Synergies and trade-offs in sustainable dairy farming systems: a novel efficiency approach

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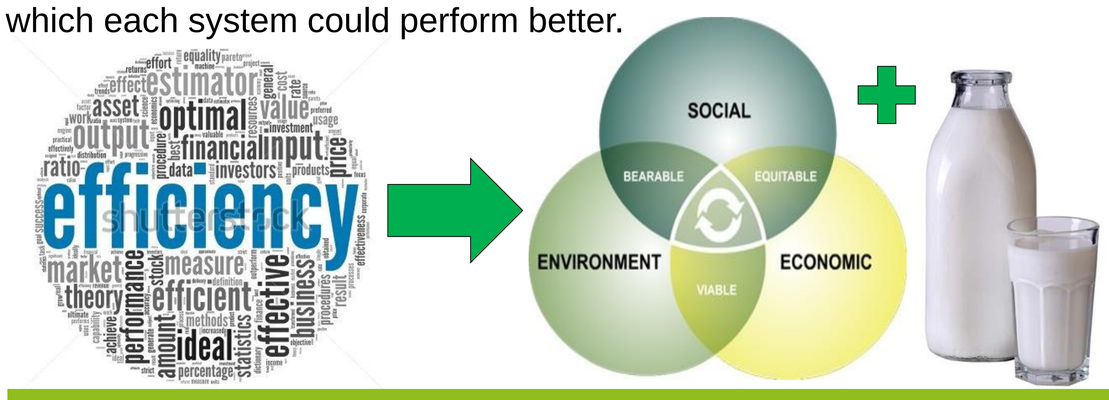
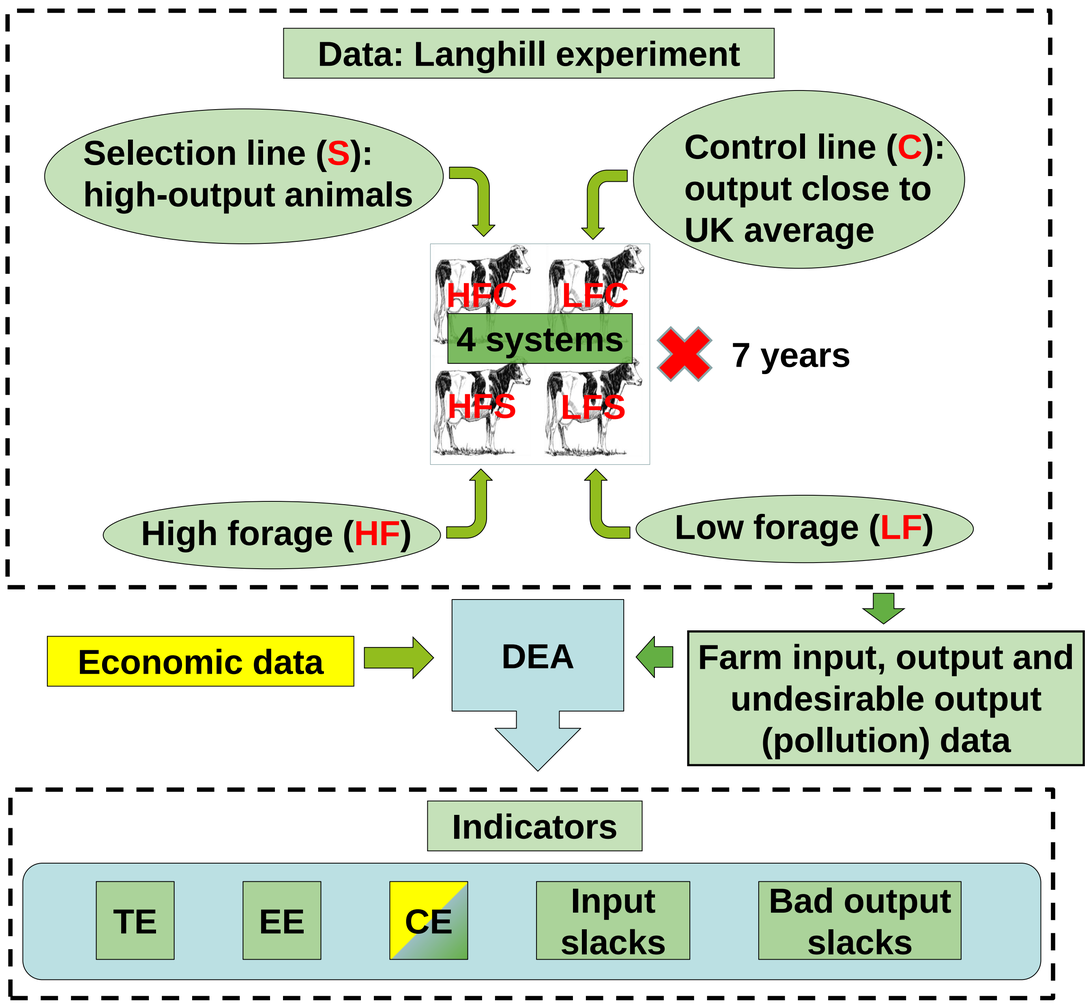
Introduction

World food production must increase to meet greater future demand without exacerbating climate change and despite dwindling resources. Appropriate measures of efficiency are therefore essential for farms to become- and remain- economically, socially and environmentally sustainable. This study used a slacks-based measure of efficiency (**SBM**) (Tone, 2001) within a Data Envelopment Analysis (**DEA**) framework to identify synergies and trade-offs between the technical (**TE**), environmental (**EE**) and economic (cost) efficiencies (**CE**) of dairy farms; and between four contrasting dairy systems; by using data from a long-term genetic line × feeding systems experiment (the "Langhill" experiment; Pollott and Coffey, 2008). The **slacks** represented farm resource/pollutant excesses and helped identify specific aspects in which each system could perform better.



Methods



Results

❑ **Kendall's *tau* rank correlation coefficient:**

1. TE & EE strongly correlated → **"Win-win". See conclusions (1st bullet)**
2. EE & CE modestly correlated → **Trade-offs between systems? Further inspection below**
3. TE & CE weakly correlated → **Trade-offs between systems? Further inspection below**

❑ **Kruskal-Wallis test + Figure 1:**

1. HFS **SB*** LFC & LFS for CE → **Unexpected! See Conclusions (2nd bullet)**
2. HFC **SB** LFC & LFS for CE → **Unexpected! See Conclusions (2nd bullet)**
3. LFS & LFC **SB** HFC for Land Use & Fertilizer **SP**** → **Expected. See Conclusions (3rd bullet)**
4. HFS & LFS **SB** HFC for greenhouse gas (GHG) SP → **Novel finding! See Conclusions (4th bullet)**

*__SB__: "significantly better than".
**SP: savings potentials. See Figure 1.

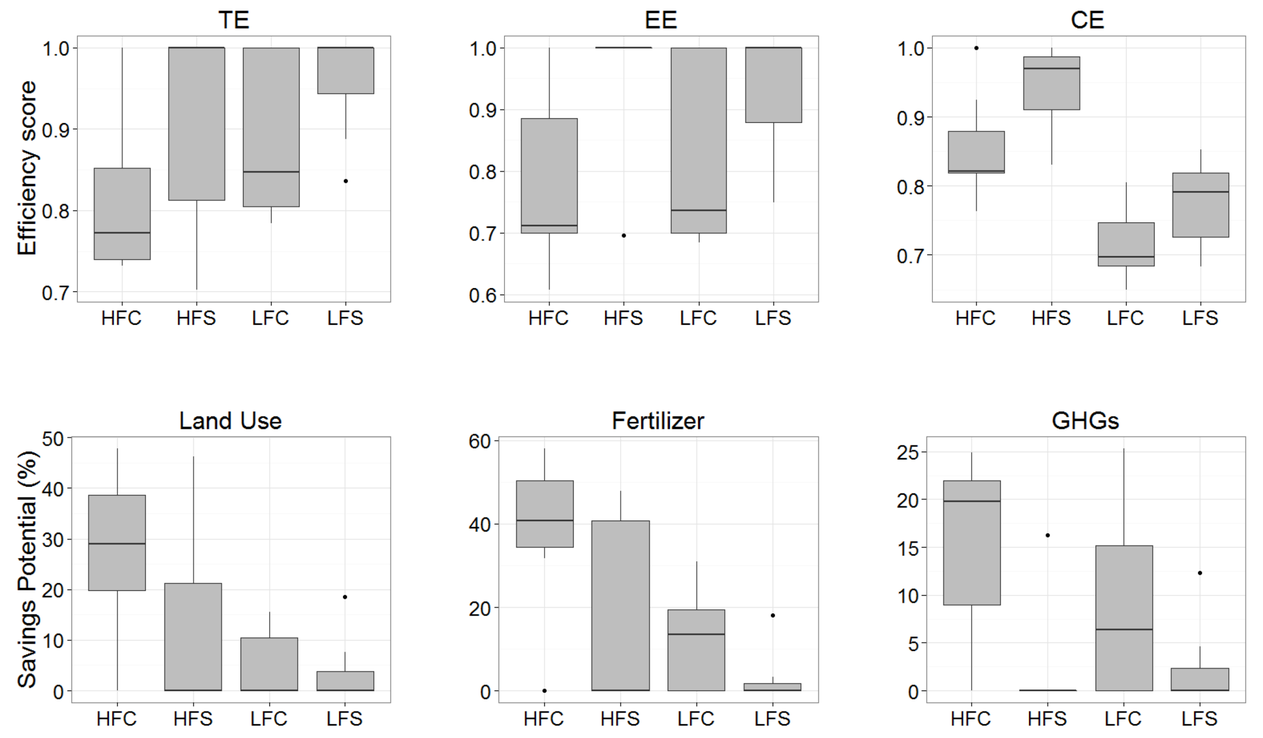


*Figure 1. Box plots for efficiency scores (row 1) and input/undesirable output savings potentials (**SP**; row 2). SP = ratio of input/undesirable output slacks over their corresponding input/undesirable output.*

Conclusions

- Synergy: Technically efficient farms also efficient in their production of pollution. Result in line with Shortall and Barnes (2013).
- Trade-offs for CE: This is dependent upon the specific cost structures and assumptions applied to the Langhill herd and so needs further investigation in commercial units.
- Significantly better performance of LF over HFC for Land Use and Fertilizer expected as LF systems housed all year round and their diet largely based on bought-in concentrates. Nevertheless, what would have been the result had land use and fertilizer applications been accounted-for regarding bought-in feeds?
- In line with Toma et al. (2013), we found that genetic merit could have differential effects on the systems' environmental performance. However the SBM indicated specific reasons for this difference (i.e. GHG emissions performance), through the disaggregation of efficiency into SP. Thus, SBMs superior to "traditional" DEA models.
- This study helps guide policy in sustainable dairy farming. Combining the SBM framework with an abundance of data available in SRUC's Langhill database, there exist numerous opportunities for further research.

References

Pollot, G.E. and Coffey, M.P. 2008. Journal of Dairy Science 91 (9), 3649-3660.
Shortall, O.K. and Barnes, A.P. 2013. Ecological Indicators 29, 478-488.
Toma, L., March, M., Stott, A.W. and Roberts, D.J. 2013. Journal of Dairy Science 96 (11), 7014-7031.
Tone, K. 2001. European Journal of Operational Research 130 (3), 498-509.

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