Quorn Footprint Comparison Report

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Carbon Trust Advisory Limited
4th Floor, Dorset House, 27-45 Stamford Street, London, SE1 9NT
T: +44 (0)20 7170 7000 F: +44 (0)20 7170 7020 www.carbontrust.co.uk
Carbon Trust Advisory Limited is a limited company registered in England and Wales Number 06274284
Registered at 4th Floor, Dorset House, 27-45 Stamford Street, London, SE1 9NT

Authors

Karl Hsu, Analyst

John Kazer, Certification Manager

Tom Cumberlege, Associate Director

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1 Introduction

This report summarises the Carbon Trust's research into carbon, water, and land use footprints for the common protein sources soy, beef, chicken, pork, and fish, and compares these impacts against Quorn's mycoprotein, mince, pieces, sausages, and vegan fishless fingers.

The footprint data identified in the research shows how each source of protein compares to Quorn's products. We acknowledge there are differences in the production methods and resource requirements for each source of protein. The research has prioritised studies that evaluate the impact of these sources of protein as produced within the UK and continental Europe, as well as the import country of origin when most is sourced from elsewhere.

2 Footprinting Introduction

We have researched the carbon, water, and land use footprints for each product in this report in order to provide a full view of their environmental impact.

2.1 Carbon footprint

The carbon footprint assesses all the greenhouse gases (GHGs) released from the various processes required to produce the finished product from the 'cradle to the processing gate' boundary. While the term carbon footprint is used throughout this report, the measurement units are carbon dioxide equivalent (CO_2e). CO_2e is a reference unit to assess the global warming potential of a range of different GHGs. For example, methane has a global warming potential 28 times greater than carbon dioxide (Greenhouse Gas Protocol).

Using chicken as an example, the total impact of all GHGs released along the value chain are assessed.

Lifecycle analysis studies evaluate all the GHGs released from the cultivation of feeds via the use and manufacturing of synthetic fertiliser, transportation, heating and lighting requirements, and processing energy.

2.2 Land use footprint

The land footprint focuses on the physical area required to produce the finished product. This mainly involves the land that the product is raised on (such as the area livestock require to live on) and the land used to grow the feed that the livestock consume. The land footprint is expressed in terms of hectares per kg of finished product (ha kg^{-1})

2.3 Water footprint

Water footprints assess the total amount of water affected during the processes required to produce the finished product. This includes water consumed by the animals (such as water that livestock have drunk), water used to produce the feed, rain and dirty water that returns to rivers and water consumed during processing.

Water footprints have been divided (Water Footprint Network, 2011) between ‘green water’, ‘blue water’, and ‘grey water’:

- Green water is related to water from precipitation in vegetation and soil, which is the greatest category of water consumption
- Blue water is surface and ground water consumed by food production, which relates to the growing of feed for the livestock and soy itself
- Grey water is the amount of water needed to dilute pollution and is a product of activities such as polluted water from manure, fertiliser, or pesticides, which would be applicable to the growth of livestock and feed

The water footprint is expressed in litres per kg of finished product ($L\ kg^{-1}$)

In regard to the analysis, blue water is the most important footprint for direct comparisons, as it is most easily measured and controlled by businesses. Green water, although often a large value, represents water that although temporarily affected by agriculture, is not removed from the natural system. Grey water is difficult to estimate, and in Europe is already regulated by water quality regulations.

3 Assumptions

We made a number of assumptions in the process of gathering and calculating the environmental footprints for the food products. A boundary of ‘cradle to processor gate’ was used for all five products, and all the footprinting studies express the environmental impacts on a ‘per kg of edible product’ basis. This allowed for consistent footprints across the products for comparison. A range of footprints was also provided rather than just an average, so that greater detail is provided in the distribution of footprints and what makes up the average. These ranges exist due to variation in study results, what factors are included (such as with or without land use change (LUC)), sub-regions, and categories of species. Therefore, the low and high figures are a result of differentiating figures from the references used. This also allows Quorn to achieve the best level of transparency when discussing these comparative figures.

4 Footprint Results

In this section, we summarise the results for each protein source according to the three footprints studied. The key assumptions and carbon, land, and water footprints for each protein source (soy, beef, chicken, pork, and fish) are also discussed. The following section provides a detailed analysis of how these footprints compare to the chosen Quorn products – Mince, Pieces, sausages, vegan fishless fingers, and mycoprotein.

4.1 Soy

The soy carbon, land, and water footprints were all gathered from online agricultural sources and research papers. Soy, compared to the other sources cannot be calculated based on the resources that are used in growing the product (for example, this refers to the feed provided to the animals for the meat sources). Therefore, all three footprints for soy are based on the researched data from papers, articles, and agricultural organisations.

A limitation of soy compared to the other products is that the majority (90%) is produced outside of the UK and Europe boundary, in the US, Brazil, and Argentina (Nadathur, Wanasundara, & Scanlin, 2017), (WWF, 2018). However, as the UK and Europe source soy from the regions it is mostly produced in, it can be said that the global figures are the same for the UK and Europe. Results for soy were also found to be in a range of products of the bean, for example, 13% is used directly for soymilk, dofu, miso, and tempeh, and 87% is used for soymeal and oil (Nadathur, Wanasundara, & Scanlin, 2017). This is because soybeans are processed into several co-products, which means that additional carbon emissions and water consumption occur. Multiple soy products also results in allocation between them. For example, what proportion of the bean is used for different products varies according to the products made. A product, which uses a small amount of the bean, may have a smaller footprint per kg. In addition, there are different ways to process soy beans which have different energy requirements. In order to simplify the comparison to Quorn's product we did not take into account the variability in the amount of soybean used in final products or the various different manufacturing techniques used to process soy beans, as limited public information exists and this would be in a boundary that is post-soy production. This was also due to many products made from soy, and for this comparison, it was best to compare mycoprotein to the footprints for the raw, fresh bean.

A wider variability in emissions exists compared to the other protein sources, and can be associated with geographic location, management practices, and soil type (Cerri, et al., 2017). Geographic location can influence the range due to the varying management practices and soil types in different regions – for example, South East Asia peat soils will release more carbon than oxisols in Brazil. For example, soy is often grown in Brazil, which will have different cultivation and land management operations compared to soy that's grown in South East Asia. The geographic locations will therefore have an influence on all three footprint aspects – carbon from the climate, land use, and soil classification differences, water from the climate and local practices, and land from the regional practices of different regions.

4.1.1 Carbon

The average carbon footprint we use for fresh soybeans is 1.02 kg CO_2e kg^{-1} (Audsley, et al., 2009), (Carbon Trust database).

Several issues are involved in determining the footprint of soy, and the results can vary greatly. The carbon emissions of the soy product only takes into account the proportion of the entire emissions associated with the part of the original soy bean and husk/shell that is used. Direct LUC also plays a significant role in the footprint of soy, as soy is one of the main vegetation species that is grown in deforested areas (see below for a comment on 'indirect' LUC). When an area of existing land-use (typically native grassland, forests or rainforests depending on the region) is cleared to make room for agriculture, all of the embodied carbon in the existing vegetation is removed. Proportions of soil carbon is also released into the atmosphere when the top layer is disrupted during the clearing of the pre-existing vegetation. If included in the carbon footprint calculation, this can dramatically increase the results. For example, when excluding LUC, the footprint of soy can range between 0.3-0.8 kg CO_2e kg^{-1}, but when LUC is included, it can range between 0.1-17.8 kg CO_2e kg^{-1} depending on the scenario (conversion of tropical forest, forest plantations, perennial crop plantations, savannah, and grasslands), cultivation (tillage, reduced tillage, and no tillage), and soybean transportation systems (Castanheira & Freire, 2013). The overlap in the minimum figure (with LUC being 0.1 kg CO_2e kg^{-1} and without being 0.3 kg CO_2e kg^{-1}) is due to tillage systems having higher GHG emissions than no tillage or reduced tillage. The original conversion of land and the original land choice has a large influence on the wide range in the footprint. For example, soybean cultivation on degraded grassland results in the lowest emissions, and cultivation in wet tropical regions has the highest GHG emissions (Castanheira & Freire, 2013).

There is on-going debate regarding the best, most useful or most accurate way to calculate LUC emissions (Euractiv, 2017). One aspect is the difference between direct and indirect changes. The former is when land is cleared and used directly for soy. The latter occurs when soy is grown on cropland previously used for something else and the displaced crop then moves, causing indirect LUC. We have not included indirect LUC in this study.

4.1.2 Land

The land footprint for soy relates to the area required to grow the crop rather than any indirect land use such as that required to grow the feed for livestock. LUC also does not affect the land footprint (unlike the carbon footprint), as this aspect of soy production starts after an area of land has been cleared. Land footprint results were more consistent than carbon in terms of region, as the majority of soy is grown in the Americas. However, the land footprint is 0.0004 ha kg^{-1} for Brazil (Dalgaard, et al., 2008), a result supported by the following FAO data in Table 1.

Table 1 – Summary of global soy production based on 5-year averages *(FAO, n.d.)*

	Average yield (t ha^{-1})	Average (ha)	Global share
China	1.80	6,782,261	6.8%
India	1.05	11,362,486	11.4%
USA	3.12	32,340,640	32.4%
Mexico	1.67	206,632	0.2%
Argentina	2.76	19,017,652	19.1%
Brazil	2.87	29,698,124	29.8%
France	2.71	83,011	0.1%
Italy	3.51	233,409	0.2%
Total		99,724,214	
Weighted average	2.65		
Weighted average yield (ha kg^{-1})			0.00038

4.1.3 Water

Green water is the water category with the greatest value, with an average of 1655 L kg^{-1}. Blue and grey water are much lower at 520 L kg^{-1} and 485 L kg^{-1} (Table 2) (Ercin, Aldaya, & Hoekstra, 2012) (Water Footprint Network, 2011). See section 2.3 for an overview of the different types of water footprint category.

Table 2 – The ranges and average of fresh soybean water footprints

Water category	Low (L kg^{-1})	Average (L kg^{-1})	High (L kg^{-1})
Green	1260	1855	2070
Blue	70	240	520
Grey	37	573	1100

4.2 Beef

4.2.1 Carbon

Data from studies consistent with the methodology developed by the Carbon Trust was used (DairyUK and DairyCo, 2010). This dairy methodology is fully compatible with IDF dairy guidelines (IDF, 2015) and is applicable to beef, being consistent with FAO beef studies (Gerber, et al., 2013) (Opio, et al., 2013), (FAO, 2016). It has also been used over 100,000 times on nearly 40,000 beef farms in the UK and Ireland (Bord Bia, 2014) (EBLEX, 2012).

The boundary therefore includes all feed production, manure storage and spreading, and enteric methane for the UK and Europe. In terms of herd structure, the supporting suckler herd and replacements are allocated to the resulting beef produced and sold regardless of whether they are maintained on the final (finishing) farm or not. As the boundary of these footprints are cradle to processing gate, the carbon footprint for beef also includes the conversion ratio for live weight to carcass weight (54%) and the de-boning of the carcass to edible meat (an additional 25%) (EBLEX, 2012).

A crucial point of continuing debate is how to manage the interaction between dairy and beef herds, where surplus dairy calves are transferred to beef production. Economic allocation is used to estimate the environmental (carbon, water, and land) impact associated with dairy calves fattened for beef, which we assumed here to be a 95:5 split between milk/cull cows and calves to beef (E-CO_2 personal communication). Other methods (feed energy requirements etc.) may result in slightly different ratios, but the overall result in this context is not significantly different.

Other key data includes the type of feed and efficiency of the suckler herd. Emissions are high when a large numbers of animals are maintained for longer in order to produce finished animals. The main causes we consider are health, husbandry, feed quality, and deforestation. Health and husbandry determine the size of the suckler herd and number of required replacements, whilst feed quality determines the rate of finisher maturity. The more animals and the longer they are on farm, the higher emissions per kg of meat tend to be; poorer health and feed also tend to lead to higher emissions.

Results were split between beef types: general beef (where results were for beef generally and not specific like mixed or grazed) (Audsley, et al., 2009) (EBLEX, 2013), mixed (multiple species or class of livestock on the same grazing area), and grazed (a single species that graze). Grazed beef resulted in the highest emissions, with an average of 121 kg CO_2e kg^{-1}, followed by mixed beef (27 kg CO_2e kg^{-1}), and lastly general beef (16 kg CO_2e kg^{-1}) (Table 3).

Table 3 – The ranges and average of beef carbon footprints in the UK and Europe

Beef category	Low (kg CO_2e kg^{-1})	Average (kg CO_2e kg^{-1})	High (kg CO_2e kg^{-1})
General	15	16	18
Mixed	20	27	30
Grazed	121	121	121

4.2.2 Land

The land use requirements for beef were calculated using the Carbon Trust model with the same structure and core herd assumptions to quantify the land utilised by different production systems. The land footprint is a factor of both herd management and feeding regime, as cattle require a much larger living/grazing area compared to pork and chicken. The living area for grazing cattle is the same as the feed area as a single area/field is used for both.

Beef cattle require approximately 2% of dry matter per body weight per day (EBLEX, 2011). Therefore, a 600kg cow eats about 12kg of dry matter per day; young stock less according to age. If a highly nutritious diet is used – then the animals rear very quickly due to the higher nutritional value per kg dry matter. Alternatively, if it is a wholly grass-based diet (lots of exercise and variable digestibility), it can take up to 3 years to raise to slaughter weight due to poorer grass quality (Cohn, Bowman, Ziberman, & O'Neil, 2011).

By quantifying the amount of dry matter required to feed livestock it is possible to calculate their land use requirements and how much dry matter is sourced from grass (and whole-crop forage) v supplementary feeds. An important land-sparing effect is generated by using supplementary feeds, for example, brewers grains (waste barley from brewing). These typically have a land (and carbon) footprint of 10% of the emissions of the original crop due to economic allocation between beer (for example) and these by-products. This therefore reduces the supplementary feed land use requirements by 90%.

With a mixed beef system, there is a split between grass and concentrate. A standard makeup of 20% concentrate for UK diets has been assumed (Williams, Audsley, & Sandars, 2006). Yield data for the UK comes from DEFRA's annual farm statistics (DEFRA, 2014). An assumption for yield of grass per hectare can be made (various assumptions exist) depending on variety/fertiliser. A mid-value of 10 t ha^{-1} has also been assumed, which has quite a big impact on land footprint. The nutritional value will also have a big impact but this is largely reflected in the time taken to finish the cattle. In the summer cattle will be grazing from fields directly, but farms also require fields used to produce silage.

The main modelling criteria used to evaluate the land footprint of beef are listed below with specific details provided in the data source section:

- The herd structure and herd management is a variable (e.g. birthing rate and replacement rate)
- The final weight of the animal and the kill out ratio is also a variable (reflects amount of meat produced in the allotted time)
- The total amount of meat produced is based upon typical finished weights, kill out ratio and a contribution from culled suckler cows
- The time to finish varies, according to relative digestibility of the diets
- To validate the findings we looked at diet make up. We also looked at farms from existing industry studies
- Intensive Mixed – mostly grazed with 20% supplement
- Extensive farm (100% grass-based)
- Dairy calves – The incoming youngstock footprint figure is lower than specialist beef animals as the number of mothers you need to maintain to produce the beef animal is low due to 5% allocation between calves compared to milk (also assume lower quality meat with lower KO ratio and finish weight compared to Intensive Mixed)

Grazed beef has the higher average footprint of 0.0049 ha kg^{-1}, followed by mixed beef with an average of 0.0035 ha kg^{-1}. The land footprint for general beef was 0.0068 ha kg^{-1}, however, this figure is for Canada and is not comparable with the UK and Europe footprints of mixed and grazed beef, as the areas that cattle of raised on are much larger in Canada (Rias Inc., 2016).

4.2.3 Water

Water calculations substitute land use for water utilisation. Therefore, the water content of feed was calculated, rather than hectares per feed.

Although Water Footprint Network (WFN) data was used for the feed and grazing water use (Mekonnen & Hoekstra, The green, blue and grey water footprint of farm animals and animal products, 2010), the herd modelling results in higher water footprints per kg of meat compared to WFN data (Mekonnen & Hoekstra, A Global Assessment of the Water Footprint of Farm Animal Products, 2012). This is due to our more comprehensive 'bottom-up' methodology that properly models herd structure rather than relying upon top-down assumptions based on national statistics. The key difference between our results and those of Mekonnen and Hoekstra is that they estimate 16kg of feed (dry mass) is required per kg meat, whilst we estimate 27kg (UK intensive beef). The reason for this difference is that the bottom-up approach includes the support herd necessary for specialist beef. It is interesting to note that using a 2 year raising and finishing period and data from EBLEX, we calculate that 15.7kg DM feed kg^{-1} meat is required based purely on the finished animal.

In total, grazed beef has the highest water footprint in all three water categories, and general beef has the lowest average footprint (Table 4).

Table 4 – The average water footprints for the three beef categories in the UK and Europe

Beef category	Green water (L kg^{-1})	Blue water (L kg^{-1})	Grey water (L kg^{-1})
General	13,921	752	1016
Mixed	15,500	250	4000
Grazed	16,500	300	5000

4.3 Chicken

The following footprints relate to the rearing practices for broilers and layer chickens in the UK and Ireland, where broilers are loose housed on litter with automatic feed and water, and layers are housed in a variety of cage, barn, and free range systems with automatic feed and water. However, most references did not specify the rearing practices and can therefore be assumed to be an average.

4.3.1 Carbon

The carbon footprint has been calculated by reviewing publications such as (Audsley, et al., 2009) (Clune, Crossin, & Verghese, 2017) (MacLeod, et al., 2013).

The carbon footprint was calculated using data from FAO analyses of 10 reports (adjusted to same method/boundary) (MacLeod, et al., 2013). This is comparable to UK and Ireland industry figures.

Industry data from the UK and Ireland was certified by the Carbon Trust against PAS 2050 (confidential results) and uses a method fully consistent with the FAO (MacLeod, et al., 2013), which provides equivalent footprints.

LUC from imported soy is a big factor, as shown by the following table summarising results from 10 previous studies at farm gate (Table 5) (MacLeod, et al., 2013). The average carbon footprint of chicken in the UK and Europe has reduced to 4.6 kg CO_2e kg^{-1} due to the lower results of recent studies, however, a 55% uplift was applied in order to convert the emissions to edible meat as per beef. This range however is wide, with a low figure of 2.8 kg CO_2e kg^{-1} and high of 9 kg CO_2e kg^{-1} (Table 5) (Audsley, et al., 2009) (Clune, Crossin, & Verghese, 2017)(Carbon Trust Database).

Table 5 – The difference between the carbon footprint including LUC v without LUC

Feed Assumption	Low kg CO_2e kg^{-1}	Average kg CO_2e kg^{-1}	High kg CO_2e kg^{-1}
With LUC (soy)	6.2	9.9	12.4
Without LUC	3.9	5.7	8.5
Average	4.4	5.9	9

4.3.2 Land

The land requirements for chicken is 0.0007 ha kg^{-1} in the UK and Ireland. The majority of the land footprint is based on the area required to grow the feed of the chicken, and the composition and amount of feed. This also does not include the animal's living area, as that would be negligible in comparison to the total land footprint due to feed production. The grain for broilers and grain for the layers, is based on typical UK diet (Williams, Audsley, & Sandars, 2006). The parent birds have been discounted as non-material to the footprint based upon previous experience.

The main feed ingredients, the yield (kg per hectare), and typical UK feed amounts required to produce a kg of meat were determined (Williams, Audsley, & Sandars, 2006) (Carbon Trust data). This data allows a straightforward calculation to estimate the land required (ha) per kg of chicken meat.

4.3.3 Water

The water footprint for chicken was calculated in the same way as land, where the water footprint of each feed was used in conjunction with the feed required per kg of meat. The result is the same as reported by the water footprint network for the UK and Ireland. The same assumptions have been made about feed yield and proportions as the land calculations.

Table 6 – The ranges and average of chicken water footprints in the UK and Europe

	Green water (L kg^{-1})	Blue water (L kg^{-1})	Grey water (L kg^{-1})
Water footprint	3500	70	400

4.4 Pork

4.4.1 Carbon

The carbon footprint of pork was calculated based entirely from figures researched from articles, papers, and online agricultural sources. The resulting average carbon footprint for pork (edible meat) is 8.29 kg CO_2e kg^{-1} (Table 7) (Audsley, et al., 2009) (BPEX, 2011) (Clune, Crossin, & Verghese, 2017) (MacLeod, et al., 2013) (Smith, 2013). This figure relates to typical housed rearing practices in the UK and Europe.

Table 7 – The ranges and average of pork carbon footprints in the UK and Europe

	Low (kg CO_2e kg^{-1})	Average (kg CO_2e kg^{-1})	High (kg CO_2e kg^{-1})
Carbon footprint	7.05	8.29	10.89

As is the case for poultry, feed and manure management can have large influences on the carbon footprint for pork. The emissions arising from feed production can account for 60% and those from manure management can account for 27%. These two processes also vary between rearing practices. Storage of manure generates emissions within the production system. These vary according to style (anaerobic liquid storage creates methane and dry storage with bedding, nitrous oxide) and time. Removing manure regularly (e.g. to spread on fields or process in anaerobic digesters) is a good way to reduce livestock emissions.

4.4.2 Land

The land footprint model was adapted from the chicken calculations, as that was the most similar land-use situation in terms of land used to grow the pig feed, and living area (which is very minor in comparison to the land-use from feed). This calculation based on the pig feed data resulted in a land footprint of 0.0012 ha kg^{-1}.

4.4.3 Water

The water footprint – similar to the carbon footprint – was calculated based purely on figures researched from articles, papers, and online agricultural sources. This information however, was only available as a global figure; a boundary of UK and Europe could not be found. The global average therefore, was 5070 L kg^{-1} for green water, 416 L kg^{-1} for blue water, and 509 L kg^{-1} for grey water (Mekonnen & Hoekstra, A Global Assessment of the Water Footprint of Farm Animal Products, 2012).

4.5 Fish

The boundary for fish is wild caught, as that is the criteria that would be most similar to what Quorn's product (vegan fishless fingers) is compared against. Therefore, land and water footprints do not apply (as no land or feed are required) and these are excluded from this study. A variety of common fished species were used in the following carbon footprint calculations, such as cod, haddock, and tuna.

4.5.1 Carbon

Carbon footprints of fish were gathered from a range of online food/fish specific sources and research papers. The majority of emissions from sea caught fish comes from the fishing process, therefore, no emissions are associated with the growth of fish compared to farmed fish, as it all occurs naturally. The average footprint for edible meat (3.9 kg CO_2e kg^{-1}) was calculated using a variety of caught-fish species, as described below (Table 8). Tuna had the highest footprint of the wild fish species, at 5.01 kg CO_2e kg^{-1}, and cod had the lowest, with an average of 2.48 kg CO_2e kg^{-1} (Audsley, et al., 2009) (Buchspies, Tolle, & Jungbluth, 2011) (Ziegler, 2012) (Cermaq, 2012) possibly due to the greater distances travelled and energy to fish for deep ocean species like tuna.

Table 8 – The ranges and average of fish carbon footprints in the UK and Europe

	Low (kg CO_2e kg^{-1})	Average (kg CO_2e kg^{-1})	High (kg CO_2e kg^{-1})
Carbon footprint	2.5	3.9	8.3

The average carbon footprint for wild caught fish is roughly 67% of the footprint of farmed fish (33% less) (Clune, Crossin, & Verghese, 2017) (Environmental Working Group, 2011) (Rias Inc., 2016). This difference is due to lack of energy and resources (such as feed) required for farming fish, as described above. The most common fish species farmed in the UK however, is salmon, but the species that are wild caught are mainly cod, haddock, and tuna. This presents an issue with comparing wild caught to farmed fish, as the species are not consistent.

5 Comparison

This section compares the results of the five sources of protein against Quorn's certified carbon footprints for Quorn Mince, Quorn Pieces, Quorn Sausages, Quorn Vegan Fishless Fingers, and Mycoprotein. The footprints of these products are typical of Quorn's range. These products are compared against their most relevant source of traditional protein:

Quorn Mince → Beef

Quorn Pieces → Chicken

Quorn Sausages → Pork

Quorn Fishless Fingers → Fish

Mycoprotein → Soy

Grazing beef has the highest average carbon footprint (121 kg CO_2e kg^{-1}), and soy the lowest (1.02 kg CO_2e kg^{-1}) of all of the analysed sources of protein. Chicken and pork are around the same, at the lower end of 5.9-8.3 kg CO_2e kg^{-1}, and fish has the lowest carbon footprint of the animals at 3.9 kg CO_2e kg^{-1} (Table 9).

Beef generally has the highest land footprint of 0.0068 ha kg^{-1}, and chicken with the lowest of 0.0007 ha kg^{-1} (Table 9). Beef also has the highest footprint comparing blue water at 750 L kg^{-1}, and chicken has the lowest water footprint of 70 L kg^{-1} (Table 9). We focussed on blue water for comparisons because this has most relevance for Quorn's manufacturing process and is most important when considering the impact of agriculture on water scarcity and stress.

An important feature of beef production (much less so for chicken) is the range of environmental efficiencies found between farms. This range tends to be reasonably independent of the specific system, at least as practiced within a given country. For example, in the UK the range of beef GHG footprints has been shown to vary by as much as 8 fold (EBLEX, 2012).

Table 9 – Summary of the average carbon, land, and water footprints for soy, meat, and Quorn

	Carbon (kg CO_2e kg^{-1})	Land (ha kg^{-1})	Green water (L kg^{-1})	Blue water (L kg^{-1})	Grey water (L kg^{-1})
Soy	1.02	0.0014	1,855	240	573
Beef - General	16.21	0.0068	13,921	752	1,016
Beef - Mixed	26.67	0.0035	15,500	250	4,000
Beef - Grazed	121.00	0.0049	16,500	300	5,000
Chicken	5.93	0.0007	3,500	70	400
Pork	8.29	0.0012	5,070	416	509
Fish	3.94	N/A	N/A	N/A	N/A
Mince	1.744	0.00038	1184	48	314
Pieces	1.72	0.00025	1006	47	286
Sausages	1.606	*tbc*	*tbc*	*tbc*	*tbc*
Vegan fishless fingers	*tbc*	*tbc*	*tbc*	*tbc*	*tbc*
Mycoprotein	1.137	0.00018	539	35	202

Table 10 – The low, average, and high carbon footprints for all products

	Low (kg CO_2e kg^{-1})	Average (kg CO_2e kg^{-1})	High (kg CO_2e kg^{-1})
Soy	0.30	1.02	17.80
Beef - General	15.42	16.21	17.64
Beef - Mixed	20.00	26.67	30.00
Beef - Grazed	121.00	121.00	121.00
Chicken	4.40	5.93	9.00
Pork	7.05	8.29	10.89
Fish	2.48	3.94	8.31

Table 11 – The low, average, and high land footprints for all products

	Low (ha kg^{-1})	Average (ha kg^{-1})	High (ha kg^{-1})
Soy	0.0004	0.0014	0.0025
Beef – General	0.0068	0.0068	0.0068
Beef – Mixed	0.0035	0.0035	0.0035
Beef – Grazed	0.0049	0.0049	0.0049
Chicken	0.0007	0.0007	0.0007
Pork	0.0012	0.0012	0.0012
Fish	N/A	N/A	N/A

Table 12 – The low, average, and high blue water footprints for all products

	Low (L kg^{-1})	Average (L kg^{-1})	High (L kg^{-1})
Soy	70	240	520
Beef – General	550	752	955
Beef – Mixed	250	506	761
Beef – Grazed	300	300	300
Chicken	70	70	70
Pork	372	416	459
Fish	N/A	N/A	N/A

For further information on the water footprint categories, please refer to section 2.3.

Cells that are "tbc" are still to be added by Quorn

5.1 Quorn Mince comparison

Quorn Mince is compared against the footprints of beef, as that is the closest product to Mince. The percentages below show the proportion of beef's footprints that Quorn Mince represents.

Table 13 – Ratio of Quorn Mince footprints to beef

	Carbon	Land	Green water	Blue water	Grey water
Beef - General	11%	6%	9%	6%	31%
Beef - Mixed	7%	11%	9%	9%	8%
Beef - Grazed	1%	8%	7%	16%	6%

5.2 Quorn Pieces comparison

Quorn Pieces is compared against the footprints of chicken, as that is the closest product to Pieces. The percentages below show the proportion of chicken's footprints that Quorn Pieces represents.

Table 14 – Ratio of Quorn Pieces footprints to chicken

	Carbon	Land	Green water	Blue water	Grey water
Chicken	29%	36%	29%	67%	72%

5.3 Quorn Sausage comparison

Quorn's Sausage is compared against the footprints of pork, as that is the closest product to Sausages. The percentages below show the proportion of pork's footprints that Quorn Sausage represents.

Table 15 – Ratio of Quorn Sausage footprints to pork

	Carbon	Land	Green water	Blue water	Grey water
Pork	19%	*tbc*	*tbc*	*tbc*	*tbc*

5.4 Quorn Vegan Fishless Fingers comparison

Quorn vegan fishless fingers is compared against the footprints of fish, as that is the closest product to the fishless fingers. The percentages below show the proportion of fish's footprints that Quorn's fishless fingers represents.

Table 16 – Ratio of Quorn Fish Finger footprints to fish

	Carbon	Land	Green water	Blue water	Grey water
Fish	*tbc*	N/A	N/A	N/A	N/A

5.5 Quorn Mycoprotein comparison

Quorn mycoprotein is compared against the footprints of soy, as that is the closest product to mycoprotein. The percentages below show the proportion of soy's footprints that mycoprotein represents.

Table 17 – Ratio of Quorn mycoprotein footprints to soy

	Carbon	Land	Green water	Blue water	Grey water
Soy	112%	13%	29%	18%	42%

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