

Bayesian Belief Networks for the management of GHG emissions

for the UK agricultural sector

BBN for the management of GHG emissions in the UK agricultural sector

- Why?
- What are they?
- Benefits
- Preliminary results
- Conclusions



Why attempt the farmers' GHG estimation problem?

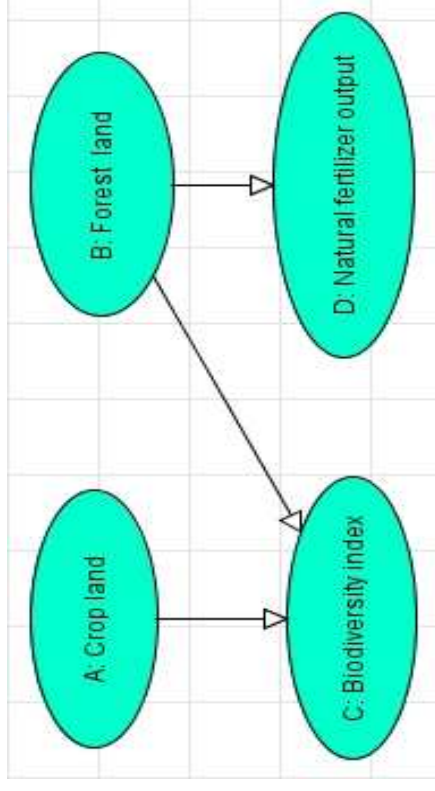
- There are a number of estimation mechanisms around but most of them are of a deterministic nature and don't target agricultural sector
 - CALM from the CLA generates a number and provides very generic suggestions in their output, the farmer would be hard to convince on their usefulness
 - National atmospheric emissions inventory too coarse (only estimates emissions at the economic sector level)
 - Other carbon calculators are not targeted at the farmers, and reviewing the IPCC guidelines, it is likely that a one solution fits all does not exist
- There is a lot of uncertainty associated with the estimation of GHG emissions, but few appear to come up front with this reality and explain how they deal with it
- BBNs have been used in other applications for the environment sector
 - Crome: system built to assess the impact caused by rainforest logging, to the biodiversity of an ecological system
 - Aalders: system developed to understand better the different drivers of land-use change in the Grampian region of the northeast of Scotland
 - MERIT project: water resource management methodology usable throughout Europe

What are BBN?

The underlying theoretical framework is probabilities, i.e. Bayes' rule.

$$P(B / A) = \frac{P(A / B) \times P(B)}{P(A)}$$

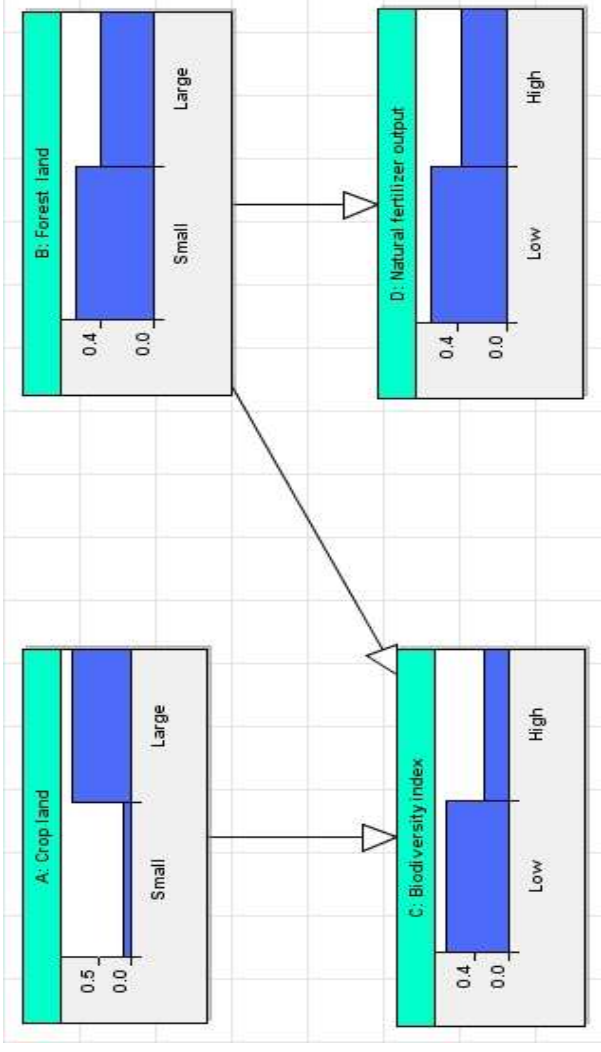
A Bayesian Network (BN) is a way of describing the relationships between causes and effects, and is made up of nodes and arcs



Graph or topology of a bayesian network

The guts of a BBN

The graph shows the shape of the marginal probabilities of the factors in the network



Dependent nodes also include the conditional probabilities

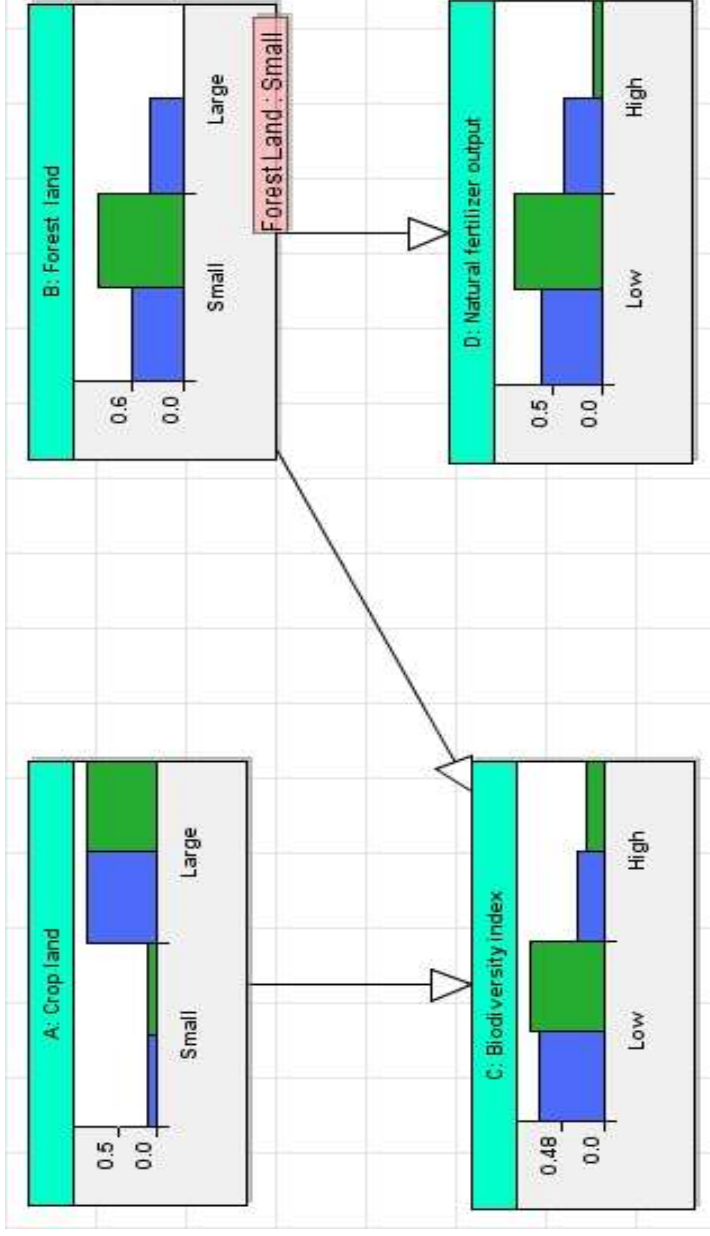
B: Forest Land		Small	Large
D: Natural Fertilizer output	Low	0.9	0.2
	High	0.1	0.8

NPT for node D: "Natural Fertilizer output"

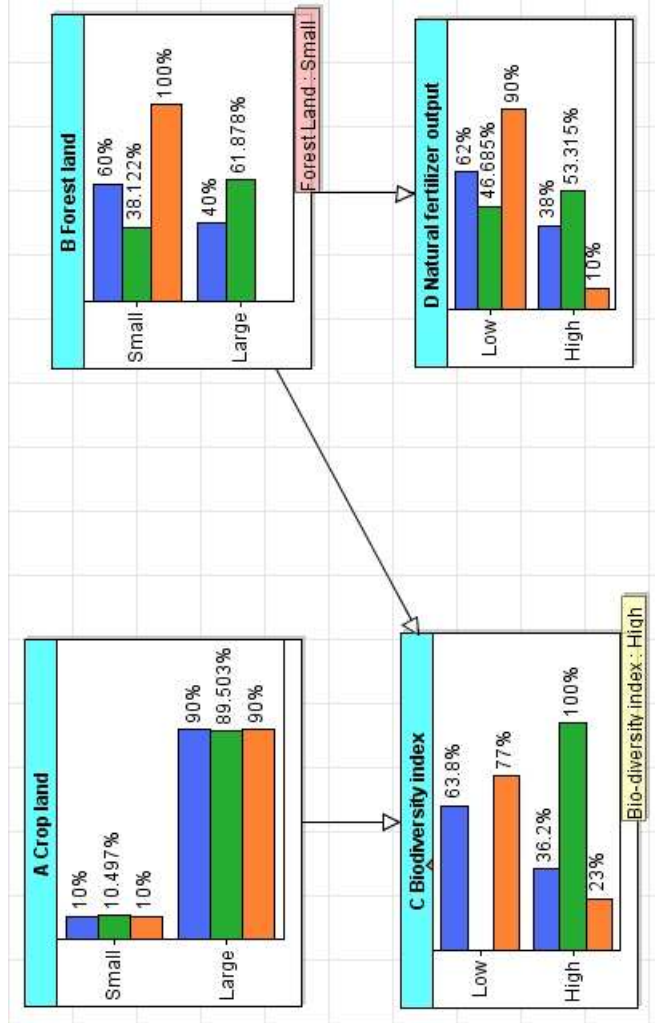
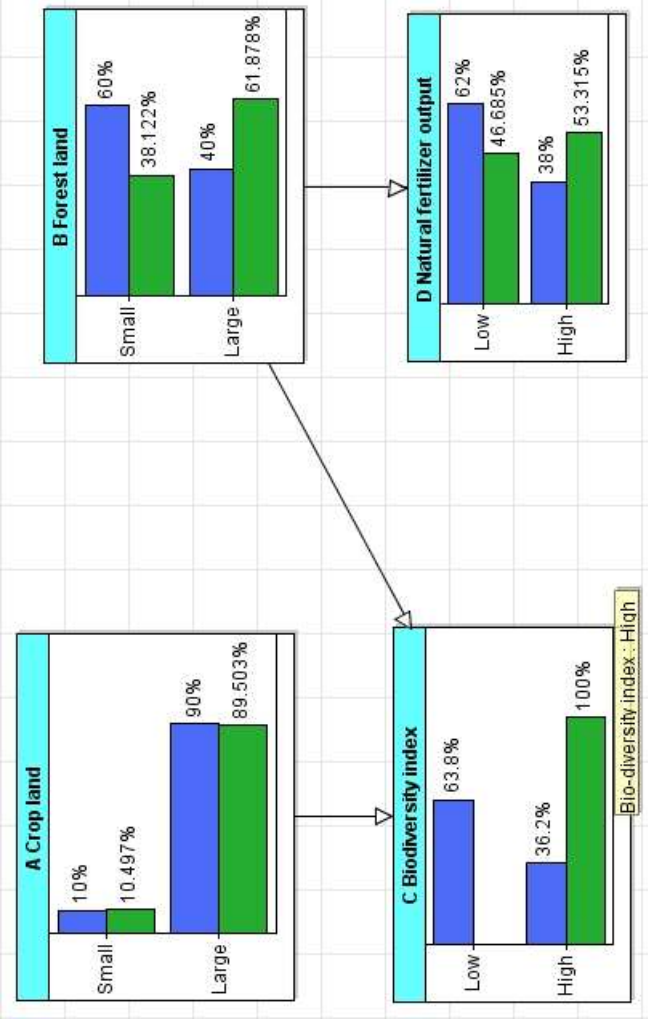
Reasoning with a BBN

the farm manager decides to decrease the amount of land covered by forest.

How does this change affect the probabilities of the other nodes in the network?



Bio-diversity index = High

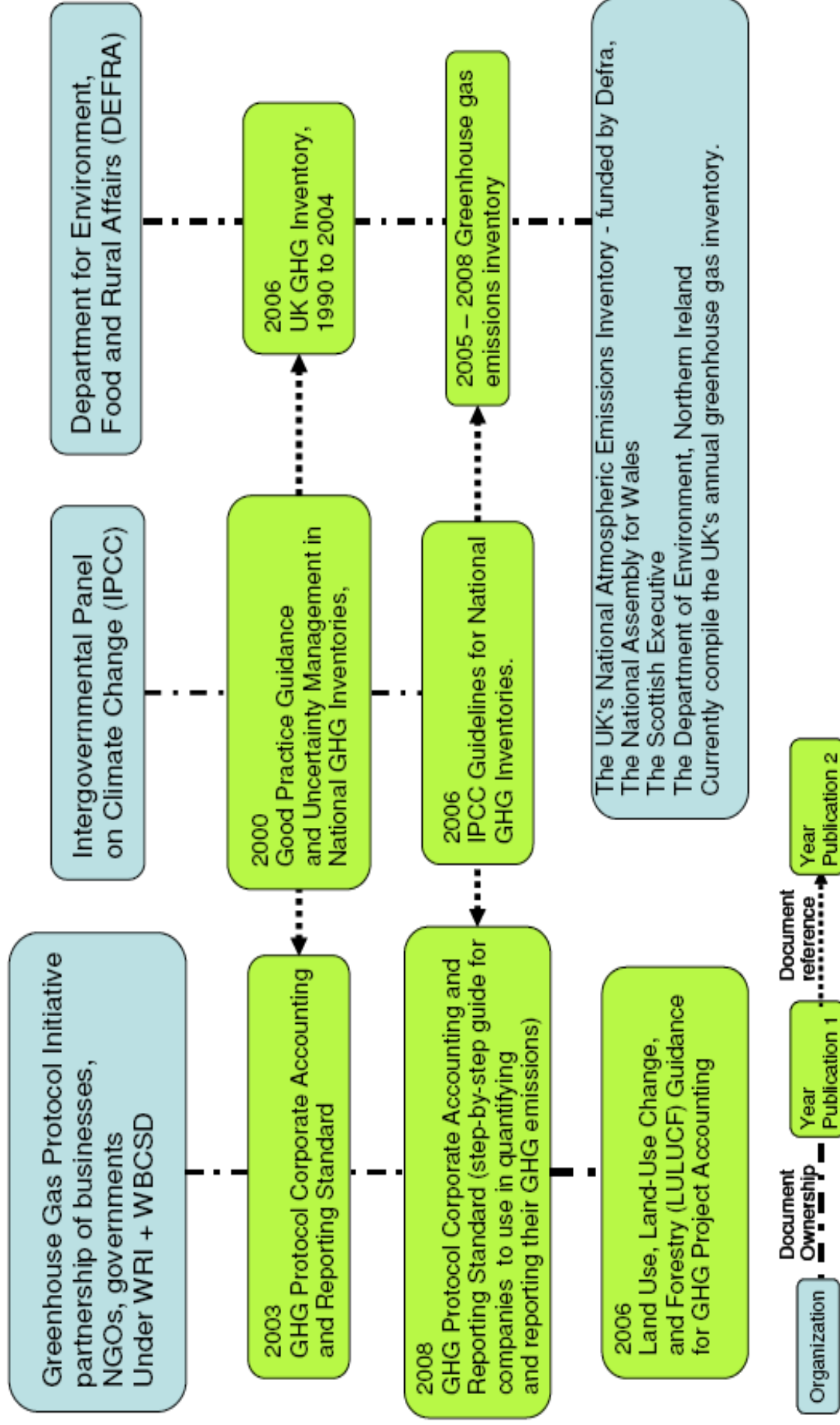


Integrated view of the scenarios

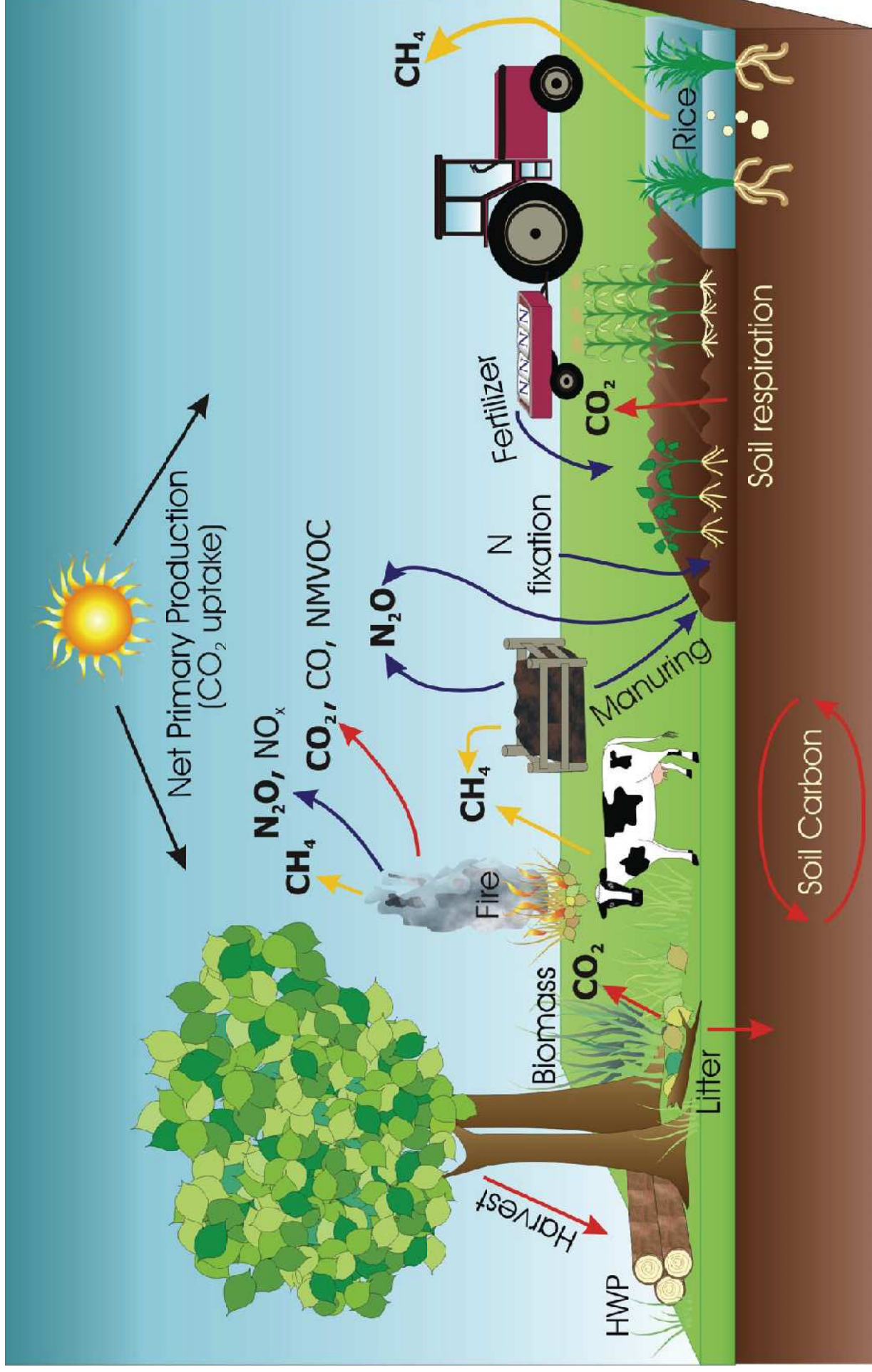
Benefits of using BBN

- Bayesian probability is all about revising probabilities in the light of actual observations of events.
- Explicitly model causal factors.
- Reason from effect to cause and vice versa.
- Overturn previous beliefs in the light of new evidence.
- Make predictions with incomplete data.
- Combine diverse types of evidence including both subjective beliefs and objective data.
- Arrive at decisions based on visible auditable reasoning.

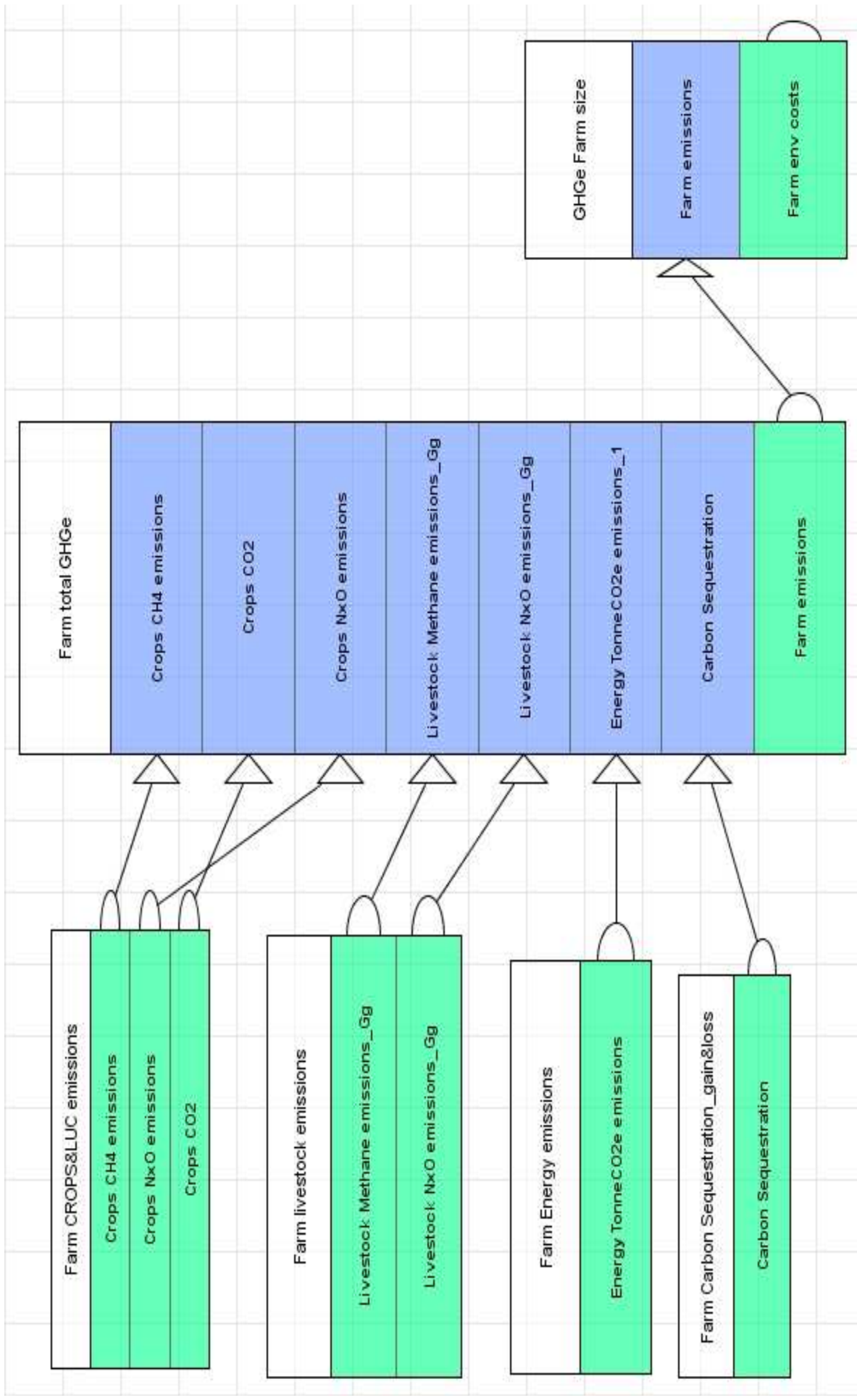
Organizations and guidelines on GHG estimations (International + UK)



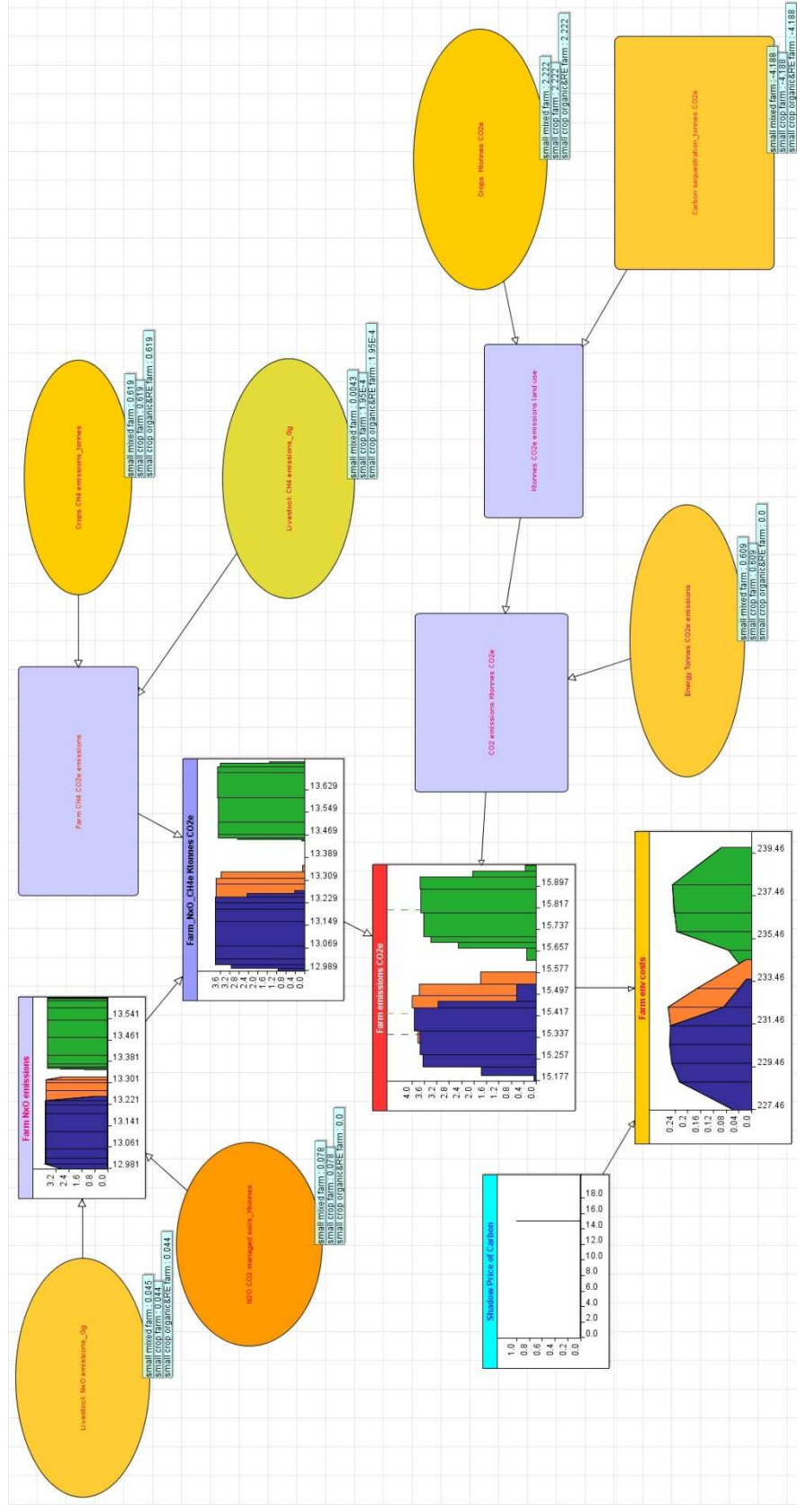
Agriculture, Forestry and Other Land Use (IPCC)



Top Level BBN UK Farm GHGe estimates

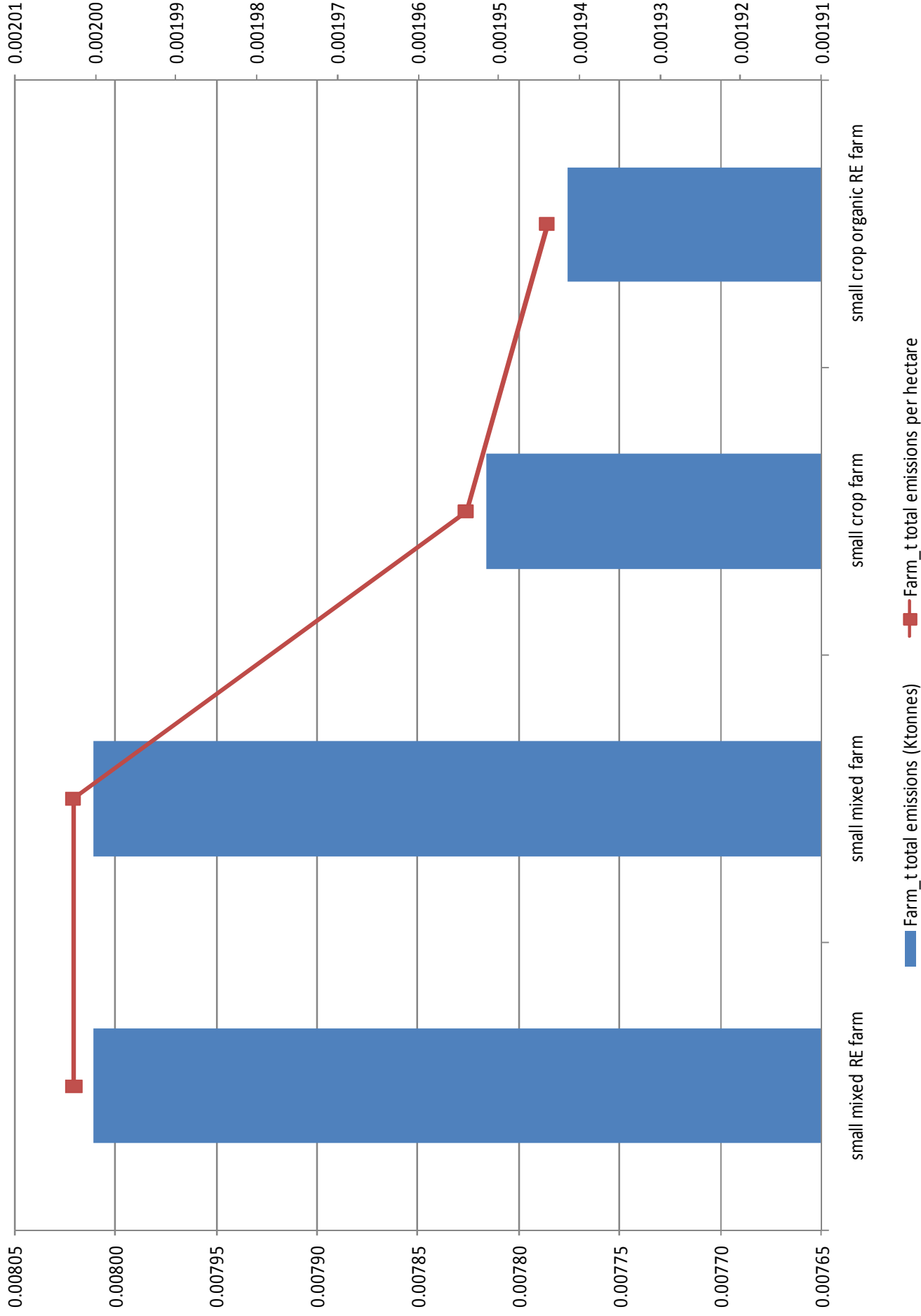


Farm total GHGe estimates



Purple: small crop organic & RE Orange: small crop Green: small mixed

small farm scenarios total emissions vs. emissions per hectare



Conclusions

- The results presented only scratch the surface of what can be achieved
 - Need better data on the energy used on farms
 - Need better data on LUC practices on farms
 - Need better data on the generation of GHGs on a farm
- Current estimation methods simply provide numbers but are deficient in relating them to the farmers' reality and explaining how uncertainty is managed
- Current results with the BBN seem to show that going vegetarian looks like the quickest way for the sector to comply with the ZCB scenario
- It is still very unclear how beneficial it would be for a farmer to replace all its energy resources to renewables or to become organic
- The IPCC guidelines in their basic form depend mostly on linear models, and it is far from clear, if this is the case in reality
 - The work at CEH looks at the potential of a Bayesian framework for estimating parameter and modelling output uncertainties in leaf area index (LAI) dynamics, tree height, and above ground biomass

**ANY CANDIDATES PREPARED TO
PROVIDE RESOURCES THAT WILL KEEP
THIS BALL ROLLING?**

ANY QUESTIONS?