Trade-offs of integrating trees for food production, profitability and net-zero

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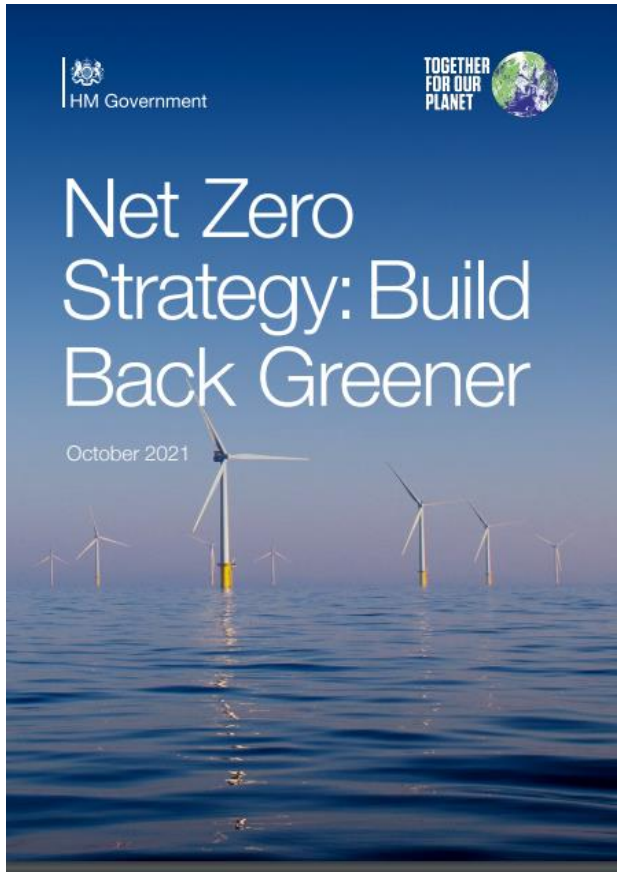
Introduction - Background



The UK has committed to achieve **net-zero** greenhouse gas (GHG) emissions **by 2050** (UK Government, 2019).

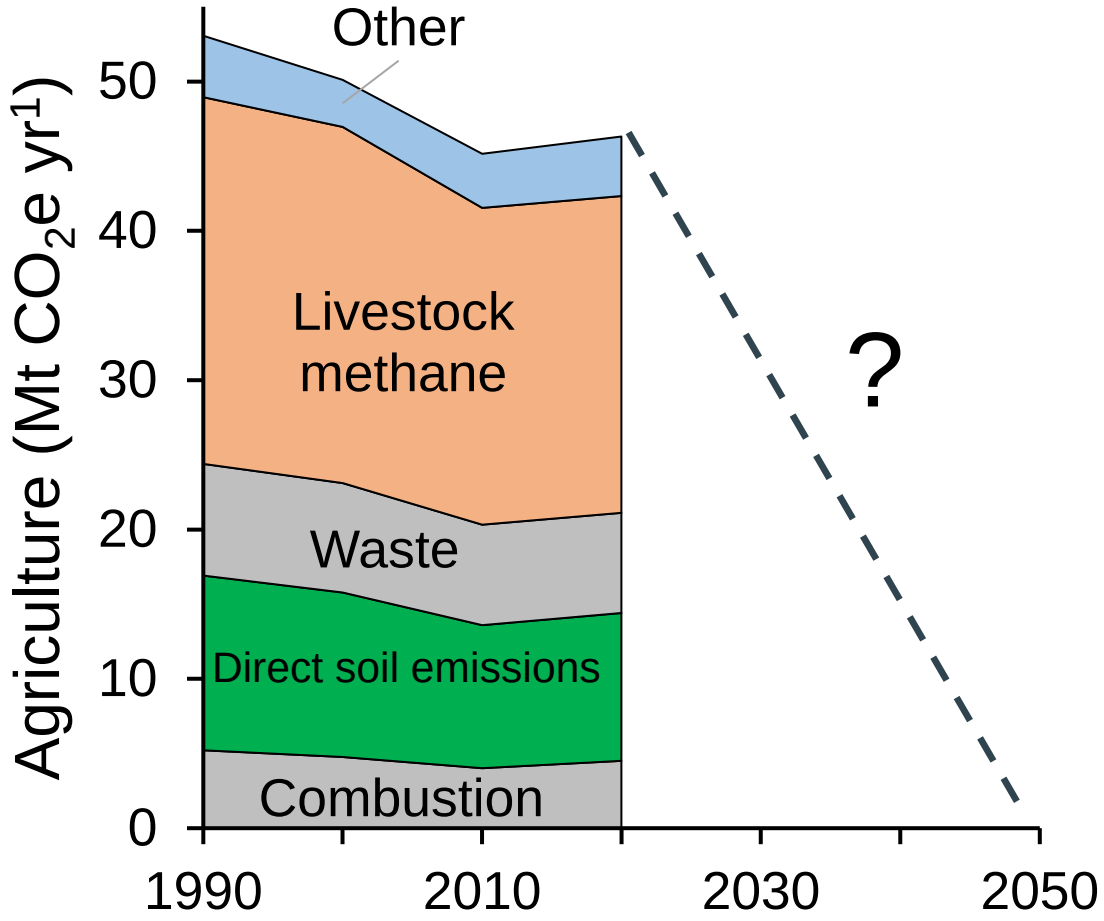
UK's agricultural sector produced about **10%** of the UK's total territorial GHG emissions in 2019 (UK Government, 2021).

National Farmers Union commits to achieve **net-zero** GHG emissions **by 2040** (NFU, 2019).

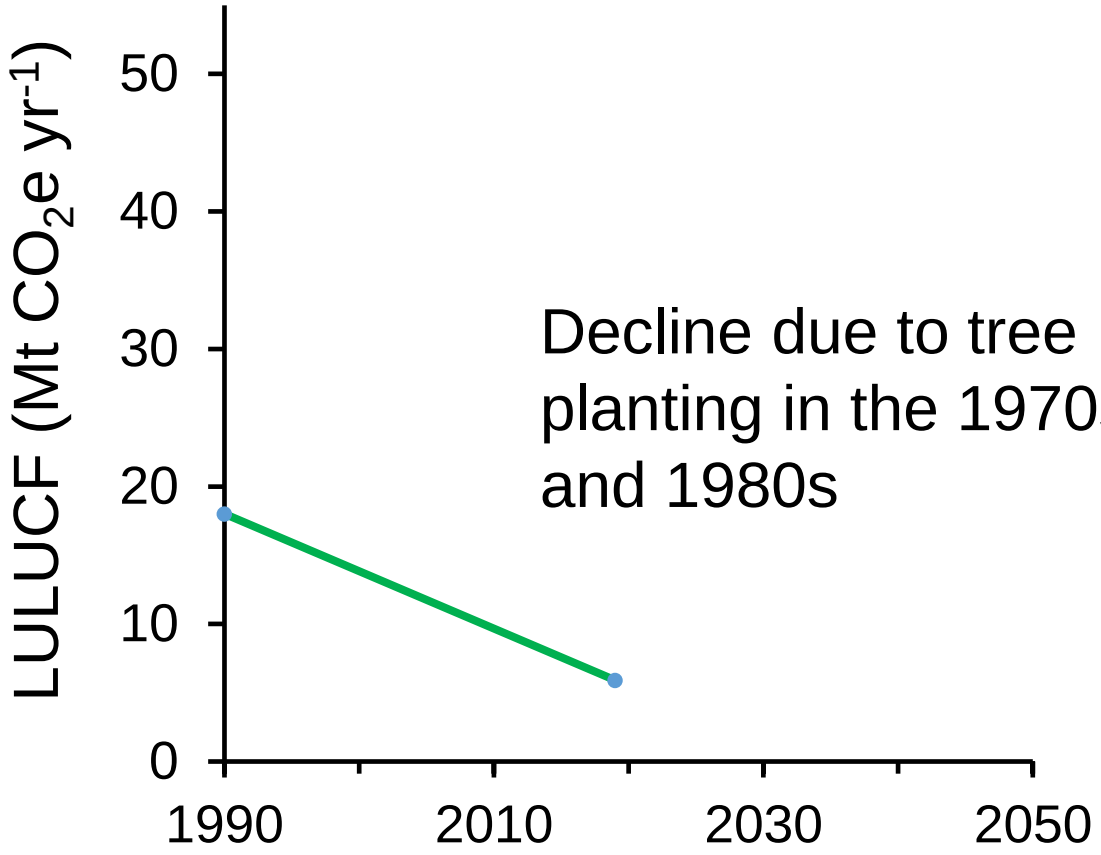
As part of an MSc group project, Cranfield investigated the challenges faced by farmers and the role of trees on farms (EU project: Agromix).

UK agriculture, land use and climate change

UK **agriculture** GHG emissions of 46 Mt CO_2e, in 2019 (~10% of UK total)



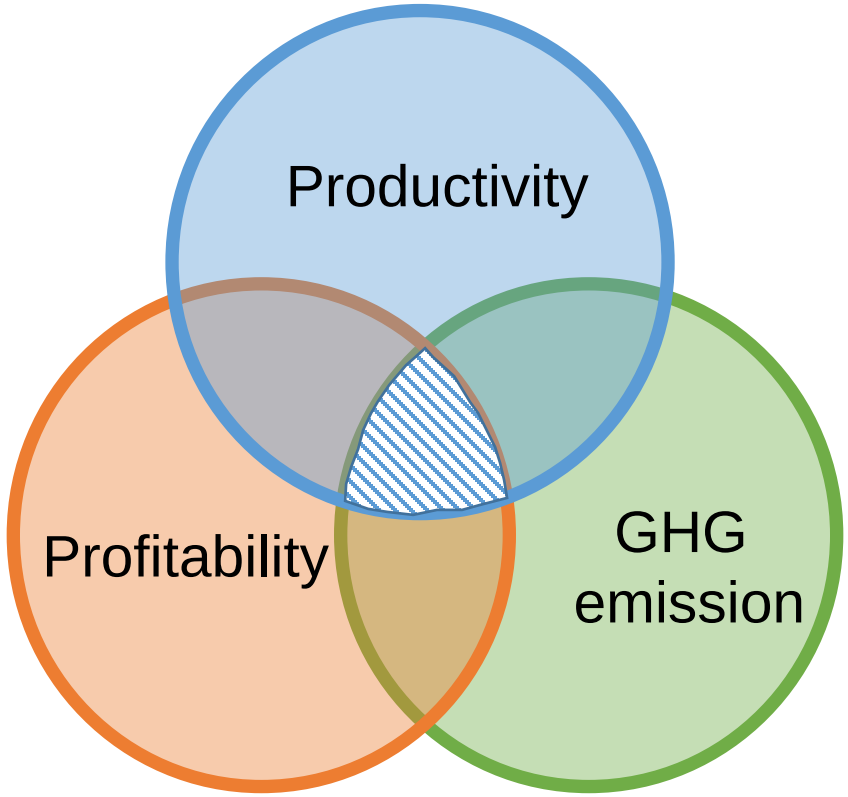
Land use and land use change and forestry emissions of 6 Mt CO_2e in 2019



Burgess and Graves (2022)

Aim and objectives

Aim: To compare the effect on food production and profitability if each farm business achieves net-zero greenhouse gas emissions in the Marston Vale



Objectives

1. To determine the current land use in the Marston Vale.
2. To determine the range of farm sizes and farm types in Marston Vale and to spatially allocate representative farms in Marston Vale.
3. To predict the mean level of food production, GHG emissions, and net margin for each modelled farm.
4. To determine and compare the land use, productivity, and profitability implications of a scenario that achieves net zero for each farm.

Marston Vale - Total area around 16,000 ha

Method
- Supervised image classification approach
- Satellite imagery (Landsat 8 collection 2 level 2)

Principal arable crops:
- Spring and winter wheat (4,228 ha), 26%
- Spring and winter barley (1,028 ha) 6%
- Winter field beans (652 ha) 4%
- Oilseed rape (231 ha) 1%

Other land cover:
- Woodland (1,793 ha) 11%
- Grassland (2,251 ha) 14%
- Urban/built areas (3,704) 23%

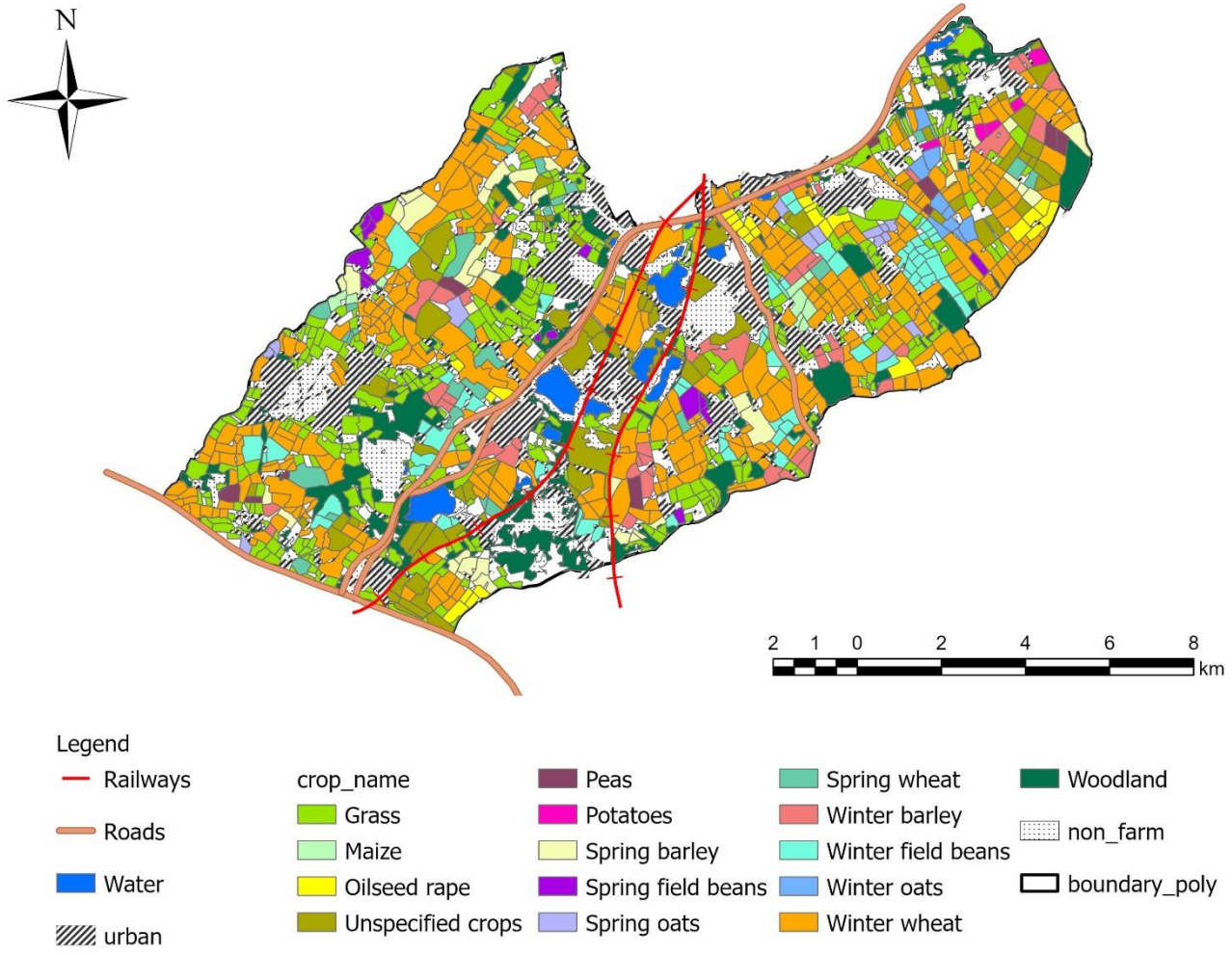
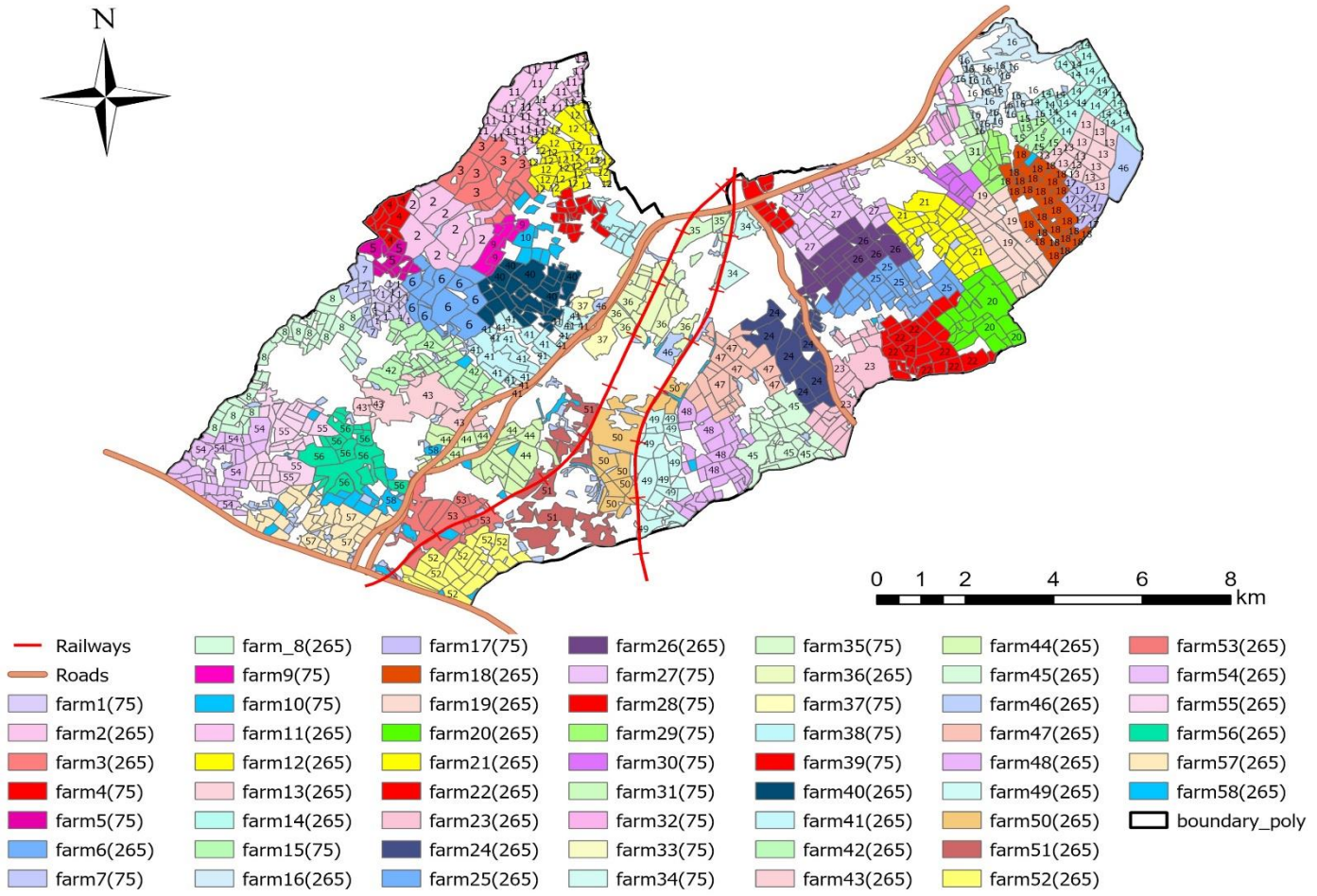


Figure 2. Marston Vale land cover map 2022

Spatially allocate hypothetical farms

Marston Vale was divided into
58 farms of either 75 ha or 265 ha

	Mean area (ha)	Number of farms
50 – 100 ha	75	19
> 100 ha	265	39
Total		**58**



The predicted farm size distribution for Marston Vale was derived from the farm size data for Central Bedfordshire and Bedford Borough
(Defra June Survey, 2021)

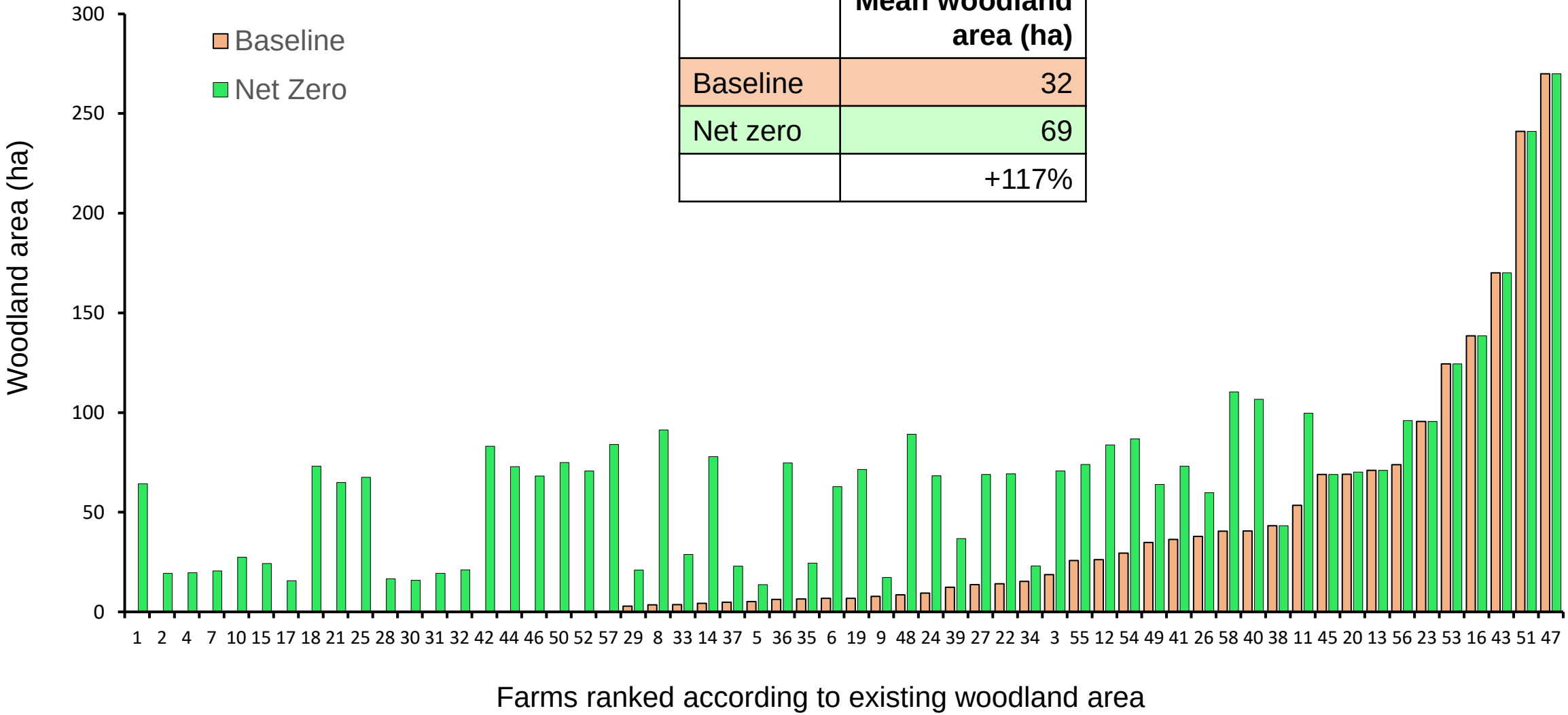
Assumptions

Crop	Yield	Benchmark UK emissions intensity	Total consumable food	Total GHG emissions	No. per hectare	Total GHG emissions
Arable	(t ha^{-1})	(kg CO_2e kg^{-1})	(kg)	(kg CO_{2e} $head^{-1}$)		(t CO_2e ha^{-1} yr^{-1})
Wheat	8.6	0.38				3.27
Barley	7.3	0.33				2.41
Oilseed rape	3.5	0.74				2.60
Spring crop (oats)	6.1	0.31				1.90
Spring crop (peas)	4.0	0.41				1.64
Spring crop (potatoes)	50.4	0.22				11.10
Spring crop (beans)	4.3	0.1				0.43
Grassland						
Suckler beef		23.4	342.9	8022	0.63	5.05
Sheep		25.2	21.9	551	5.9	3.25
Woodland						
Oak, Beech, SAB						-10.65

(Langford and Foot 2022; Redner et al., 2022; Woodland Carbon Code 2021)

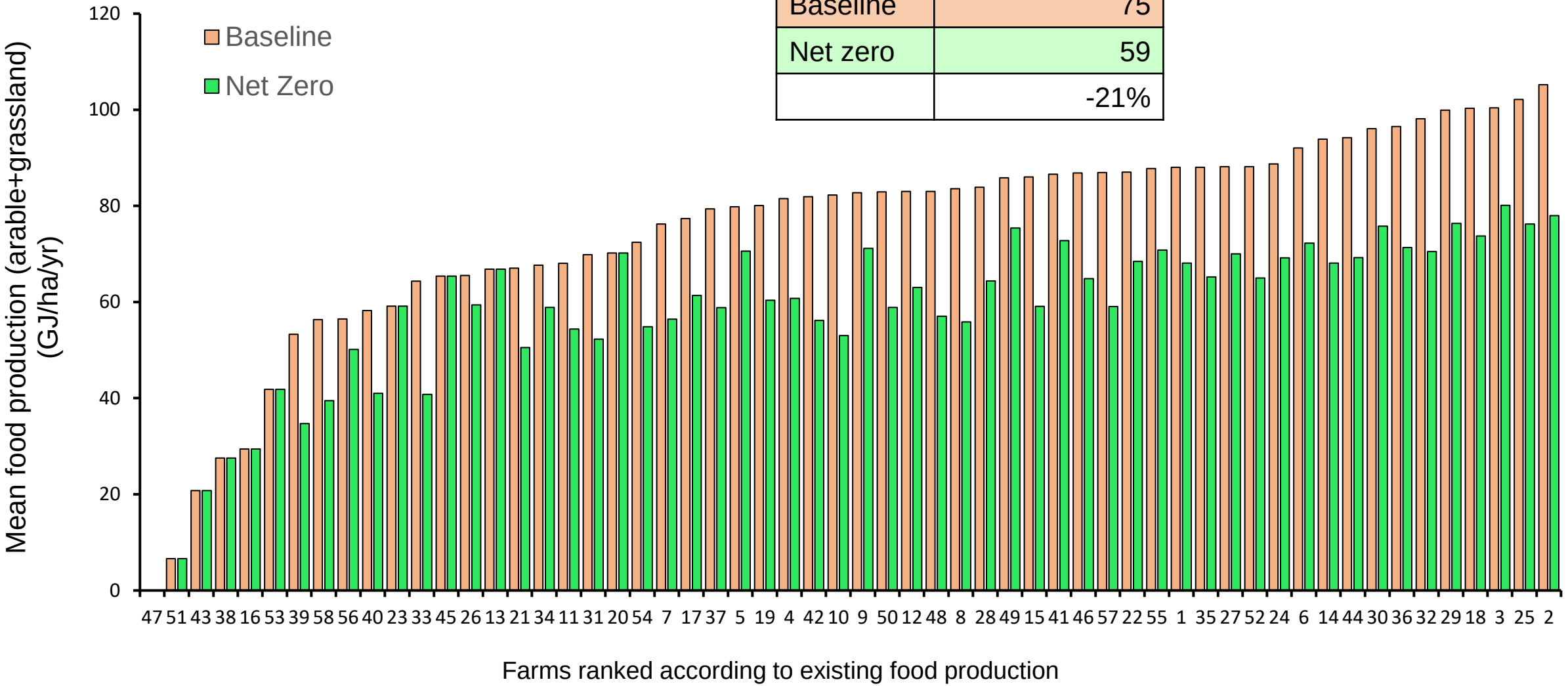
Farms can achieve net zero by adding woodland

	Mean woodland area (ha)
Baseline	32
Net zero	69
	+117%



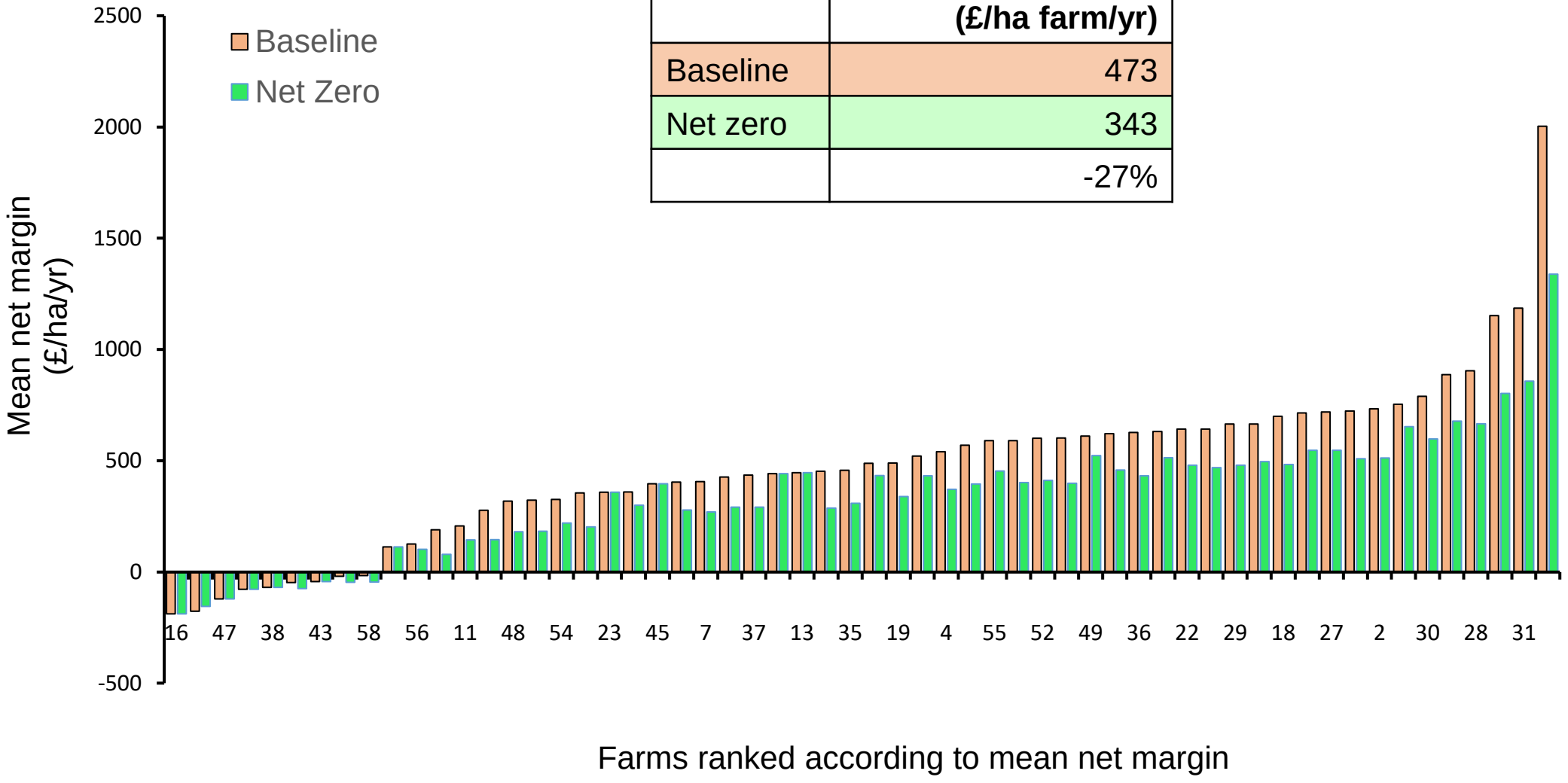
Food production

	Mean food production (GJ/ha farm/yr)
Baseline	75
Net zero	59
	-21%



Profitability

	Mean profitability (£/ha farm/yr)
Baseline	473
Net zero	343
	-27%



Conclusions

- Integrating trees into Marston Vale agricultural land, can achieve net zero
- New size of woodland area, had to double compared to the current
- This in turn decreased food production and profitability on average by 21% and 27%
- Calculations did not account for any governmental support
- There are efficiencies in setting net zero targets at a landscape rather than an individual farm-level
- If the analysis was to look beyond the farm-gate, emissions would have been created elsewhere to compensate for the loss in food production

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Acknowledgements

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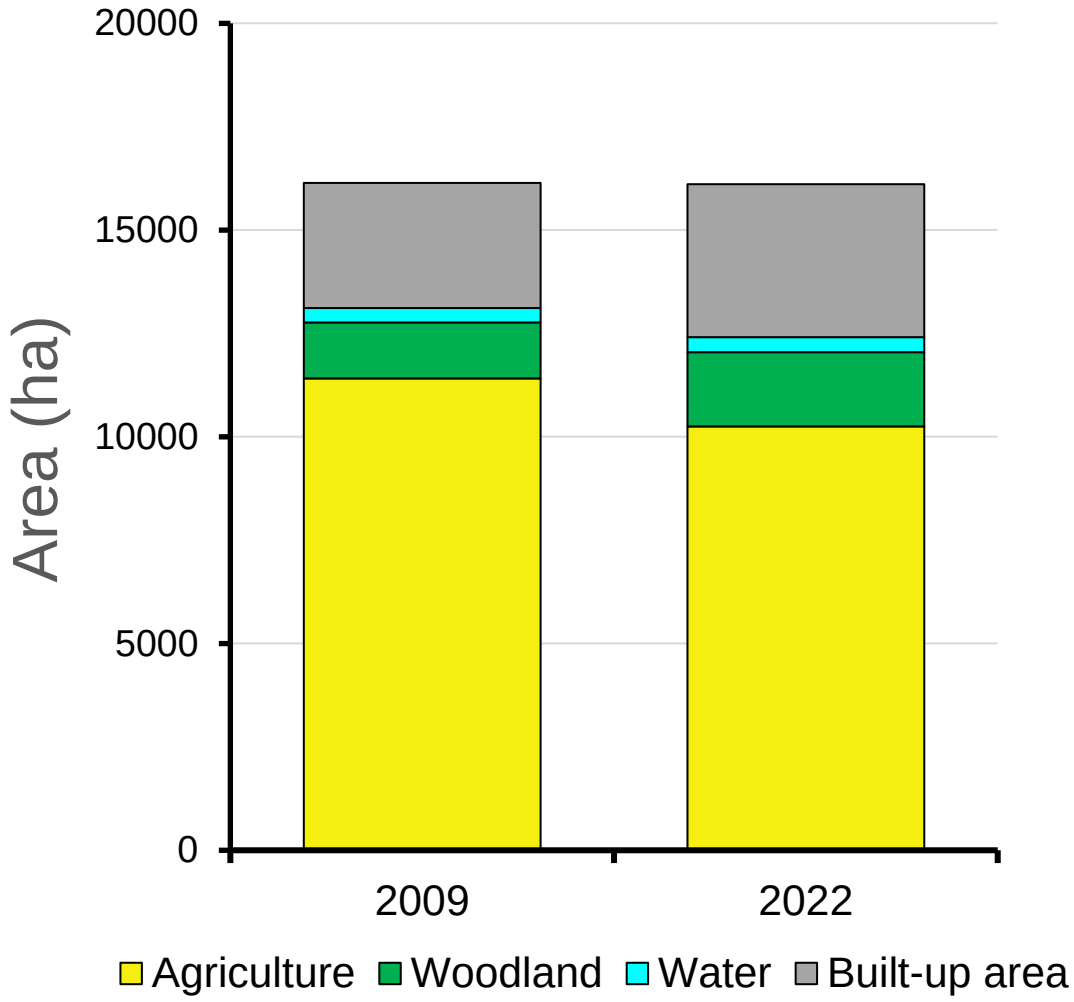
Land cover comparison between 2009 and 2022

Land-use type	Area in 2009 (ha)	Area in 2022 (ha)	Change (ha)
Agricultural	11,413	10,254	-1,159
Woodland	1,352	1,793	+488
Built-up areas	3,020	3,704	+683
Water	352	339	-13



(Burgess et al., 2012)

Life cycle assessment

Crop names	Area in 2022 (ha)	Baseline (100% UK)	59.6% Marston Vale	Sequestered CO_2 in trees	40.4% US	Transport from US	Deforestation or grassland conversion in US	Avoided fossil fuel
Winter wheat	3924	14578	8686		8632	1230	42868	
Grass (sheep)	1463	21895	13045		9090	39	10244	
Unspecified crops	1249	3525	2100		1991	317	8014	
Grass (beef)	1013	25403	15135		10267	56	4196	
Winter field beans	652	1085	646		774	82	6148	
Winter barley	534	1507	898		851	136	3426	
Spring barley	494	1394	831		788	125	3169	
Spring wheat	309	1148	684		680	97	3376	
Oilseed rape	231	778	464		480	31	1799	
Spring oats	124	320	191		265	27	1224	
Spring field beans	123	205	122		146	15	1160	
Peas	121	202	120		136	16	922	
Winter oats	108	279	166		231	24	1066	
Maize	85	249	148		90	30	291	
Potatoes	49	221	132		101	65	171	
Forestry	1793		562	-43931				-49117
TOTAL		**72789**	**43931**	**-43931**	**34523**	**2290**	**88075**	**-49117**

Reduced production in MV: -28,858
New trees in MV : -43,931
Avoided fossil energy : -49,117

Total : -122,000

40.4% US : 34,523
Transport from the US : 2,290
Grassland conversion in US : 88,075

Total : 124,800