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Lamb Production and Wales: A Holistic Environmental Footprint

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- Lamb production is the backbone of Welsh agriculture and also makes a significant economic contribution across the rest of the UK.
- Lamb production is associated with several environmental impacts including greenhouse gas emissions, soil, water and air quality, biodiversity and land use. However, possible benefits exist in the form of conservation and social benefits.
- While our understanding of the processes behind the environmental impacts are continuously being improved, uncertainties are still present. Further research is required to better understand these uncertainties and capture potential benefits of the system in order to aid in decision making towards sustainable food production in the future.

Livestock systems and the impact of eating meat are receiving high levels of criticism and speculation globally. The environmental impact of our diets combined with an ever-increasing global population raises concerns for future food security and sustainability of food production systems. Livestock systems can contribute to a variety of environmental impacts, e.g. forestry loss and biodiversity decline, greenhouse gas emissions, ammonia emissions, soil erosion and leaching and runoff of nutrients. Some of these losses represent an inefficient use of valuable resources. Furthermore, there are concerns over resource use in farms including water and energy use from both direct on–farm impacts and over the entire product life cycle, including energy used for producing, shipping and storage of farm inputs.

Red meat is often discussed in this context, with lamb and beef under fire. However, lamb production is an important industry in Wales and supports rural communities as well as being a key player in delivering environmental stewardship schemes. At present, there is a generalisation between different production systems with possible co-benefits derived from

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sheep farming not being clearly presented. The role of livestock and farmers in the future sustainability of our diet must be carefully considered.

Lamb Production in the UK and Wales

Sheep farming is a widespread industry in the UK with 34.3 million sheep being recorded in the most recent agricultural census (2019). Production systems are generally stratified in the UK, which involves exploiting hill, upland and lowland areas (tiers) to maximise production. Sheep production makes significant economic contribution to the UK. UK figures from 2019 show that the total sheep meat produced was 288,600 tonnes (65300 tonnes from Wales), equating to a national income of £2,510million (approximately £124million from Welsh Lamb). With regards to employment, UK figures from 2015 showed that sheep farming supported 34,000 on farm jobs and 111,415 jobs in related sectors. This had an overall worth of £291.4million to the economy.

Greenhouse Gas Emissions

Globally, methane accounts for 50%, carbon dioxide 26% and nitrous oxide 24% of overall livestock emission sources. Lamb production systems are associated with these three main greenhouse gases (GHGs): methane, nitrous oxide and carbon dioxide. Methane is primarily produced as a by-product of digestion via enteric fermentation – a digestive process in ruminants that allows the animal to effectively process coarse plant material. It is also produced from manure management practices. A variety of inter-linking factors can influence the level of methane produced. This includes the level of feed intake, the feed type, feed digestibility and environmental factors such as temperature and weather. Other factors that can alter methane production are animal specific such as size and genetics related to breeding. Nitrous oxide is emitted from soil following nitrogen fertiliser and manure applications. For a grass-based system like lamb production, deposition of excreta (urine and dung) onto grasslands is the primary source of nitrous oxide. However, the level of emission is highly variable, dependent on a variety of soil and environmental factors and is difficult to predict. Rainfall increases soil moisture content enhancing conditions for nitrous oxide emissions. Soil moisture in turn is affected by the soil texture (e.g. clay content) and soil structure. Variability is also found across seasons due to differences in temperature, wind

speed and humidity. Further variability is present across soil types. Animal diet and the level of crude protein intake affects urine and dung composition, and ultimately nitrous oxide emission from urine and dung patches. Lastly, carbon dioxide arises through energy use on farm (e.g. fuel) and during production of animal feeds.

Other Environmental Impacts

It's not all about carbon! There are several environmental impacts that arise from livestock production. Ammonia is a gas that is emitted from excreta deposited by grazing stock in the field and from manure management and use of urea-based fertilisers. According to 2017 figures, sheep in the UK contributed 9.7kilotonnes of ammonia, 4% of the country total. Ammonia is not a greenhouse gas but does have other environmental impacts with respect to air and water quality. Ammonia deposition on land negatively impacts biodiversity and global habitats. It causes acidification of habitats and disrupts the nutrient balance in soils and waterways, thus affecting plants and promoting eutrophication. It also has implications for human health due its contribution to the production of particulate matter (PM). These small particles in the atmosphere can spread large distances and cause various health conditions including respiratory and cardiovascular diseases.

Livestock systems also impact water availability and quality. Nitrogen and phosphorus can be lost from farms via runoff and leaching after livestock manure and fertiliser applications, resulting in excess being transferred into nearby water ways. This transfer of nutrients can lead to eutrophication, having a detrimental effect on aquatic biodiversity.

In grasslands, alteration has occurred due to increased grazing, stocking rates and fertiliser use across all land types. Upland habitats have experienced decline in recent years including changes in grass composition and significant decreases in bird populations. While the exact reasons for these changes are unclear, it is suggested that excessive sheep grazing has affected the diversity of arthropods – a key prey of many bird species. Long term field trials show sheep grazing affects the species present with the number of vascular plants, grasses, mosses and liverwort declining yet shrubs, sedges and herbs increasing.

Negative impacts on soil quality can also be seen in livestock production. Intensification, specifically higher stocking rates, results in soil degradation leading to greater soil compaction and erosion. Increased grazing has been observed to cause the soil pore size to move towards higher micro-porosity and less total porosity than would naturally occur, particularly under cattle grazing but the effect is less pronounced under sheep grazing.

The Other Side of the Coin: Sheep Farming Benefits?

Benefits also come from these systems. Sheep farming in the UK, and particularly Wales, often occurs in upland areas. Specifically, land management and economic activity in these areas is linked to other ecological and social benefits and may also be unsuitable for other farming methods. As such, it is important to consider a holistic view of production in these areas as they are linked to various benefits not captured by traditional environmental foot-printing frameworks. One such way is through use of the ecosystem services framework. Ecosystem services (ES) describe the benefits derived from ecosystems and include supporting (soil formation and photosynthesis), provisioning (food, water or timber), regulating (climate, water and waste regulation) and cultural services (recreation, aesthetics and spiritual fulfilment). However, use of this has been limited for lamb production systems.

A key aspect is that the extent of the negative effects is dependent on the agricultural system itself and in some instances, grazing animals can aid in conservation. There is some evidence that moving to extensive grazing systems and reducing stocking rates instead of an intensive system can increased plant biodiversity and species richness, albeit over an extended time period. It is also linked to increased insect diversity. Small ruminants, such as sheep, can be effectively used for conservation grazing in areas that would be difficult to manage otherwise due to poor land quality or terrain. In some environments lack of grazing has caused increased fire damage due to a higher density of ground flora allowing fires to spread more easily. Use of livestock (particularly sheep) for conservation grazing is commonplace in national parks and ensures protection and access of these areas for the general public.

The cultural benefits of sheep farming, particularly in Wales, should be considered. Agricultural figures from 2015 show the importance of livestock in Wales, with 51% of sector outputs derived from them. 29% of the UK sheep flock is in Wales and 35% of Welsh agricultural holdings are used for sheep and cattle grazing (primarily on LFA land). The land

management as a result of farming creates paths and landscapes for recreation, boosting tourism. Access to the natural environment is also linked to an increase in overall wellbeing. Farming supports other businesses in the local area. Farming links directly to cultural heritage with traditional ways of life preserved for the future of the UK, be it names of places being derived from farming terms or the preservation of traditional stone walls. Agricultural associations foster a local community and organise local events, contributing to a sense of belonging for a variety of people. The role of these areas in carbon sequestration and their benefits for other agri-environment targets should also be considered.

A Lack of Information

The stratification of lamb production and the frequent movement of animals makes the prediction of environmental impacts more difficult. This occurs due to environmental factors being so variable across different altitudes and areas of the UK and the animals present in different altitudes also being variable. Modelling of food production systems is complex due to its intrinsic variability. Data availability and interpretation remain two key challenges for considering any food production system.

Life Cycle Assessment (LCA) is a technique used to assess the wider environmental impacts of a product throughout its full life cycle, including its production, transportation, use and disposal. Simplification and lack of transparency in LCA methodology is known to cause issues when comparing different meat production systems or considering substituting systems. Sheep farming is a multi-functional venture with value derived from sheep meat and co-products including wool and milk. The methodology used to allocate emissions to different outputs of a system (e.g. wool or milk), can change the overall picture of emissions associated with the different products. Studies have shown this can result in the burden of emissions being incorrectly shifted to one aspect. Carbon storage in grasslands is also an important function supported by grazing systems, but including this in a carbon footprint is difficult due to a lack of commonly used methodologies.

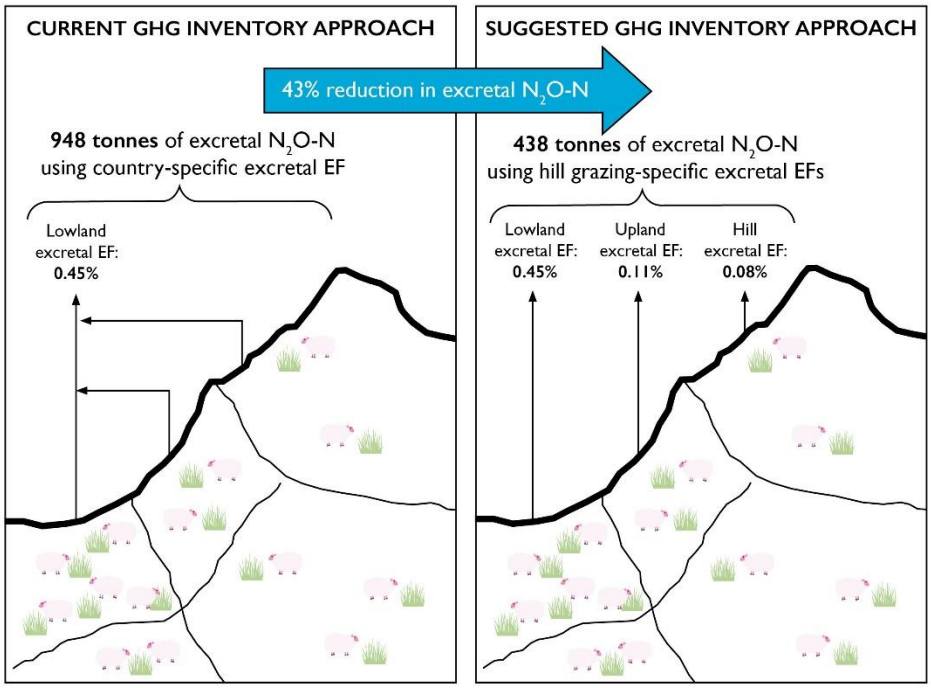

Figure 1: Impact of revised nitrous oxide emission factors **on overall nitrous oxide from sheep**

With regards to GHGs and the resulting carbon footprint, it is likely that variation will be present between lowland, upland and hill sheep systems as available forage, forage quality and animal size, breed and behaviour will all be changeable. However, there is a lack of evidence as to the breadth of difference. For nitrous oxide, field trials conducted in Wales showed a decrease in the urine patch nitrous oxide emission factor when moving from lowland to upland, potentially decreasing the nitrous oxide from upland sheep farming by 43% (Fig.1.). In 2019 the Intergovernmental Panel on Climate Change (IPCC) emission factor for nitrous oxide from sheep urine was lowered from 1% to 0.3%, having implications for previously completed carbon footprints. In addition, there is limited understanding on how methane from enteric fermentation varies between altitude although a difference is likely due to the differences in plant species and digestibility.

Furthermore, in order to help compare different GHGs they are converted to carbon dioxide equivalents. This has traditionally been done by using the Global Warming Potential (GWP):

how much a GHG traps heat in the atmosphere over a specific time frame equivalent to carbon dioxide. However, this method is not thought to effectively capture the temporal pattern of warming exerted by short lived GHGs such as methane which remains in the atmosphere for just 12 years on average. A new approach of considering methane, known as GWP*, is being considered, as it is believed that this more accurately captures the temporal dynamics of warming exerted by methane over its short lifetime in the atmosphere.

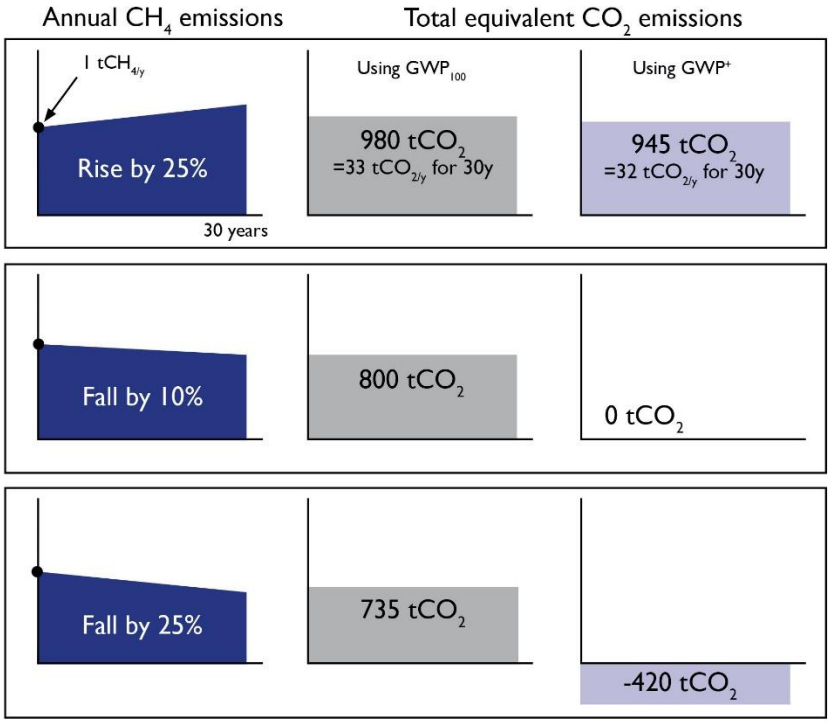

Figure 2: GHG emissions **scenarios under GWP_{100} and GWP^***

As figure 2 shows, using GWP* significantly alters the climate impact of methane across various scenarios in comparison to the current GWP accounting method (GWP_{100}). This of course has implications for lamb production systems, where a major GHG is methane but there is no consensus yet on whether the use of GWP* is an acceptable accounting approach for national greenhouse gas inventories and carbon foot-printing. In general terms, GWP* is better than GWP_{100} for representing a temporal ***change*** in climate warming associated with a

change in methane emissions, but GWP_{100} is more useful than GWP* for attributing an *average* warming effect to specific countries or activities as required for national accounting and foot-printing purposes.

To the Future…

As discussed, the environmental impact of our food production systems cannot be ignored. Agriculture remains a key source of greenhouse gas emissions and livestock systems produce methane, nitrous oxide and carbon dioxide. It is also important to consider the other environmental impacts such as air and water quality, resource use and biodiversity. However, limitations in the accounting methodologies exist including a lack of data and little disaggregation between different systems. Extensive grass-based systems typical for lamb production can also be used for environmental protection, promoting carbon sequestration (helping to offset agricultural carbon), conservation efforts and social benefits such as supporting rural communities. For a country like Wales where lamb production is a backbone industry, the need for a holistic approach to the impacts of sheep production systems is even more pivotal. Variation between production systems and altitudes within sheep farming is present and so further research is required to better quantify this variation, allowing a clearer picture to be created. Greater understanding will aid in decreasing our environmental impact but also aid in sustainability of food production systems for the future.