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The role of meat in strategies to achieve a sustainable diet lower in greenhouse gas emissions: A review

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Abstract

Food consumption is responsible for a considerable proportion of greenhouse gas emissions (GHGE). Thus, individual food choices have the potential to substantially influence both public health and the environment. Meat and animal products are relatively high in GHGE and therefore targeted in efforts to reduce dietary emissions. This review first highlights the complexities regarding sustainability in terms of meat consumption and thereafter discusses possible strategies that could be implemented to mitigate its climatic impact. It outlines how sustainable diets are possible without the elimination of meat. For instance, overconsumption of food in general, beyond our nutritional requirements was found to be a significant contributor of emissions. Non-voluntary and voluntary mitigation strategies offer potential to reduce dietary GHGE. All mitigation strategies require careful consideration but on-farm sustainable intensification perhaps offers the most promise. However, a balance between supply and demand approaches is encouraged. Health should remain the overarching principle for policies and strategies concerned with shifting consumer behaviour towards sustainable diets.

Highlights

- Outlines the complexity of attaining a diet lower in greenhouse gas emissions
- Demonstrates how meat can be part of a sustainable diet
- Assesses possible mitigation strategies than could be implemented to lower dietary greenhouse gas emissions

Keywords

Sustainable diet; climate change; greenhouse gas emissions; meat; nutrition; mitigation

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1. Introduction

Food consumption influences not only human health but it also contributes towards increased agricultural demand which may lead to excess resource use and environmental externalities (Blair & Sobal, 2006; Marlow et al., 2009). As a result there has been a growing appreciation of the need to investigate pathways in which food consumption contribute towards climate change (Hyland et al. 2016a). Nutritionists have traditionally emphasised the importance of healthy eating while focusing less on wider sustainability issues. However, the nutritional aspect of consumption should not be evaluated in isolation; rather, it should also incorporate environmental measures such as its climatic impact (van Dooren et al., 2014). The Food and Agriculture Organization (FAO) of the United Nations have defined sustainable diets as "*diets with low environmental impacts which contribute to food and nutrition security and to healthy life for present and future generations. Sustainable diets are protective and respectful of biodiversity and ecosystems, culturally acceptable, accessible, economically fair and affordable; nutritionally adequate, safe and healthy; while optimizing natural and human resources*" (FAO, 2010). Given that agriculture is a significant contributor towards anthropogenic greenhouse gas emissions (GHGE), addressing diet offers an opportunity for climate change mitigation.

The climatic impact of food is quantified by assessing the global warming potential of the GHGE associated with production and consumption. The global warming potential is a relative measure of how much heat relative to carbon dioxide a greenhouse gas traps in the atmosphere (Röös et al., 2014). The magnitude of individual gases' emissions are subsequently categorised in terms of their carbon dioxide equivalent (CO_2eq) to compare and report emissions. Nitrous oxide and methane are particularly important greenhouse gases arising from agricultural practices and have a global warming potential of 298 and 25 respectively (IPCC., 2007). The primary method used to assess GHGE of food is life-cycle-assessment (LCA) with several studies adopting an economic input–output analysis (Jones et al., 2016; Joyce et al., 2014). In LCA, emissions generated and resources used at all phases, or during a particular defined phase, in a product's lifecycle are quantified and used to calculate its respective environmental impact (Baumann & Tillman, 2004). Each stage is defined by a system boundary which indicates the point along the food chain at which emissions are assessed and aggregated. In practice, the boundaries of LCA are shortened where the choice of system boundary is dependent on the food item being assessed. The main

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sources of emissions from the life cycle of food products are generated on-farm with only 12% derived from food system activities after production as outlined in Figure 1 (Röös et al., 2014). Post-farm emissions include refrigeration, storage, packaging, transport, retail activities, production, waste disposal, etc.

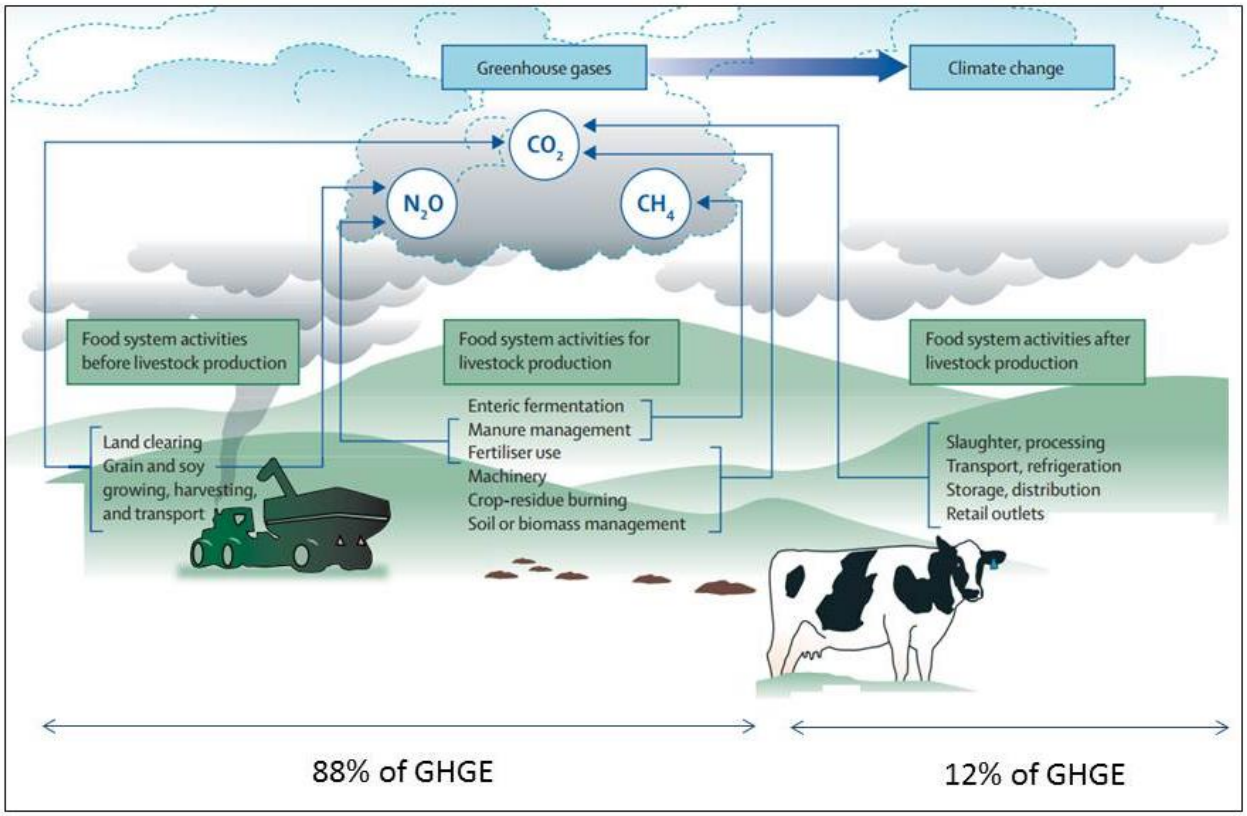


Figure 1. Processes in the food and agriculture system that lead to greenhouse-gas emissions (adapted from Friel et al., 2009).

The particular agricultural systems that are required to produce food have the potential to alter the levels of GHGE associated with consumption (Joyce et al., 2014). It is widely acknowledged that consumption of animal products contributes significantly to anthropogenic GHGE which drive climate change. The contribution of livestock towards such emissions is particularly important as the sector accounts for 14.5% of total global anthropogenic GHGE (Gerber et al., 2013). The primary GHGE associated with animal production systems are methane and nitrous oxide. Nitrous oxide and methane are particularly powerful greenhouse gases when compared to carbon dioxide. The two gases have a global warming potential 298 and 25 times that of carbon dioxide respectively (IPCC, 2007). However, it is the methane generated from enteric fermentation that differentiates red meat and dairy production from other agricultural systems as methane is a by-product of the digestion process associated with ruminant animals. For this reason the carbon footprints of

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beef and lamb are typically much higher than other foods (Berners-Lee et al., 2012; Carlsson-Kanyama & González, 2009; Macdiarmid et al., 2012; Röös et al., 2015). Conversely, plant based foods are associated with lower levels of emissions (Joyce et al., 2014). The adoption of sustainable diets can be facilitated and enabled by appropriate policies and incentives (Meybeck & Gitz, 2017). The aim of this review is to highlight the complexities regarding sustainability and meat consumption and to evaluate possible supply and demand strategies that could be implemented to achieve a diet lower in GHGE.

2. The complexity of sustainable diets

Diets are composed of individual foods that are aggregated to form nutritionally sufficient dietary patterns but trade-offs of one food for another can make meeting certain nutritional requirements more difficult (Heller et al., 2013). Different methods can be used to assess food consumption in a population (Payne et al., 2016). Food consumption from self-selected diets is assessed using a dietary survey or a food frequency questionnaire, whereas modelling can be used to develop a theoretical diet. Both approaches yield comparatively different results in terms of the range of GHGE from overall diets.

By their very definition sustainable diets should be environmentally friendly while also being nutritionally desirable. Considering that plant based foods have a considerably lower climatic impact than food of animal origin (Masset et al., 2014), and the apparent better health of vegetarians compared to omnivores (Key et al., 2006), it is often assumed that plant based diets are beneficial for both heath and the environment (Baroni et al., 2007; Berners-Lee et al., 2012; Marlow et al., 2009; Stehfest et al., 2009). The nutritional integrity of a diet is important and diets that may be the most beneficial for the environment could lead to nutrient deficits (Meier & Christen, 2013). Diets which avoid animal products are not necessarily healthy as they are often restrictive which may result in deficiencies in some nutrients (Key et al., 2006). Foods of animal origin provide many micro-nutrients that are beneficial for human health (De Smet & Vossen, 2016). The high content of essential amino acids and micronutrients present in animal products should therefore not be overlooked when formulating dietary recommendations that considers both nutrition and GHGE (Smith et al., 2012). Omnivorous diets can be healthy if they contain fruit, vegetables, nuts, legumes, cereals and are complimented with red meat, dairy, and fish (WHO, 2003). It has been

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suggested that recommendations to reduce the consumption of unprocessed red meats are unnecessarily restrictive (Binnie et al., 2014). The complexity of making recommendations on sustainable diets is further complicated as some foods which are particularly low in emissions are energy-dense and have a poor nutritional profile (Hendrie et al., 2014; Payne et al., 2016).

2.1 The relationship between meat consumption and dietary GHGE

Ingrained in the food culture of many societies is the consumption of meat (Clonan et al. 2015; Clonan et al., 2014; Henchion et al., 2014; Onwezen & van der Weele, 2016). The sustainable diet discourse has been inclined to concentrate on food groups with high GHGE such a food products derived from ruminant animals. This narrow focus overlooks overall dietary patterns across a population. A growing section of the literature suggests a need for a more holistic approach to reducing dietary emissions rather than focusing solely on lowering meat consumption. There is much debate over how to optimise diet, and how to attain a sustainable diet. The studies outlined in Table 1 serve to highlight the complexities in attaining diets lower in GHGE.

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Table 1. Studies which outline the complexities in attaining diets lower in greenhouse gases.

Authors	Study type	Outcome/recommendations
Vieux et al. (2012)	Habitual diet based on French national nutrition survey	Greenhouse gas emissions associated with quantity and calorific intake. Replacing fruit and vegetables for meat not the best approach to reducing dietary emissions.
Hyland et al. (2017)	Habitual diet based on Irish national nutrition survey	There was no significant difference in the total emissions of the highest red meat consumers and the lowest red meat consumers.
Masset et al. (2014)	Habitual diet based on French national nutrition survey	The main factors that were identified to have a more sustainable diet which were lower in GHGE: reduced energy intake and reduced energy density.
Wilson et al. (2013)	Modeling study based on diets which meet New Zealand nutrient recommendations	Vegan diets resulted in slightly higher emissions than other 'low emitting diets'. There was a trade-off between increased daily food cost and consuming food associated with lower emissions
Hendrie et al. (2016)	Australian Health Survey data on food consumption integrated with an input–output model	The most effective strategy to reduce emissions is to focus on diet quantity, in terms of eating to one's energy needs, and diet quality, that is consuming adequate core foods and less discretionary foods.
Macdiarmid, (2013a) and Macdiarmid et al. (2012)	Diets modelled to meet UK dietary recommendations	A sustainable diet that meets dietary requirements for health with lower emissions can be achieved without eliminating meat or dairy products.

The majority of studies concerning diet and its climatic impact point towards the association between consumption of animal based foods and dietary GHGE (Auestad & Fulgoni, 2015). Nevertheless, a diet low in meat and high in fruit and vegetables is not always sustainable (Macdiarmid, 2013b). A reduction in meat consumption does not necessarily lead to reductions in overall emissions and may even increase dietary GHGE depending on the foods that are used in its place (Perignon et al., 2017). Macdiarmid (2013) outlines potential conflicts between health and the environment with regard to fish consumption (can fish stocks support recommended consumption levels?), and low fat dairy and lean meat consumption (fats and other cuts of meat need to be utilised to avoid waste). Thus, it should be acknowledged that environmental externalities may simply be traded when one food is replaced by another.

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Some studies have concluded that the adoption of a sustainable diet is possible without the elimination of meat (Hendrie et al., 2016; Macdiarmid et al., 2012). To consider the impact of different dietary patterns on the climate segmentation, analysis was undertaken by Hyland et al., (2017) which identified three distinct emission patterns within the Irish population. The *Unsustainable* emissions pattern attained the highest carbon footprint by generating significantly higher emissions from alcohol, processed meat and carbonated beverages. The *Culturally Sustainable* emission pattern was characterised by having the highest red meat intake. Yet, they did not differ significantly in their overall carbon footprint when compared to the *Nutritionally Sustainable* which had the lowest red meat consumption and were defined by significantly higher consumption of fruit and vegetables. Hence, rather than red meat consumption or any one single food group determining which emission pattern had the highest overall emissions it was the aggregated effect of total consumption that determined total dietary emissions. Indeed, many studies have shown that reducing food intake in accordance to energy requirements can lead to significant decreases in overall GHGE without the need to modify consumption patterns (Hendrie et al., 2016; Masset, Vieux, et al., 2014; Vieux et al., 2012). Perignon et al. (2017) consequently suggests there is no need to avoid entire food categories to adhere to the concept of dietary sustainability.

3. Strategies to achieve sustainable diets lower in GHGE

Fortunately, there are a number of approaches that can be implemented in an effort to promote diets lower in GHGE. Consumers find the joint concept of healthy and environmentally friendly foods an acceptable idea (Hoek et al., 2017). Yet, there prevails many challenges in implementing acceptable and effective strategies. Dietary emissions can be lessened by using non-voluntary measures such as Pigouvian tax. Responsibility can alternatively be passed onto consumers by providing tools for change within the market model. These include strategies such as carbon footprint food labelling as well as encouraging the reduction of food waste. Dietary guidelines which link nutrition with sustainability could also be beneficial in terms of increasing consumer acceptance and awareness of the issue. Approaches which take responsibility away from consumers by reducing emissions through supply chain efficiency gains represent another strategy to reduce GHGE induced by meat consumption (Hyland et al., 2016b).

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3.1 Carbon tax

The negative environmental externalities associated with meat consumption could be mitigated in theory by means of a Pigovian tax (Pigou, 1957). A Pigovian tax involves an increase in prices which corresponds to the marginal damage costs; therefore, meat products would carry their related social costs. The tax would promote not only sustainable consumption but also sustainable production. Arguments have been made in favour of a meat consumption tax rather than a meat production tax due to the high monitoring costs of production (Edjabou & Smed, 2013; Nordgren, 2011; Wirsenius et al., 2010). Wirsenius et al., (2010) suggests that the emission intensities of different meat products should be weighted accordingly when implementing a carbon tax. In their study, a carbon tax was set at 16% for ruminant meat, 5% on pork, and 4% on poultry meat.

Carbon taxes offer many advantages and can be an effective means of mitigation. For instance, Säll and Gren (2015) found that a tax on meat and dairy consumption could reduce GHGE by 12% in Sweden. However, it has been shown that consumers respond unfavourably to such taxation measures (Vanhonacker et al., 2013). There are also numerous objections to a carbon tax as it can fail to take into account the complexities of production systems associated with livestock farming. In certain circumstances production contributes towards climate change mitigation. The climatic impact of ruminants grazing on marginal grasslands without concentrated feed may be compensated through carbon sequestration (Allard et al., 2007). A weighted tax would also encourage production of pork and chicken which would have particular ramifications; namely in terms of increased competition with humans for feed (De Vries & De Boer, 2010), as well as animal welfare disparities compared to extensive ruminant production systems (Potthast & Meisch, 2012).

3.2 Carbon labelling

The concept of the carbon footprint can be traced back as being a subset of the ‘ecological footprint’ which was proposed by Wackernagel (1996) in the early 1990s. It can be defined as a measure of the exclusive total amount of GHGE that are directly and indirectly caused by an activity, or that are accumulated over the life stages of a product (Nijdam et al., 2012). The methodology of carbon footprinting is continually evolving (Pandey et al., 2011), and is based on LCA guidelines (ISO, 2006) and PAS 2050 (2011), which are usually combined with emissions algorithms recommended by the Intergovernmental Panel on Climate Change

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(IPCC). The environmental impact of food consumption is usually quantified by life cycle assessment and displayed on a product using a carbon label. In LCA, emissions and resource use that occur at all phases in a product's lifecycle are quantified and used to calculate its respective environmental impact (Baumann & Tillman, 2004). A carbon label serves as important indicator of a systems impact on the global environment by identifying where emissions can be reduced in the food system. The ability to communicate a value which is both globally applicable and accepted is one of the attractions of the carbon label.

Carbon labelling has developed as a meaningful market-oriented tool to motivate greenhouse gas emission reductions (Liu et al., 2016). Röös et al. (2013) encourages the implementation of carbon labelling for meat products but emphasised that such a label can generate conflicts with other environmental externalities as it assesses only one aspect of sustainability. Carbon labelling of food products can influence consumer purchase decisions but consumers are likely to know little about the actual carbon footprints of meat or its substitutes. Governments, manufacturers, and marketers therefore need to raise consumers' carbon literacy to encourage more informed choices related to carbon labelling (Sharp & Wheeler, 2013). For targets related to climate change to be attained and responded to, sources of information must be trusted and attractive; the message relevant, clear and coherent; and the audience motivated and able to act (Fielding et al., 2014).

Consumers are increasingly aware of the environmental impact of the food they consume (Briggeman & Lusk, 2011). Nevertheless, sales of produce with environmentally positive attributes (i.e. organic foods) are low for various reasons: perceived high price, strong habits governing food purchases, perceived low availability, lack of marketing and information, lack of trust in the labelling system, and low perceived customer effectiveness (Röös et al., 2013). These obstacles also apply to products that display a carbon label and many are even greater for carbon-labelled products as they may not bring any personal benefit to the consumer. It is difficult to predict the potential impacts of carbon labelling in the market (Edwards-Jones et al., 2009). Consumers shop quickly and habitually, and consequently may not notice carbon labels amongst a large number of other labels that are frequently displayed on products (Sorensen, 2009). Gadema and Oglethorpe (2011) suggest that carbon labelling is a long way from translating expressed consumer preference into action and relying on consumer guilt is inappropriate. However, the carbon label is influential in helping customers to make more informed choices and has a positive impact on a company's image and reputation (Sharp & Wheeler, 2013; Upham et al., 2011). It is important therefore that a carbon labelling scheme is carefully introduced to avoid confusion.

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Hence, Röös et al. (2014) recommends that products are placed in one of three groups according to a red/yellow/green 'traffic light' system.

3.3 Nutritional guidelines

Policy makers must ensure that dietary guidelines go beyond concern for current generations and encompass the nutritional and environmental needs of future consumers (Clonan et al., 2014). Thus, the concept of assimilating sustainability into nutrition policies is gaining global momentum. The tension between the environmental impacts of meat production and the achievement of a nutritional guidelines has been recognized at the international level (FAO, 2010), and increasingly in policies implemented at a national level.

Brazil, Germany, Qatar, and Sweden represent some of the few countries where climate considerations are formally recognised in national dietary guidelines (FAO, 2016b; Livsmedelsverket, 2015). The guidelines adopted by these nations recommend high intake of fresh fruits and vegetables with limited red and processed meat consumption. They stress that a largely plant-based diet is preferred, both from a health and environmental perspective. However, it could be argued that such recommendations neglect to take into account the complexities of achieving a diet that is both nutritious and sustainable (Perignon et al., 2017). More countries are likely to follow in implementing nutritional guidelines with environmental considerations as sustainable consumption becomes a more pressing issue. For instance, both the Netherlands (Stichting Voedingscentrum Nederland, 2016) and the UK (Buttriss, 2016) have recently published their most recent set of dietary guidelines, which emphasised the importance of a more plant-based diet low in animal protein. Specific recommendations include limiting red and especially processed meat consumption for both health and environmental reasons. Australia and the US have discussed the inclusion of sustainability in their respective national nutritional guidelines but for now have opted not to officially adopt the concept into national policy; meanwhile, quasi-official guidelines exist for Estonia and France (FAO, 2016b). Quasi-official guidelines are defined as advice produced by institutions that are recognised or accredited by Government but that do not sit within a ministerial department and whose recommendations do not constitute official policy. For instance, although the official dietary guidelines of Estonia and France do not discuss environmental concerns, the issue of diet and sustainability is nevertheless promoted by other government messages which ask consumers to be conscious of the environmental impact of their dietary choices.

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A resistance remains to the amalgamation of a sustainability dimension into nutritional guidelines despite an increasing amount of dietary recommendations being conscious of the environment. Trevena et al. (2015) found that that despite agreement, sustainability was a significance policy component, however variances in how actors from civil and corporate societies framed its meaning and solution resulted in a lack of shared vision to advance the concept. Assimilating climate considerations into national dietary guidelines is problematic due to the complexities of simultaneously achieving dietary guidelines and reducing GHGE associated with food consumption. Red meat is frequently targeted to reduce carbon emissions, yet it is the sole dietary source of certain essential nutrients; thus, eliminating it from diet could present health challenges (Binnie et al. 2014). Indeed, many studies have shown the difficulties of concurrently adhering to dietary recommendations and reducing dietary emissions (Hendrie et al., 2016; Masset et al., 2014; Vieux et al., 2012). Therefore, any food policy instruments developed for health and sustainability reasons should be holistic in nature rather than concentrating on one food group. It is also imperative that nutritional guidelines emphasise that overconsumption of food is inextricably linked to higher dietary emissions; which is one aspect of the sustainable diet discourse that has gathered little attention and yet would have significant implications in not only tackling sustainability but also addressing the increasing global obesity epidemic.

3.4 Reduce food loss and food waste

Addressing food waste and food loss would reduce pressures on food production and related GHGE (Venkat, 2011). Food loss refers to the decrease in food quantity or quality, which makes it unfit for human consumption (Parfitt et al., 2010). Food waste is a subset of food loss and relates to behavioural issues; for instance, consumers discarding food that is fit for consumption (Hodges et al., 2010). However, both food losses and food waste are commonly referred to as food waste. In the developed world as much as 40% of food is wasted before it reaches the consumer (either on the farm or during the transportation and processing of food) or after it has been purchased (i.e. at home) (Buttriss, 2011; FAO, 2011). In Europe, this translates to 95-115 kg of consumer food waste per capita annually (FAO, 2016a).

Globally, approximately 1.3 billion tonnes of food is wasted each year (FAO, 2011). There is considerable variation in food waste across food groups with fresh fruit and vegetables having considerably higher wastage than other food categories. Conversely, meat

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waste is notably lower with many developed countries having wastage rates of typically less than 10% (Parfitt et al., 2010). The relatively large climatic impact of meat suggests that reducing meat loss and waste should receive at least as much attention as other food groups although it comprises towards a smaller share of losses.

3.5 Farm mitigation

The climatic burden accumulates throughout the food system and substantial reductions in dietary emissions can be realised other than targeting consumers directly. Technological adoption at the farm level to reduce the emissions associated with production perhaps represents the best approach to lowering overall dietary emissions from meat consumption (Gerber et al., 2013; Hyland et al., 2016b). These changes could allow for consumption of meat of lower climatic impact, resulting in lower dietary emissions without having to significantly change consumer behaviour. This can support the inclusion of and increased prominence of climate considerations when implementing dietary guidelines (FAO, 2010).

The demand for more varied and resource-intensive food, particularity animal-source foods, has risen substantially through global population growth coupled with an increase in incomes in developing countries (Smith et al., 2012). . The global food price spike of 2007-08 brought increased attention to the fact that global demand for food was starting to rise faster than supply (Mitchell, 2008). These challenges require action throughout the food system to meet the multiple challenges of increasing the provision of food while lowering emissions associated with its production. It is widely acknowledged that one of the best and most effective ways that the livestock industry can reduce emissions is by increasing efficiencies of production (Elliot et al., 2014; Pullar et al., 2011). In fact, the FAO predict that if the higher emitters adhere to the production practices of their least emitting peers, emissions associated with meat production could be reduced by 30% (Gerber et al., 2013).

Some mitigation measures may require an alternative and less productive focused ethos which may not be favoured by the farmer (Garnett et al., 2013). However, many mitigation measures are a win-win in terms of production and the environment which will appeal to a broad spectrum of farmers regardless of their environmental ethos (Hyland et al. 2016; Hyland et al. 2015). Against this backdrop, the concept of sustainable intensification has been championed (The Royal Society, 2009). The principle of sustainable intensification is based on increasing output without adverse environmental impacts, and without the cultivation of more land (Garnett & Godfray, 2012; Smith, 2012). Some authors consider that the concept should go further than requiring no additional environmental harm; thereby

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involving increases both in food production and the flow of eco-system services (Firbank, 2009; Foresight Report 2011; Garnett et al., 2013) while not compromising animal welfare (Wathes et al., 2013). Other studies have called for it to include additional economic and social dimensions (Barnes et al., 2011; Barnes & Thomson, 2014; Garnett et al., 2013). As such, farming systems can be thought of being as meeting many of the principles promoted by the FAO in terms of sustainable diets by providing food that is economically, culturally, ethically, and environmentally fair.

4. Implications

Scientists, stakeholders, and consumers should recognise the environmental, economic, social, cultural, and health aspects of a sustainable diet (von Koerber et al., 2017). Meat consumption is entrenched in the food culture of many societies (Clonan et al. 2015; Clonan et al., 2014; Henchion et al., 2014; Onwezen & van der Weele, 2016). Although meat contributes greatly towards dietary GHGE, a diet which is meat free may be unpalatable to many as most consumers prefer diets which contains some meat rather than those classed as meat-free (Graça et al., 2015; Schösler et al., 2012). However, this review outlines how it is possible to adhere to the principles of a sustainable diet while consuming meat.

Altering consumer behaviour is notoriously difficult and advocating meat-free or reduced meat diets may consequently be met with consumer ambivalence. For instance, although over half of Irish and British consumers perceive sustainability as being important in the food choices they make, only a third fully understand the concept (Bord Bia, 2015). Indeed, campaigns over numerous decades calling for increased intake of fruit and vegetables have been largely unsuccessful despite consumers being actively targeted by government and health organisations (Rekhy & McConchie, 2014). Consumers are often unwilling to alter their dietary behaviour and climate responsibility is often dependent on egalitarian and communitarian worldviews and such views are often impended by the prevailing ethos of mea-culpa within society (Moser, 2010; Shi et al., 2015; Spence & Pidgeon, 2010). ‘Less but better’ and ‘less and more varied’ consumption of meat has been subsequently proposed as dietary mitigation strategies which could potentially appeal to consumers (de Boer et al., 2014). Meat can be defined as ‘better’ if it achieves a spectrum of outcomes for climate change, the environment, animal welfare, human health, livelihoods, social justice and social values (Sutton & Dibb, 2013).

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A substantial challenge exists in engaging individuals with messages which promote sustainable diets as consumers are often sceptical of the scientific evidence which links meat consumption with climate change (Macdiarmid et al., 2015). From a public health perspective, a reduction in consumption of some high emitting food groups may impact on the provision of many micronutrients and highlights the complexity of the issue. The potential contribution to an emissions decrease which can be expected from both consumers and the food system respectively is an important issue. In many countries, policy makers implement labelling policies that are designed to inform consumers of the carbon footprint of products and to encourage different purchasing behaviours. However, human behaviour is complex and altering consumer practices towards more environmentally tendencies presents many challenges. It is recommended that health should remain the overarching principle for policies and actions concerned with shifting consumer behaviour based on this motivation, as this personal benefit has the greater potential to support behaviour change (Hoek et al., 2017).

5. Conclusion

Diets are considered sustainable if they adhere to the principles outlined in the FAO definition of what constitutes a sustainable diet. Meat consumption influences not only human health but it also has been identified as a contributor of anthropogenic climate change. However, diets are composed of individual foods that are aggregated to form dietary patterns. A reduction in meat consumption does not necessarily lead to reductions in overall emissions and may even increase dietary GHGE depending on the foods that are used to replace it. It is suggested there is not a need to avoid entire food categories to adhere to the concept of dietary sustainability. There has been increased focus on effective and appropriate mitigation strategies in an effort to reduce the livestock industries' impact on anthropogenic induced climate change. Taxation, carbon labelling, nutritional guidelines, reducing waste, and sustainable intensification, all need to be carefully considered and coordinated for a multifaceted and linked strategy to ensure reduce GHGE associated with meat consumption. It is suggested that health dominates policies and measures that aspire to shift consumer behaviour towards sustainable diets.

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