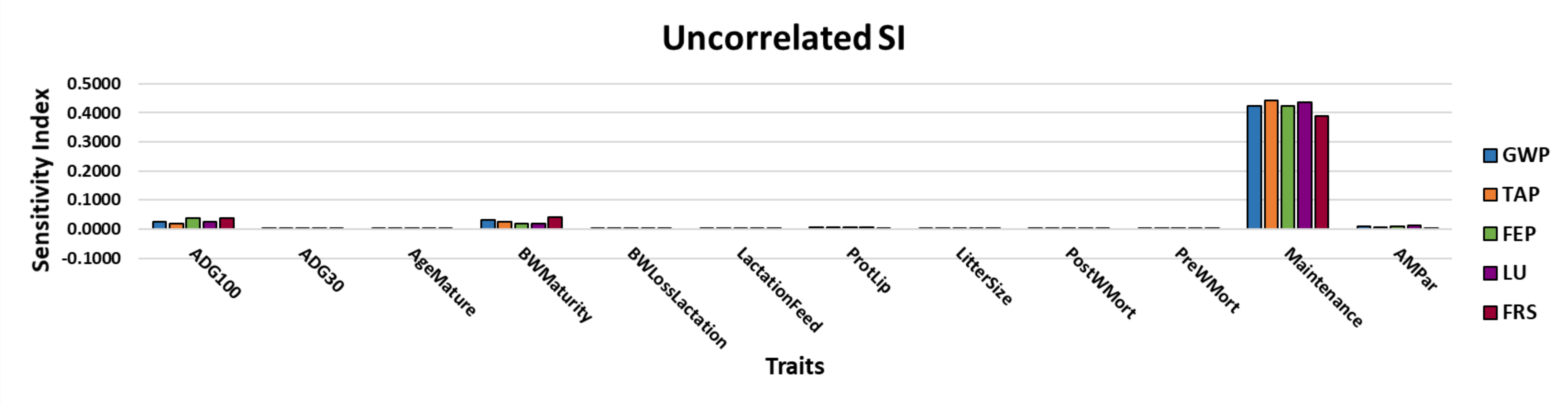

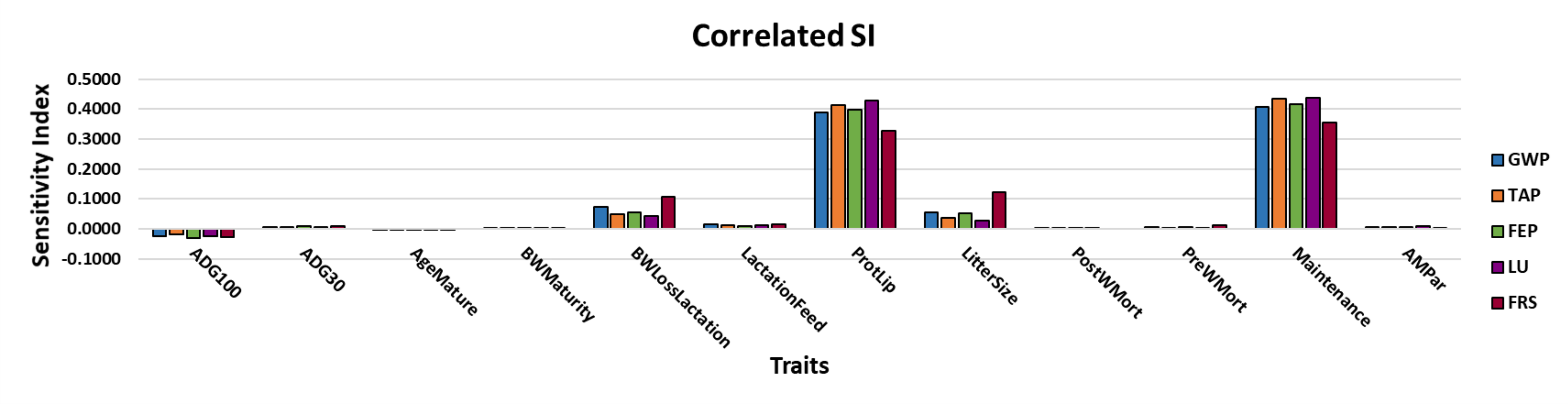

Conclusions

- Maintenance was the most influential trait on environmental impacts in the chosen Danish pig production system
- Protein to Lipid Ratio more dominant the more correlations are accounted for
- Effects on environmental impacts from clusters of traits sensitivity analyses were smaller than one at a time sensitivity analysis due to negative correlations between traits
- Depending on how correlations between traits were accounted for, very different conclusions can be reached
- Future LCA studies should consider implementing similar sensitivity analyses for correlated variables

Acknowledgement

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Thank you for your time

Any questions?

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