

Geosci. Model Dev. Discuss., referee comment RC2  
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## Comment on gmd-2021-228

Anonymous Referee #2

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Referee comment on "GOBLIN version 1.0: a land balance model to identify national agriculture and land use pathways to climate neutrality via backcasting" by Colm Duffy et al., Geosci. Model Dev. Discuss.,  
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This paper describes a new backcasting modelling approach to project alternative futures for Ireland's AFOLU sector and assesses scenarios which meet different definitions of climate neutrality. Such granular bottom-up models are necessary to fill the gap between national climate targets and global IAM assessments. The paper presents a significant and useful contribution to modelling science. Further, it fills a very important gap in national modelling efforts, given the very ambitious target of climate neutrality but lack of any integrated assessment tool to understand how to achieve this. I believe that this paper needs to be underpinned by a solid description of the model in the context of other mitigation tools (national mitigation models and AFOLU models) and IAMs.

### Major comments

### Literature review

The paper lacks a discussion of the model framework chosen, and it does not put this in the context of existing Integrated Assessment Models (IAMs) or other model types. What

is the implication of this type of back-casting with randomised input parameters? Are there other similar approaches (I am not aware of any)? Can the tool be used to simulate the impact of policy choices (e.g., use as an alternative to existing GHG projections) and if not why? How is this model a development on or improvement over existing national GHG models? I have no doubt that there are advantages but the paper would be greatly strengthened with a full discussion of this topic.

#### Policy relevance

To date, the main GHG mitigation measured proposed by the Irish agri sector is improving production efficiencies (genetics, protected urea, multi-species swords, feed additives etc) e.g., represented in the Teagasc MACC. It is not clear to what extent these are taken into account in the input parameters. It would be very beneficial to represent this explicitly in the efficiency parameter and have an explicit scenario around "half/full achievement of all MACC efficiency factors by 2030" for example. This would greatly aid in its policy relevance.

Further, dairy cow numbers are projected to exceed the maximum assumed in the range presented here (or already have).

Fundamentally the way the results and scenarios are presented read far more as a simulation tool rather than backcasting. Please clarify.

#### Biodiversity and water quality

Given that land use is not only fundamentally important for carbon sinks and food production; it is also essential to host and enhance biodiversity. Ireland has declared a biodiversity crisis and it is not sufficient to deal with climate change without also dealing with the very poor quality of biodiversity. Some forms of grazing (more extensive systems) are compatible with greater biodiversity, like some forest models. I think it is important for a land use model to work towards explicit incorporation of biodiversity, otherwise there is a risk that climate and food production will come at a cost to nature. Similarly, an explicit output of the model could be nitrate runoff, to highlight water pollution.

## Minor comments

### L23 AFOLU - Agri, Forestry, Other Land Use

L31 specify the year and check. Agri emissions only in 2018 accounted for more than 34% so I would expect that including LULUCF would be more.

L75 - a literal reading of Article 4 suggests emissions are balanced - this can be interpreted as climate neutral only if it's intended that a "removal" of methane includes its oxidation in the atmosphere. But then it must be clear that according to mitigation modelling "climate neutrality" is not sufficient to meet the Article 2 temperature goals, and ethical issues about how countries seek to achieve these goals remain.

### L90 "the need to"

L90 - food security: I question whether this provision in PA is meant to safeguard BAU food production of emissions-intensive foods in high-income countries. This is used by corporate lobby groups to excuse the need for mitigation so if it is used in this article I suggest more discussion and nuance.

L101 - specify the year - there is more recent data from 2020 EPA accounts - and I suggest citing the original source rather than the author's work.

L102 - what is the share of AFOLU in overall emissions and how does that compare to other countries?

In the discussion of metrics it would also be beneficial to summarise LULUCF accounting - "gross net" "net net" etc. Current EU land use account for example considers Irish LULUCF to be a sink/credit, which brings some confusion.

L116 - what is meant by "stakeholder visions"?

Fig 1: please increase the text size. No methane? Or is CO2 meant to be CO2e or GHG?

L168 - the interpretation of PA as climate neutrality as cumulative warming over the second half of the 21st century is new to me (but I am not expert in this)

Fig 2 - increase text size please for legibility.

Table 2 - Dairy cow numbers appear to be too low:  
<https://www.farmersjournal.ie/100-000-lift-in-cow-numbers-forecast-by-2025-655485>

The fact that cropland values are static should be explored in the discussion and possibly in future iterations of the model. Most crops are used for animal feed. I understand that future iterations will consider imported feed also so an future key parameter could be the share of animal feed from domestic vs imported.

"The proportion of grass production consumed by livestock via grazing and feeding on conserved grasses (silage and

hay)." this is not clear to me. What is done with the remaining grassland?

L204 - production intensity is based on national averages. This could be addressed in subsequent model iterations. The emissions intensity of farms varies widely; reducing production on more emissions-intensive systems would be low-hanging fruit.

L280/Table 3 - what do these coefficients relate to?

Fig 3 - increase font size. Including units in different parts of these graphs would be helpful for understanding, and distinguishing what is an input variable. This is also the case for equations such as eq (2).

L370: this line suggests that LU emissions from soil (e.g., drained organic soil) are not included here but the following paragraph suggests it is.

Fig 4.. Increase font size please

Fig 8&9 - these can be developed to greatly aid understanding. it is not possible to see which scenarios are "hidden", for example, the font size is too small and colours hard to distinguish. Axes units (0.0000005) not easy to understand and charts in fig 9 are very compressed.

L604 "Net marginal (CO<sub>2</sub>e emissions accounted for) CO<sub>2</sub>e sequestration time series from 1990 to 2050" - explain (related to comment on LULUCF emissions accounting). How is this related to Fig9?

Fig 11 - Paul Price's work has suggested that cumulative GWP\* and GWP100 gives a more accurate representation of ongoing warming impacts. A discussion on this would be beneficial.

Important to note that none of these scenarios meets climate neutrality in the conventional GWP100 sense.

Results section: it would be very valuable to include outputs of food production (litres of milk etc) and total land use (total share of land under grass, conifer, etc) given that the model is presented as a tool for assessing trade-offs between food production and mitigation, and nitrate runoff to reflect water quality.

L642: Simply IAMs not IAMS models

L707: Solar and wind renewable electricity also require land use.

This section is quite dense: a list of development priorities would be beneficial.

References - many do not have years