Ecological Economics 131 (2017) 119–128

Contents lists available at ScienceDirect

Ecological Economics

journal homepage: www.elsevier.com/locate/ecolecon

Trimming the excess: environmental impacts of discretionary food consumption in Australia

Michalis Hadjikakou

Sustainability Assessment Program (SAP), School of Civil and Environmental Engineering, UNSW Australia, Sydney, NSW 2052, Australia

ARTICLE INFO

Article history:
Received 16 March 2016
Received in revised form 16 June 2016
Accepted 4 August 2016
Available online 31 August 2016

Keywords:
Sustainable diet
Food system
Environmentally extended input-output analysis
Environmental sustainability
Planetary health
Life cycle assessment

ABSTRACT

Tackling the overconsumption of discretionary foods (foods and drinks not necessary to provide the nutrients the body needs) is central to aligning human and planetary health. Whilst the adverse health impacts of discretionary foods are well documented, the environmental and broader sustainability impacts of these products deserve more attention, especially since their consumption has been increasing in recent decades, particularly amongst low income groups. This paper presents a quantitative case study analysis of discretionary food consumption and the associated environmental impacts for households from different income groups in Australia. Environmentally extended input-output analysis is used to estimate the full life cycle environmental impacts of discretionary food consumption on the basis of household expenditures. On average, discretionary foods account for a significant 35%, 39%, 33% and 35% of the overall diet-related life cycle water use, energy use, carbon dioxide equivalent and land use respectively. These significant percentages provide further support for the need to incentivise diets that are both healthier and more sustainable, including 'divestment' from discretionary food products. The study highlights the challenges ahead, including the need for further research on food substitutions to minimise environmental and social impacts whilst maximising nutritional quality – especially amongst poorer socioeconomic groups.

1. Introduction

Western diets, typically high in energy but low in nutrients, have been linked to increased incidence of obesity and chronic disease (Friel et al., 2014; Garnett, 2014b; Tilman and Clark, 2014). At the same time, food production is responsible for up to 30% of anthropogenic greenhouse gas (GHG) emissions (Tubiello et al., 2013) and an estimated 70% of global water withdrawals (Pradhan et al., 2013). If current dietary trends continue unabated, public health costs are expected to increase significantly (Keats and Wiggins, 2014; Wang et al., 2011), while the impact of agriculture on the environment is set to intensify (Gerbens-Leenes and Nonhebel, 2002; Hedenus et al., 2014; Keyzer et al., 2005; Odegard and van der Voet, 2014).

National dietary health guidelines are increasingly making explicit reference to the importance of eating sustainably as well as healthily (Health Council of the Netherlands, 2011; Monteiro et al., 2015; Swedish National Food Agency, 2015), and the medical and public health fields are embracing the importance of environmentally sustainable diets (Demaio and Rockström, 2015; Lawrence et al., 2015a). The consensus is that, given the crucial role of food in providing nutrients, nutritional quality should be seen as a core component of food system sustainability (Lukas et al., 2015; Nemecek et al., 2016; Röös et al., 2015).

A necessary dietary modification which has unquestionably received the most attention in academic, policy and media circles is the need to limit consumption of animal products, especially red meat (Hedenus et al., 2014; Keyzer et al., 2005; Macdiarmid, 2013; Röös et al., 2015; Springmann et al., 2016). Animal-derived foods generally have a higher total environmental footprint than plant foods, owing to the significant amounts of land, water and feed required by livestock (Gerbens-Leenes and Nonhebel, 2002; Goodland, 1997; Westhoek et al., 2014; White, 2000). Additionally, enteric methane from ruminants accounts for a substantial 14.5% of total global GHG emissions from all sources (Gerber et al., 2013). Livestock production has also been linked to soil and water quality impairment, atmospheric pollution, and loss of biodiversity, all of which carry significant economic and social costs (Pretty et al., 2001). High levels of red meat consumption, especially in its processed forms, have been correlated with cardiovascular disease and certain cancers (Bouvard et al., 2015; Pan et al., 2012). Reducing red meat consumption thus presents a double dividend to both human and environmental health. Since all types of animal protein tend to have a comparatively high environmental footprint, smaller meat portion sizes, taxes on meat and promoting vegetarian alternatives have all been proposed as solutions (de Boer et al., 2014; Hedenus et al., 2014).

While the higher environmental footprint of meat consumption vis-à-vis other foods is undeniable, I argue that focusing only on reducing meat consumption obscures a more fundamental distinction in the

E-mail address: m.hadjikakou@unsw.edu.au.

http://dx.doi.org/10.1016/j.ecolecon.2016.08.006
0921-8009/

environmental impacts of our dietary choices: between what is discretionary and non-discretionary. Previous studies have considered the environmental implications of discretionary consumption of goods and services (Druckman and Jackson, 2010; Sanne, 2002) and the use of discretionary time (Chai et al., 2015; Druckman et al., 2012) but the dietary aspect of discretionary consumption is still understudied.

Discretionary foods are described in the Australian Dietary Guidelines (ADGs) as: "foods and drinks not necessary to provide the nutrients the body needs, but that may add variety. Many of these are high in saturated fats, sugars, salt and/or alcohol... They can be included sometimes in small amounts by those who are physically active, but are not a necessary part of the diet" (NHMRC, 2013, p.144). Food types that fall into this category include cakes and biscuits; confectionary and chocolate; pastries and pies; ice confections, butter, cream, and spreads which contain predominantly saturated fats; processed meats and fattier/salty sausages; potato chips, crisps and other fatty or salty snack foods; sugar-sweetened soft drinks and cordials, sports and energy drinks and alcoholic drinks (ABS, 2014b; NHMRC, 2013). By contrast, non-discretionary (or core) foods are those recognised as belonging to the core food groups: fruit, vegetables, cereals, legumes, nuts and seeds, dairy and fresh meat.

The medical and public health literature has shown that higher consumption of discretionary foods is conclusively linked to higher incidences of overweight/obesity and non-communicable diseases (NCDs) (Cohen et al., 2010; Friel et al., 2014; Johnson et al., 2011; Monteiro et al., 2011; Moodie et al., 2013). Indeed, the negative impact of meat consumption on human health is more strongly correlated with the discretionary consumption of processed meat than with unprocessed meat (Micha et al., 2012). However, as Carlsson-Kanyama et al. (2003); Pearson et al. (2014) and Friel et al. (2014) argue, the environmental impacts of discretionary food consumption have been largely ignored. These impacts are potentially significant, and potentially avoidable: discretionary food is largely considered superfluous to nutritional requirements (if dietary intake is above adequate), and could in many cases be eliminated from diets without substitution of other products – thus avoiding negative rebound[1] effects in terms of environmental or nutrition impact, as seen in some studies when meat consumption is reduced (Heller and Keoleian, 2015; Tukker et al., 2011; Vieux et al., 2012). A complicating factor which needs to be considered is the socioeconomic context of discretionary food consumption and its relation to environmental impact, especially given that poorer socioeconomic groups tend to obtain a higher proportion of their dietary energy from these foods (Darmon and Drewnowski, 2008; Serra-Majem et al., 2004; Thorpe et al., 2016).

While the policy focus to date has been on curbing current meat consumption trends, a reduction in the production and consumption of discretionary foods should be seen as a key complementary sustainability priority - one that potentially allows for a more nuanced understanding of dietary choices. Amidst the complexity of composite health and sustainability indicators (Drewnowski et al., 2015; Lukas et al., 2015; Röös et al., 2015) and public reluctance to reduce meat consumption (Lea and Worsley, 2008; Macdiarmid et al., 2016), the discretionary versus non-discretionary argument can provide a simplifying health-driven conceptual framework that challenges the current food production and consumption system by re-emphasising non-discretionary food provision.

The aim of this paper is to quantify the share of food-related environmental impacts associated with discretionary foods across several key environmental indicators and for different socioeconomic groups, and to discuss the implications of these results in the context of promoting healthier and more sustainable diets for all. Section 2 provides a review of available literature on the drivers of discretionary food consumption along with estimates of their environmental impacts. In Section 3, data from Australia are used to estimate the share of dietary energy intake, expenditure and environmental impact associated with discretionary foods. The paper concludes (Sections 4 and 5) by reiterating the urgency of treating the issue of unsustainable food consumption in a manner that addresses the underlying causes, one of which is the proliferation of discretionary food.

[1] Rebound refers to cases where the environmental gains arising due to altered consumption behaviour (for example, eating less discretionary food) could be offset by increased consumption of other items or activities (not necessarily food-related) with a potentially higher environmental impact (Hertwich, 2005).

2. Discretionary Food Consumption Drivers and Impacts

2.1. Use of the Term 'Discretionary Food'

In this study I have adopted the term 'discretionary foods' because it aligns with the economic concept of discretionary consumption, thus emphasising that the consumption of these foods should, in principle, be seen as both nutritionally and environmentally superfluous. 'Discretionary' food is a concept that is increasingly used in the public health literature (An, 2015; Barosh et al., 2014; Cohen et al., 2010; Friel et al., 2014; Watson et al., 2016), although 'non-core' food is also used (Hendrie et al., 2014; Johnson et al., 2011; McGowan et al., 2012), as is the more colloquial term 'junk food' (Pearson et al., 2014; Popkin et al., 2012; Pretty et al., 2015), although there are some subtle differences as some discretionary products like butter or cream are not commonly considered junk foods. There is also a significant overlap between discretionary foods and 'ultra-processed' foods, defined as hyper-palatable, cheap, ready-to-consume food products made from processed substances extracted or refined from whole foods (Monteiro et al., 2011; Monteiro et al., 2013; Moodie et al., 2013).

2.2. Drivers of Discretionary Food Consumption

There are several reasons why discretionary foods, despite their obvious health impacts, are widely consumed around the world. The first is their intense palatability, owing to a high fat, sugar, and/or salt content, which impairs endogenous satiety mechanisms (Monteiro et al., 2013; Moodie et al., 2013; Popkin et al., 2012). When consumed in moderation, certain discretionary foods can often be associated with pleasure and comfort and can even have cultural importance (Garnett, 2014b). However, the proportion of daily calories derived from discretionary foods in many developed and rapidly developing economies suggests that their consumption is excessive and difficult to curtail.

Most discretionary foods are also aggressively promoted to consumers (Hawkes, 2006; Kearney, 2010; Monteiro et al., 2011). This is mainly due to their high degree of profitability which, according to both Albritton (2009) and Carolan (2011), tends to be positively correlated to the amount of processing. It is therefore unsurprising that food manufacturers, fast food chains and supermarkets are actively promoting highly-processed discretionary food items through advertising campaigns and special deals, often targeting lower socioeconomic areas and, increasingly, consumers in the developing world (Darmon and Drewnowski, 2008; Stanton, 2015).

Discretionary foods also provide a seemingly affordable and convenient option for consumers. In many cases discretionary foods may even displace core foods, leading to nutrient deficiencies, overweight and other health problems (Friel et al., 2014). This is becoming increasingly common with evidence suggesting that the cost of wholesome food has been increasing at a faster rate than that of processed food in high income countries like the US and the UK as well as in transitioning economies such as Brazil, Mexico and China (Keats and Wiggins, 2014; Monsivais et al., 2010). Discretionary foods are thus more readily consumed by poorer socioeconomic groups (Barosh et al., 2014; Dixon and Isaacs, 2013). The problem of cost is often compounded by a lack of available time to prepare nutritious meals (Jabs and Devine, 2006; Welch et al., 2009).

I therefore argue that many foods classified as discretionary in a nutritional sense (especially processed meats and dairy products) are no longer discretionary for people who cannot afford healthier non-discretionary options, or who have become conditioned to a lifestyle where the taste and convenience that comes with those discretionary food options has become the norm. This raises challenging environmental and social equity considerations which are discussed later on in the context of the Australian case study.

2.3. Evidence of Environmental Impacts of Discretionary Food Choices

Unlike for core food products, there appears to be a real paucity of specialised environmental life-cycle assessment (LCA) studies for discretionary products. The high degree of processing and packaging associated with most discretionary food products suggests that their environmental impacts are not negligible (Bradbear and Friel, 2011; Friel et al., 2014; Pimentel et al., 2008; Sage, 2012). The limited available quantitative evidence is still sufficient to suggest that discretionary foods may have significant and diverse environmental impacts.

In an LCA study based on food diary data from ten Swedish households, Carlsson-Kanyama et al. (2003) found that desserts like cakes, chocolate and ice cream and beverages like soft drinks and alcoholic drinks accounted for up to one third of total life cycle energy embedded in food, with larger life cycle energy inputs on a per portion basis than the majority of fruits, vegetables and grains. Chocolate even had comparable or higher life cycle energy inputs than some of the meat and fish products considered in the study. A recent LCA study from Switzerland also concluded that milk chocolate is a product with a considerable environmental impact (3.5% of total food-related impact for Swiss consumers) (Jungbluth and König, 2014). According to Pimentel et al. (2008), a hypothetical reduction of junk food intake from the current US level of 33% down to 10% would conserve significant amounts of energy, and improve health. In Australia, recent estimates show that non-core foods contribute about 27% of total food-related GHG emissions (Hendrie et al., 2014).

Blair and Sobal (2006) use the term 'luxus consumption' to refer to consumption beyond metabolic needs. They estimate that up to 18% of available food in the US food system can be considered luxus consumption. This equates to an ecological footprint of 0.36 ha of farm land and ocean per person, which is more than the total per capita ecological footprint in a developing country like Bangladesh. Using carbonated beverages as an example (a prime example of a discretionary food item), the authors calculate that the luxus consumption of 31.8 l per capita per year of sweetened soda required vast amounts of land, energy, fertiliser and pesticides to produce the corn used to make high-fructose corn syrup, in addition to the considerable energy cost for plastic used for bottling the beverages[2].

The handful of studies mentioned here quantify the environmental impacts of discretionary food intake as a side issue, and focus solely on energy and GHG implications (Carlsson-Kanyama et al., 2003; Hendrie et al., 2014; Pimentel et al., 2008). In reality, the diversity of discretionary foods means that specific products may have very different impact intensities across different environmental indicators. There thus remain important knowledge gaps in this area, especially with regards to non-energy or GHG-related environmental impacts associated with the full supply chain (including production, processing, packaging, transport and marketing) of discretionary foods, and how these compare to the environmental impacts of non-discretionary food products. The current study contributes towards addressing these gaps by employing large datasets from recent nutrition and household expenditure surveys in Australia, along with a nutritionally recognised definition of discretionary foods.

[2] In another study, Jungbluth et al. (2012) find that soft drinks and alcoholic beverages contribute about 18% to nutrition-related total life cycle environmental impact.

3. Estimating the Environmental Impacts of Discretionary Food Consumption: an Australian Case Study

3.1. Overview of Data and Approach

Australia offers an ideal case study because it is a country where high discretionary food consumption is of particular concern as, along with physical inactivity, it is the main driver of increasing rates of obesity and NCDs (NHMRC, 2015; Thorpe et al., 2016). 63% of Australians are now classified as overweight or obese, with health problems due to excess weight imposing a substantial economic burden on individuals, families and the health system (Colagiuri et al., 2010). The latest Australian Health Survey (AHS) introduced an approach to distinguish between discretionary and non-discretionary foods across all food products and categories (ABS, 2014a).

The case study uses both publicly available and privately-tailored food intake datasets from the latest editions of the AHS (ABS, 2014b, 2015b) and the Australian Household Expenditure Survey (HES) (ABS, 2011) to identify the nature of discretionary dietary intake across major demographic, socioeconomic and geographic segments of the population. Combining the two different dietary datasets from the AHS and HES by weighting the contribution of dietary energy across individual food groups and cross-tabulating across different demographic and socioeconomic groups, allows for the determination of dietary energy intake from discretionary and non-discretionary foods (see Section 3.2). Following a similar procedure to determine discretionary and non-discretionary shares from the HES subsequently allows for the calculation of environmental impacts of discretionary foods purchased by each of the five household income quintiles (see Section 3.3).

The environmental intensities (impact per dollar) of the life cycle of selected food groups, including CO_2 equivalent (an indicator of global warming potential), water use (an indicator of pressure on water resources), ecological footprint (an established footprint indicator which aggregates different land uses such as cropland, grazing land, fishing ground, forest land, carbon uptake land, and built-up land into global hectares - see Wackernagel et al., 1999; Wackernagel and Rees, 1998) and life cycle energy use[3], are calculated using the Eora multi-regional environmentally extended input-output (EEIO) model (Lenzen et al., 2012; Lenzen et al., 2013). EEIO models are a commonly used top-down LCA approach ideally suited to estimating environmental impacts associated with food and other types of expenditure (Duchin, 2005; Reynolds et al., 2015; Tukker et al., 2011). The advantage of multi-regional EEIO analysis is that it directly relates expenditure on specific products to total life cycle environmental impact, including all inputs and imports in the supply chain. An additional advantage of performing the environmental impact analysis using consumer expenditure is that the footprint results also capture waste (as they include the environmental impact of all food purchased by a household, including what will eventually be wasted). (see Appendix B - Supplementary material 1–for detailed methodology, calculations, assumptions, uncertainty and limitations).

3.2. Discretionary Energy Intake Across Population Segments

Fig. 1 shows the percentage of dietary energy intake from discretionary foods in relation to total dietary intake across a number of different population groups, as compared to the age-weighted average (35.4%) for an Australian resident. There is a high discretionary energy intake across all population groups, ranging from 32.6% for adult women to 38.6% for boys. There are also differences between income groups, with the lowest (35%) and highest (34%) income quintiles having below average percentage discretionary energy intakes, whereas the

[3] This refers to the energy embedded in the production and supply of a good and is different to the total dietary energy intake presented in Figs. 1 & 2, which is the energy ingested when products are consumed.

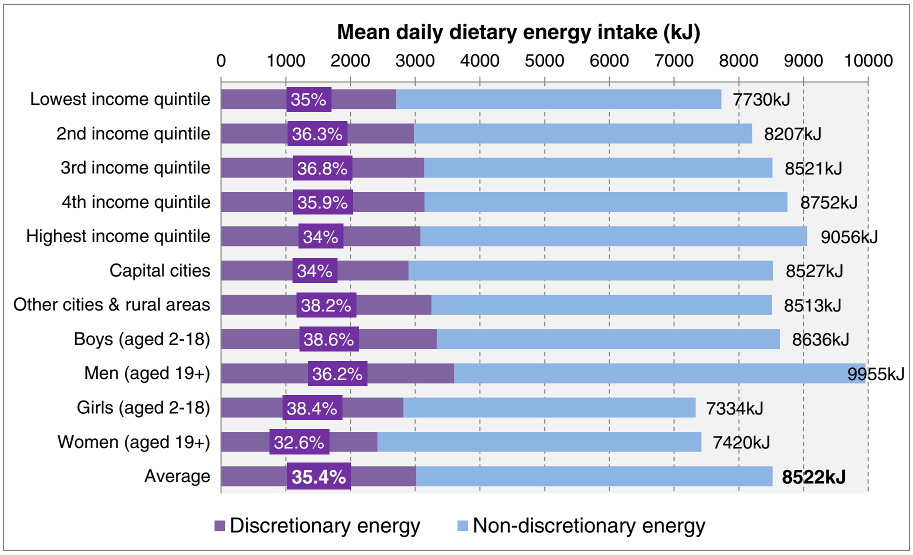

Fig. 1. Percentage discretionary dietary intake in relation to reported energy intake for different demographic, socioeconomic and geographic segments of the Australian population. (Source: author's calculations based on ABS, 2014b, 2015b).

other three income quintiles registered above average discretionary food percentages (35.9%–36.8%). Additionally, there is a considerable difference between people residing in the capital cities (34%) compared to those living in smaller cities and rural areas (38.3%). These findings are consistent with previous studies reporting that lower socioeconomic groups and people from rural or more remote areas of Australia tend to obtain more of their dietary energy from discretionary foods (AIHW, 2012; Barosh et al., 2014; Thorpe et al., 2016), although the exception in this case appears to be the lowest income quintile which tends to have less than average percentage contribution from discretionary foods. Any consideration of environmental impacts and pro-health and -environment dietary modifications must thus be sensitive to socioeconomic variables. The following analysis concentrates on differences between income quintile groups (results for other population groups are available in Appendix B - Supplementary material 1).

It is important to note that it is commonly accepted that survey participants tend to under-report their food intake. In the AHS this has been estimated to be around 17% for men and 21% for women (and likely to be considerably higher for overweight and obese individuals), with discretionary foods being particularly sensitive to underreporting because of a general awareness of socially acceptable or desirable dietary patterns (ABS, 2014a, 2015a). Therefore, both the total energy intake and the share of discretionary food presented in Fig. 1 are most likely to be underestimates. This study does not account for the levels of physical activity which may also vary between population groups. While recommended dietary energy intakes vary depending on the level of physical activity, and energy intake alone may not be an adequate indicator of dietary quality, the main purpose of the results presented in Figs. 1 and 2 is to illustrate the share of discretionary/non-discretionary foods – which is independent of the level of physical activity. This is subsequently used to determine expenditure shares for the purpose of computing environmental impacts (Fig. 3). Any detailed nutrition advice would need to consider all these factors, and is outside the scope of the current study.

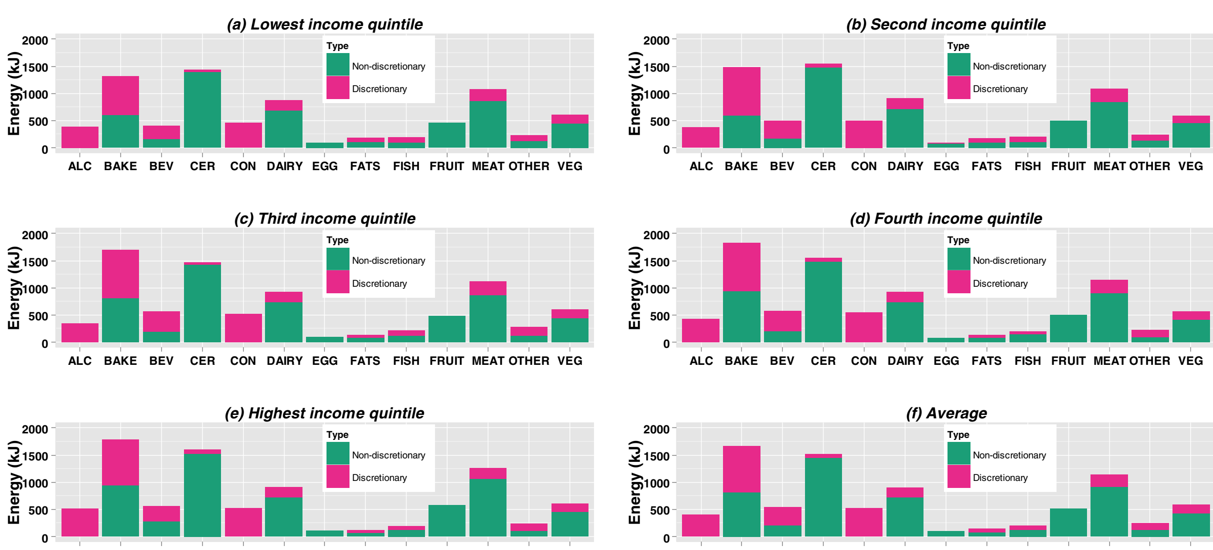

Fig. 2. Discretionary and non-discretionary daily per capita dietary energy intake as reported by gross income quintiles (ALC = alcohol, BAKE = baked goods, BEV = beverages, CER = cereals, CON = confectionary and condiments). (Source: author's calculations based on ABS, 2014b,2015b).

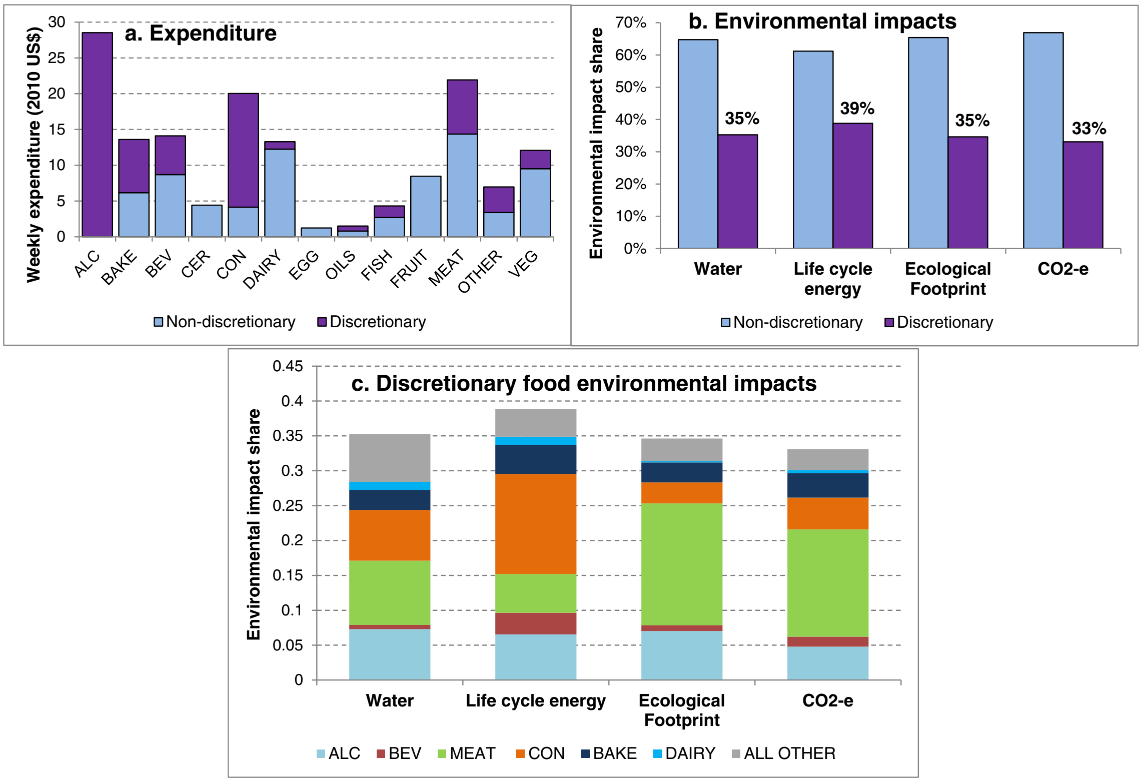

Fig. 3. Discretionary vs. non-discretionary expenditure per product group (a) along with percentage of total environmental impact (b) and percentage from main discretionary food groups (c) for an average household in Australia (for non-discretionary environmental impact breakdown and for full results see. supplementary material 1, 4 and 7 in Appendix B). (Source: author's calculations based on the Australian HES and the Eora input-output tables and environmental extensions).

Fig. 2 shows the contribution of major food categories to discretionary energy intake for selected income quintile groups (for age/gender groups and geographic groups see Appendix B - Supplementary material 1). Baked goods, confectionery and condiments account for the majority of energy intake from discretionary foods, followed by alcoholic and non-alcoholic beverages, meat and dairy. Considering the relative caloric contribution of food groups as illustrated in Fig. 2 is an important first step to pinpoint the areas of concern for each population group being considered. It appears that, even though overall discretionary energy shares for different income groups vary (see Fig. 1), the provenance of that energy tends to be very similar, with the majority of discretionary energy contribution coming from products belonging to the same food groups. However, this is not necessarily the case from an environmental perspective, especially since discretionary foods can be energy-dense even in small quantities. Environmental impact is thus commonly estimated by employing either quantities (grams) or monetary units ($). The solution proposed here is to use food expenditure estimates from the Australian HES (ABS, 2014a), as they are consistent with EEIO analysis. The HES contains expenditure across 594 products, including 126 individual food items. On the basis of the official health survey classification (ABS, 2014a), each of the HES food items were classified as discretionary or non-discretionary. Expenditure was then aggregated to the Eora Australian input-output food classification, which comprises 33 food product sectors for which environmental intensities per dollar have been calculated using EEIO (see Appendix B for datasets and step-by-step methodology).

3.3. Household Expenditure and Environmental Impact Estimates

Fig. 3a shows average food expenditure across the main food groups from Fig. 2. Alcohol (ALC) and condiments & confectionery (CON) account for the majority of discretionary food expenditure, followed by baked products (BAKE), non-alcoholic beverages (BEV) and meat (MEAT). These are the same product groups responsible for the majority of dietary energy intake (see Fig. 2), implying a degree of consistency between the AHS and the HES, although comparing the 'Average' dietary energy intake profile in Figs. 2 to 3(a) shows that expenditure is higher for groups that have a relatively lower contribution to dietary energy intake, notably alcohol. Fig. 3b shows the calculated environmental impact shares of discretionary and non-discretionary food across all four environmental indicators. Discretionary food consumption accounts for 39% of total food-related life cycle energy use, 35% of water use, 35% of the ecological footprint, and 33% of food-related GHG emissions. The reason for these differences lies in the share of expenditure across food products (shown in Fig. 3a) in relation to environmental impact intensities per food product (see Table A.1). The GHG percentage (33%) is slightly higher than the 27% for non-core foods calculated by Hendrie et al. (2014), who used a previous edition of the Australian national nutrition survey from 1995. The life cycle energy percentage (39%) is also slightly higher than the 33% previously calculated by Carlsson-Kanyama et al. (2003) for Sweden. The high contribution of discretionary food products to life cycle energy use is however consistent with supply chains of processed foods requiring considerable energy inputs (Jungbluth et al., 2012; Pimentel et al., 2008; Reynolds et al., 2015). No previous study has estimated the ecological footprint or water use associated with discretionary or non-core foods, therefore direct comparisons are not possible.

Fig. 3c provides a more detailed illustration of the contribution to environmental impact from different discretionary food groups. Processed meats (MEAT) and condiments & confectionery (CON) appear to dominate environmental impacts across all four indicators, with fairly significant contributions also coming from baked goods (BAKE) and alcohol (ALC). Processed meats contribute most substantially to CO_2-e (15%) and ecological footprint (17%), owing to high GHG emissions and land use embedded in meat supply chains, consistent with previous studies reviewed in Section 1. On the other hand, condiments & confectionery

(14%), alcohol (7%) and baked products (4%) contribute most substantially to life cycle energy use, together adding up to one quarter of all total food-related life cycle energy use. This is consistent with earlier findings by Carlsson-Kanyama et al. (2003). The other category (ALL OTHER) only has a significant contribution (7%) to water use, mainly as a result of high irrigation demands for fruit and vegetables in Australia (Reynolds et al., 2015).

3.4. Socioeconomic Considerations - Elimination or Substitution?

'Trimming the excess' (complete elimination without any substitution) of discretionary food expenditure is likely to be an option for many individuals in Australia, especially amongst higher income groups where dietary energy intake is higher than the average recommended level of 8700 kJ per day (NHMRC, 2013). Table 1 displays the environmental impact contribution from discretionary foods and how this varies across high and low income groups as well as across impact categories. Energy, CO_2 and water results for the average household are consistent with previous Australian studies (Hendrie et al., 2014; Reynolds et al., 2015). The highest income quintile has, in absolute terms, significantly higher discretionary spending and total environmental impact across all indicators (see Table 1 and Table A.2). This is despite having lower dietary energy intake percentages from discretionary food (as seen in Fig. 1).

Table 1
Food-related environmental impacts calculated using EEIO on the basis of household expenditure showing contribution from discretionary foods for selected socioeconomic groups (ALL OTHER = sum of vegetables, fruit, fish and OTHER).

	Total impact (per household per week)			
	Water	Energy	Ecological Footprint	CO_2-e
	L	MJ	gha	kg
	Highest income quintile			
Total food-related impact	61,908	867	0.046	206
Discretionary impact	22,378	343	0.016	69
% Discretionary	***36.1%***	***39.6%***	***35.3%***	***33.5%***
ALC	9.1%	8.4%	8.8%	6.1%
BEV	0.6%	3.0%	0.8%	1.4%
MEAT	8.7%	5.3%	16.7%	14.7%
CON	6.8%	13.8%	2.9%	4.3%
BAKE	2.8%	4.0%	2.8%	3.4%
DAIRY	1.0%	1.0%	0.2%	0.4%
ALL OTHER	7.1%	4.1%	3.3%	3.1%
	Lowest income quintile			
Total food-related impact	23,891	334	0.018	83
Discretionary impact	7811	120	0.006	26
% Discretionary	***32.7%***	***35.9%***	***32.6%***	***31.3%***
ALC	4.0%	3.7%	4.1%	2.6%
BEV	0.4%	2.3%	0.6%	1.0%
MEAT	10.0%	6.1%	18.4%	16.2%
CON	7.2%	13.9%	2.8%	4.3%
BAKE	3.0%	4.5%	2.9%	3.6%
DAIRY	1.5%	1.5%	0.2%	0.5%
ALL OTHER	6.5%	4.0%	3.6%	3.0%
	Average household			
Total food-related impact	41,798	589	0.031	141
Discretionary impact	14,737	229	0.011	47
% Discretionary	***35.3%***	***38.8%***	***34.6%***	***33.1%***
ALC	7.3%	6.5%	7.0%	4.8%
BEV	0.6%	3.1%	0.8%	1.4%
MEAT	9.2%	5.5%	17.5%	15.4%
CON	7.3%	14.4%	3.0%	4.6%
BAKE	2.9%	4.2%	2.9%	3.5%
DAIRY	1.2%	1.2%	0.2%	0.4%
ALL OTHER	6.8%	3.9%	3.3%	3.0%

Bold is reserved for titles and income groups. Total discretionary percentage rows appear in italics (this should add up to all the other percentages).

The most fundamental difference in environmental impact shares across income groups is the higher percentage on alcohol, which, depending on the impact category, accounts for 6.1% - 9.1% of total environmental impact for the highest income group (see Table 1). Table A.2 highlights the important contribution of alcohol consumption to food expenditure, especially amongst the high income groups. Previous research from Europe also suggests that the environmental impacts of alcohol consumption can be considerable due to bottling, packaging, refrigeration and transport (Carlsson-Kanyama et al., 2003; Garnett, 2007; Jungbluth et al., 2012).

For higher income groups, the priority should be to eliminate excess consumption of discretionary foods such as alcohol, processed meats, baked goods and confectionery. From Fig. 1 it would appear that many men aged 19+ and individuals in the higher income groups are likely to have a higher than recommended desirable estimated energy requirement (DEER), especially when under-reporting is accounted for, although this will also depend on age, sex, and physical activity levels (NHMRC, 2005). A reduction in total caloric intake would be in line with previous recommendations for reducing surplus energy intake in the Australian population (Friel et al., 2014; Hendrie et al., 2014; Reynolds et al., 2015). From an environmental perspective, the only risk of dietary elimination is a rebound effect, if money saved from food reduction is then used to purchase more environmentally intensive products or services, but this risk is negligible given that discretionary foods are generally superfluous and will not require substitution – at least for higher income groups.

Reducing discretionary consumption for lower income groups would present a more significant challenge, especially where isocaloric substitutions may be required to maintain an adequate energy intake and to boost nutrition quality. It is generally known that the intake of fruit and vegetables amongst the Australian population is far below recommended levels (ABS, 2014a). Shifting spending away from discretionary food choices such as processed meats or confectionery and bakery products towards non-discretionary equivalents such as fresh meat and bread presents a win-win situation (as shown by lower environmental intensities in Table A.2). This is compatible with previous single-indicator studies on energy (Carlsson-Kanyama et al., 2003) and GHG emissions (Hendrie et al., 2014; Macdiarmid et al., 2012). Reductions in processed meat expenditure, currently accounting for a significantly higher percentage of environmental impact amongst lower income groups, offer an obvious reduction in environmental impact, with positive health impacts as well (Bouvard et al., 2015). Reduction of processed meat could present a potential challenge where this constitutes an affordable source of protein that is actually consumed as a core food – vegetal protein may be an obvious substitute in an environmental sense but this may be less socially or culturally acceptable for many households (Lea et al., 2006; Macdiarmid et al., 2016).

However, when spending is shifted from baked goods and confectionary towards fruit and/or vegetables, or from processed fruits and vegetables towards fresh produce, environmental impacts could increase for indicators other than energy (unprocessed fruit and vegetables actually have higher environmental intensities per dollar, as can be seen in Table A.1). This result is not consistent across all indicators when environmental intensity is compared per 100 g of product instead of per dollar. These findings are in line with previous studies which have shown that shifts towards healthier diets do not always result in lower footprints (Heller and Keoleian, 2015; Macdiarmid, 2013; Tilman and Clark, 2014; Vieux et al., 2012). They also highlight how the choice of functional unit can impact on findings and recommendations (Drewnowski et al., 2015; Masset et al., 2015). It is beyond the current scope to explore substitutions considering multiple functional units or nutrient density indicators, although this is acknowledged as an important avenue for further research (Nemecek et al., 2016). The study has nevertheless gone further than previous EEIO studies in this respect by employing weighted average state and national prices to calculate environmental intensity per dollar as well as per 100 g of product (see

Table A.1 and Appendix B - supplementary material 3 for conversions and assumptions).

4. Discussion

4.1. Global Relevance of Findings and Research Gaps

Notwithstanding the need for further research, the case study demonstrates that in a developed western economy like Australia, discretionary food intake and expenditure is significant across all population groups. Furthermore, this high discretionary food consumption not only has adverse health implications, but also results in significant environmental impacts. These findings are highly relevant to many other developed countries, particularly the US, the UK, Canada and New Zealand, as well as many middle income and developing economies like China, Mexico, South Africa and Brazil as they transition away from traditional diets (Monteiro et al., 2013; Popkin et al., 2012; Temple and Steyn, 2011; Tilman and Clark, 2014; Wilson et al., 2013).

For the majority of consumers, taste, cost and convenience are seen as more important than nutritional concerns, with environmental impact an even lower priority (Glanz et al., 1998; Jabs and Devine, 2006; Welch et al., 2009). Encouraging dietary shifts away from discretionary food choices is highly challenging because of the cheapness, palatability and convenience of these products. If an identical sum of money currently being spent on discretionary food was to be used to purchase non-discretionary food, especially fresh produce, it would likely yield significantly less caloric energy and would appear to present less value for money. Even though this may be desirable in many cases where overweight and obesity is an issue, it is still likely to represent an unpopular choice for lower income consumers. Economic incentives such as taxation of foods high in sugar, fat and salt, along with redistributing that revenue by subsidising healthier food choices (with extra incentives given for products with lower environmental intensities) for lower income groups, are a possible solution (Hendrie et al., 2014; Temple and Steyn, 2011; Wilson et al., 2013).

The case study also highlights the need for developing bespoke healthy and sustainable dietary recommendations for diverse population segments. Although the strong demographic, socioeconomic and cultural gradients in food consumption are well understood in the fields of public health and nutrition (Barosh et al., 2014; Drewnowski et al., 2015; Pretty et al., 2015), there is still a lack of research in the environmental sustainability field explicitly modelling food choice and necessary substitutions at the sub-national or societal level, with the majority of studies considering national-scale scenarios, based mostly on shifts to vegetarian diets. Evidence points towards health incentives providing a much stronger impetus for change amongst consumers as compared to environmental concerns (Hoek et al., 2014). A detailed substitution simulation involving a behavioural model of diet choice and recommended substitutions catering for the macro- and micro- nutrient intake needs of different age groups is outside the scope of the present study but represents a worthwhile future research avenue. A challenge is to ensure equitable outcomes across socioeconomic groups in a way that puts less pressure on families living on low incomes to make pro-environmental choices but to focus instead on improving their nutrition.

For this reason, future studies could also consider the extent to which more affluent consumers in the developed world could reduce their consumption of discretionary foods such that the environmental impact of poorer families shifting from discretionary to more healthy consumption (including increased animal protein where necessary) is offset. If less discretionary food is produced, this means either that more raw ingredients such as grains and dairy are available in their more nutritious non-discretionary forms, or that less agricultural production needs to take place, both potentially resulting in reduced environmental impacts.

It should be noted that negative economic side-effects on processed food supply chains for products like chocolate and cane sugar may end up disproportionately impacting livelihoods of lower income workers in both the developed and developing world (Garnett, 2014b). Although this could be offset by positive economic impacts on the health system through reduced availability of energy-dense obesogenic products, equitable redistribution of these gains should be seen as a research and policy priority. Today, more than ever, policymakers, researchers and consumers alike are often overwhelmed by the complexity of health, economic, social and environmental sustainability implications when it comes to food choices (Garnett et al., 2015; Hindley, 2015; Lawrence et al., 2015a). Even an obvious win-win situation in terms of health and environmental sustainability may have other repercussions, including rebounds, which need to be quantified, understood and managed. Furthermore, uncertainty in environmental impact intensities from LCA-based studies remains an important issue, due to errors in input data, and differences in the choice of system boundary and functional unit (Hallström et al., 2015; Masset et al., 2015; Nemecek et al., 2016; Vieux et al., 2012).

4.2. Policy Implications - Treating the Symptoms or the Cause?

Whilst it is evident that more research is required to comprehensively assess the life cycle impacts of different types of discretionary foods vis-à-vis core foods, this paper has argued that distinguishing between discretionary and non-discretionary foods should be seen as essential to the notion of food system sustainability. Any food system that uses scarce resources to produce food that not only fails to nourish us properly, but also harms our health and degrades our environment, cannot be considered sustainable. Even where highly processed discretionary food products have a comparatively low footprint or long shelf lives, or have highly efficient supply chains owing to large economies of scale, I argue that they still represent a largely unjustifiable use of scarce planetary resources, as they offer little nutritional value in return.

As with most environmental and sustainability problems, developing policy solutions is fraught with challenges and dilemmas, especially when, as in the case of the food system, there is a need to address immediate issues such as obesity and environmental degradation, whilst pursuing more viable and sustainable solutions in the form of systemic change. This is essentially what Garnett (2014a) advocates through a combination of efficiency, demand restraint and system transformation or what Lawrence et al. (2015b) refer to as 'different orders of change'. At the heart of the more systemic, holistic solutions lies the need to challenge the premise of food corporations operating on the sole basis of profit maximisation (Hadjikakou and Wiedmann, in press; iPES-Food, 2016; Lawrence et al., 2015a; Pretty et al., 2015). Central to this argument is the need to question the mass production and proliferation of discretionary foods and the continued targeted marketing of lower socioeconomic groups and children (Hawkes, 2006; Stanton, 2015).

Consumer-oriented policies such as promoting behavioural change through taxes, 'nudging', nutrition labelling, and better consumer education are all potential ways to address the symptoms and should certainly be employed. Dietary guidelines should also emphasise the context of preparing, valuing and enjoying food (Monteiro et al., 2015). Nevertheless, the proliferation of discretionary food highlights the need to address the root causes through appropriate government policy and regulation whilst also actively engaging with the food industry (Hawkes, 2006; Hindley, 2015; Schröder, 2013). A general call for 'divestment' away from such food products, that are harmful to health and create an unnecessary burden on the environment and the health system, should be promoted as a more sustainable business model. Such a model would be more compatible with a society and economic system that prioritises human wellbeing and the health of the environment (Jackson, 2009; Pretty et al., 2015; Victor, 2008).

5. Conclusion

This article has argued that reducing the production and consumption of discretionary food products should be seen as a crucial step towards aligning human and planetary health and creating a more sustainable food system, one which should be promoted alongside reductions in animal protein consumption. Although their adverse health impacts are well documented, discretionary foods have significant environmental impacts that are yet to be fully understood or quantified. Findings in this paper suggest that discretionary foods account for a significant percentage of food-related environmental impacts across different socioeconomic groups in Australia. This is likely to be similar in other developed countries, and increasingly in developing countries transitioning away from traditional diets. A more sustainable food system should be one where discretionary products are seen strictly as occasional treats rather than accounting for such a significant percentage of our daily food intake, household expenditure and diet-related environmental impact. Expending significant amounts of energy and environmental resources to create large amounts of profitable but highly discretionary and often unhealthy products should be seen as fundamentally unsustainable for our future, especially when faced with the challenge of achieving global food security for a larger future population. Future research and modelling must ensure that measures to encourage elimination or, where necessary, substitution with non-discretionary foods, remain equitable, in line with nutritional guidelines, and account for potential environmental trade-offs and rebounds.

Acknowledgements

The research was enabled by funding from the Australian Academy of Science through its 2015 W H Gladstones Population and Environment Fund Grant. The author also acknowledges the Australian Bureau of Statistics for their invaluable data contribution.

Appendix A. Total environmental impacts and intensities

Table A1
Calculated environmental intensities per dollar of expenditure and per 100g of product, for selected discretionary and non-discretionary products.

Food I-O sectors	Environmental intensity per $ of expenditure				Environmental intensity per 100g of product			
	Water	Life cycle energy	Ecological Footprint	CO_2-e	Water	Life cycle energy	Ecological Footprint	CO_2-e
	L/$	MJ/$	m^2/$	kg/$	L/100g	MJ/100g	m^2/100g	kg/100g
Non-discretionary								
Eggs (EGG)	190	2.53	0.68	0.48	131	1.74	0.47	0.33
Vegetables (VEG)	525	2.37	4.07	1.88	148	0.67	1.15	0.53
Fruit (FRUIT)	276	1.90	2.05	1.48	77	0.53	0.58	0.42
Fresh meat (MEAT)	437	4.07	6.55	2.65	641	5.97	9.62	3.90
Poultry (MEAT)	392	6.06	0.77	2.17	229	3.54	0.45	1.27
Milk (DAIRY)	263	9.36	0.71	0.57	47	1.65	0.13	0.10
Cheese (DAIRY)	284	5.67	0.35	0.53	306	6.13	0.38	0.57
Butter (DAIRY)	509	6.07	0.52	0.59	392	4.67	0.40	0.46
Oils and fats (FATS)	666	5.87	3.81	1.09	429	3.78	2.46	0.70
Rice products (CER)	720	5.26	1.04	1.69	201	1.47	0.29	0.47
Plain flour (CER)	748	4.48	4.53	1.22	126	0.75	0.76	0.21
Bread (BAKE)	143	3.04	0.64	0.41	75	1.60	0.34	0.22
Seafood (FISH)	582	4.84	2.55	0.57	954	7.93	4.18	0.93
Discretionary								
Veg. products (VEG)	155	5.10	2.39	0.63	66	2.18	1.03	0.27
Fruit products (FRUIT)	104	4.29	2.25	0.58	51	2.09	1.10	0.28
Beer (ALC)	133	1.10	1.06	0.21	122	1.01	0.97	0.19
Confectionery (CON)	93	6.16	0.48	0.34	175	11.61	0.90	0.64
Cakes & biscuits (BAKE)	162	3.31	1.19	0.66	159	3.25	1.17	0.65
Meat products (MEAT)	509	4.32	7.17	2.86	373	3.17	5.26	2.09

Table A2
Weekly household food expenditure (USD) and environmental impact contribution from principal discretionary food groups for gross income quintiles in Australia (ABS, 2011, and author calculations - see SI section 1.5).

Discretionary expenditure (2010 US$)	Lowest	Second	Third	Fourth	Highest	Average
ALC	9.49	17.27	27.49	34.81	53.64	28.53
BAKE	4.50	6.28	7.03	8.77	10.57	7.43
BEV	2.25	4.14	5.74	7.28	7.72	5.42
CON	8.77	13.02	15.81	19.53	22.26	15.88
DAIRY	0.76	0.90	1.08	1.06	1.38	1.04
MEAT	4.69	6.26	7.40	8.88	10.62	7.57
Total discretionary	30.46	47.87	64.55	80.34	106.19	65.87
Total food expenditure (HES)	82.20	118.56	149.75	181.38	233.67	153.08
% discretionary expenditure	37.1%	40.4%	43.1%	44.3%	45.4%	43.0%
% discretionary environmental impact						
Blue Water (l)	32.7%	34.7%	36.0%	35.1%	36.1%	35.3%
Total Energy (MJ)	35.9%	38.1%	39.3%	39.2%	39.6%	38.8%
Ecological Footprint (gha)	32.6%	34.3%	34.6%	34.8%	35.3%	34.6%
CO2-e (kg)	31.3%	33.0%	33.2%	33.4%	33.5%	33.1%

Appendix B. Supplementary data

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.ecolecon.2016.08.006.

References

ABS, 2011. Australian Household Expenditure Survey: Summary of Results 2009–10. Australian Bureau of Statistics (ABS), Canberra (Available online: http://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/6530.0Main+Features12009-10?OpenDocument).

ABS, 2014a. Australian Health Survey: Nutrition First Results – Discretionary Foods. Australian Bureau of Statistics (ABS), Canberra (Available online at: http://www.abs.gov.au/ausstats/abs@.nsf/Lookup/4363.0.55.001Chapter65062011-13).

ABS, 2014b. Australian Health Survey: Nutrition First Results – Food and Nutrients, 2011–12. Australian Bureau of Statistics (ABS), Canberra (Available from: http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/4364.0.55.0072011-12?OpenDocument).

ABS, 2015a. Australian Health Survey: Under-Reporting in Nutrition Surveys. Australian Bureau of Statistics (ABS), Canberra (Available from: http://www.abs.gov.au/ausstats/abs@.nsf/Lookup/4363.0.55.001Chapter651512011-13).

ABS, 2015b. National Nutrition and Physical Activity Survey: 2011–12, Customised Report. Australian Bureau of Statistics.

AIHW, 2012. Australia's Food & Nutrition 2012, Cat. no. PHE 163. Australian Institute of Health and Welfare (AIHW), Canberra.

Albritton, R., 2009. Let Them Eat Junk: How Capitalism Creates Hunger and Obesity. Pluto Press, England.

An, R., 2015. Beverage consumption in relation to discretionary food intake and diet quality among US adults, 2003 to 2012. J. Acad. Nutr. Diet. http://dx.doi.org/10.1016/j.jand.2015.1008.1009.

Barosh, L., Friel, S., Engelhardt, K., Chan, L., 2014. The cost of a healthy and sustainable diet–who can afford it? Aust. N. Z. J. Public Health 38, 7–12.

Blair, D., Sobal, J., 2006. Luxus consumption: wasting food resources through overeating. Agric. Hum. Values 23, 63–74.

Bouvard, V., Loomis, D., Guyton, K.Z., Grosse, Y., Ghissassi, F.E., Benbrahim-Tallaa, L., ... Straif, K., 2015. Carcinogenicity of consumption of red and processed meat. Lancet Oncol. http://dx.doi.org/10.1016/S1470-2045(1015)00444-00441.

Bradbear, C., Friel, S., 2011. Food Systems and Environmental Sustainability: a Review of the Australian Evidence, NCEPH Working Paper. Australian National University, Canberra.

Carlsson-Kanyama, A., Ekström, M.P., Shanahan, H., 2003. Food and life cycle energy inputs: consequences of diet and ways to increase efficiency. Ecol. Econ. 44, 293–307.

Carolan, M., 2011. The Real Cost of Cheap Food. 1st ed. Earthscan, Abingdon.

Chai, A., Bradley, G., Lo, A., Reser, J., 2015. What time to adapt? The role of discretionary time in sustaining the climate change value–action gap. Ecol. Econ. 116, 95–107.

Cohen, D.A., Sturm, R., Lara, M., Gilbert, M., Gee, S., 2010. Discretionary calorie intake a priority for obesity prevention: results of rapid participatory approaches in low-income US communities. J. Public Health 32, 379–386.

Colagiuri, S., Lee, C.M., Colagiuri, R., Magliano, D., Shaw, J.E., Zimmet, P.Z., Caterson, I.D., 2010. The cost of overweight and obesity in Australia. Med. J. Aust. 192, 260–264.

Darmon, N., Drewnowski, A., 2008. Does social class predict diet quality? Am. J. Clin. Nutr. 87, 1107–1117.

de Boer, J., Schösler, H., Aiking, H., 2014. "Meatless days" or "less but better"? Exploring strategies to adapt Western meat consumption to health and sustainability challenges. Appetite 76, 120–128.

Demaio, A.R., Rockström, J., 2015. Human and planetary health: towards a common language. Lancet http://dx.doi.org/10.1016/S0140-6736(1015)61044-61043.

Dixon, J., Isaacs, B., 2013. Why sustainable and 'nutritionally correct' food is not on the agenda: Western Sydney, the moral arts of everyday life and public policy. Food Policy 43, 67–76.

Drewnowski, A., Rehm, C.D., Martin, A., Verger, E.O., Voinnesson, M., Imbert, P., 2015. Energy and nutrient density of foods in relation to their carbon footprint. Am. J. Clin. Nutr. http://dx.doi.org/10.3945/ajcn.3114.092486.

Druckman, A., Jackson, T., 2010. The bare necessities: how much household carbon do we really need? Ecol. Econ. 69, 1794–1804.

Druckman, A., Buck, I., Hayward, B., Jackson, T., 2012. Time, gender and carbon: a study of the carbon implications of British adults' use of time. Ecol. Econ. 84, 153–163.

Duchin, F., 2005. Sustainable consumption of food: a framework for analyzing scenarios about changes in diets. J. Ind. Ecol. 9, 99–114.

Friel, S., Barosh, L.J., Lawrence, M., 2014. Towards healthy and sustainable food consumption: an Australian case study. Public Health Nutr. 17, 1156–1166.

Garnett, T., 2007. The Alcohol we Drink and it's Contribution to the UK's Greenhouse Gas Emissions: a Discussion Paper. Food Climate Research Network, University of Surrey.

Garnett, T., 2014a. Three perspectives on sustainable food security: efficiency, demand restraint, food system transformation. What role for life cycle assessment? J. Clean. Prod. 73, 10–18.

Garnett, T., 2014b. What is a sustainable healthy diet?, FCRN discussion paper. Food Climate Research Network, Oxford (Retrieved from: http://www.fcrn.org.uk/fcrn/publications/fcrn-discussion-paper-what-sustainable-healthy-diet).

Garnett, T., Mathewson, S., Angelides, P., Borthwick, F., 2015. Policies and Actions to Shift Eating Patterns: What Works? Food Climate Research Network, University of Oxford

Gerbens-Leenes, P.W., Nonhebel, S., 2002. Consumption patterns and their effects on land required for food. Ecol. Econ. 42, 185–199.

Gerber, P.J., Steinfeld, H., Henderson, B., Mottet, A., Opio, C., Dijkman, J., ... Tempio, G., 2013. Tackling Climate Change Through Livestock: a Global Assessment of Emissions and Mitigation Opportunities. Food and Agriculture Organization of the United Nations (FAO), Rome.

Glanz, K., Basil, M., Maibach, E., Goldberg, J., Snyder, D.A.N., 1998. Why Americans eat what they do: taste, nutrition, cost, convenience, and weight control concerns as influences on food consumption. J. Am. Diet. Assoc. 98, 1118–1126.

Goodland, R., 1997. Environmental sustainability in agriculture: diet matters. Ecol. Econ. 23, 189–200.

Hadjikakou, M., and Wiedmann, T., Shortcomings of a growth-driven food system, In: Victor, P.A., Dolter, B. (Eds.), Handbook on Growth and Sustainability, in press. Edward Elgar Publishing, Cheltenham, UK, (in press).

Hallström, E., Carlsson-Kanyama, A., Börjesson, P., 2015. Environmental impact of dietary change: a systematic review. J. Clean. Prod. 91, 1–11.

Hawkes, C., 2006. Uneven dietary development: linking the policies and processes of globalization with the nutrition transition, obesity and diet-related chronic diseases. Glob. Health 2, 4. http://dx.doi.org/10.1186/1744-8603-1182-1184.

Health Council of the Netherlands, 2011. Guidelines for a Healthy Diet: the Ecological Perspective. Health Council of the Netherlands, The Hague (Available from: http://www.healthcouncil.nl/sites/default/files/201108E.pdf accessed 24 May 2015).

Hedenus, F., Wirsenius, S., Johansson, D.J., 2014. The importance of reduced meat and dairy consumption for meeting stringent climate change targets. Clim. Chang. 124, 79–91.

Heller, M.C., Keoleian, G.A., 2015. Greenhouse gas emission estimates of U.S. dietary choices and food loss. J. Ind. Ecol. 19, 391–401.

Hendrie, G.A., Ridoutt, B.G., Wiedmann, T.O., Noakes, M., 2014. Greenhouse gas emissions and the australian diet—comparing dietary recommendations with average intakes. Nutrients 6, 289–303.

Hertwich, E.G., 2005. Consumption and the rebound effect. J. Ind. Ecol. 9, 85–98.

Hindley, C., 2015. 'Sustainable Food': Whose Responsibility is it Anyway? A Personal Commentary. In: Sloan, P., Legrand, W., Hindley, C. (Eds.), The Routledge Handbook of Sustainable Food and Gastronomy. Routledge, Abingdon, pp. 29–33.

Hoek, A.C., Pearson, D., James, S.W., Lawrence, M.A., Friel, S., 2014. Shrinking the food-print: understanding consumers to promote healthy and environmentally friendly food behaviours. In: Rundle-Thiele, S., Kubacki, K., Arli, D. (Eds.), 2014 ANZMAC Conference: Agents of Change. Australian & New Zealand Marketing Academy (ANZMAC), Brisbane, pp. 1439–1445.

iPES-Food, 2016. From Uniformity to Diversity: a Paradigm Shift from Industrial Agriculture to Diversified Agroecological Systems. International Panel of Experts on Sustainable Food systems (iPES-Food) (Available online from: http://www.ipes-food.org/reports).

Jabs, J., Devine, C.M., 2006. Time scarcity and food choices: an overview. Appetite 47, 196–204.

Jackson, T., 2009. Prosperity Without Growth Economics for a Finite Planet. Earthscan, London.

Johnson, L., van Jaarsveld, C.H.M., Wardle, J., 2011. Individual and family environment correlates differ for consumption of core and non-core foods in children. Br. J. Nutr. 105, 950–959.

Jungbluth, N., König, A., 2014. Life cycle assessment of swiss chocolate. SETAC Europe 24th Annual Meeting. SETAC, Europe (11–15 May 2014, Basel).

Jungbluth, N., Itten, R., Schori, S., 2012. Environmental impacts of food consumption and its reduction potentials. In: Corson, M.S., van der Werf, H.M.G. (Eds.), Proceedings From the 8th International Conference on LCA in the Agri-Food Sector (LCA Food 2012). INRA, Rennes, France, pp. 100–105.

Kearney, J., 2010. Food consumption trends and drivers. Philos. Trans. R. Soc. Lond. B Biol. Sci. 365, 2793–2807.

Keats, S., Wiggins, S., 2014. Future Diets: Implications for Agriculture and Food Prices. Overseas Development Institute (ODI), London (Available at: http://www.odi.org/sites/odi.org.uk/files/odi-assets/publications-opinion-files/8776.pdf (Accessed 15 May 2015)).

Keyzer, M.A., Merbis, M.D., Pavel, I.F.P.W., van Wesenbeeck, C.F.A., 2005. Diet shifts towards meat and the effects on cereal use: can we feed the animals in 2030? Ecol. Econ. 55, 187–202.

Lawrence, M., Burlingame, B., Caraher, M., Holdsworth, M., Neff, R., Timotijevic, L., 2015a. Public health nutrition and sustainability. Public Health Nutr. 18, 2287–2292.

Lawrence, M.A., Friel, S., Wingrove, K., James, S.W., Candy, S., 2015b. Formulating policy activities to promote healthy and sustainable diets. Public Health Nutr. 18, 2333–2340.

Lea, E., Worsley, A., 2008. Australian consumers' food-related environmental beliefs and behaviours. Appetite 50, 207–214.

Lea, E., Crawford, D., Worsley, A., 2006. Public views of the benefits and barriers to the consumption of a plant-based diet. Eur. J. Clin. Nutr. 60, 828–837.

Lenzen, M., Kanemoto, K., Moran, D., Geschke, A., 2012. Mapping the structure of the world economy. Environ. Sci. Technol. 46, 8374–8381.

Lenzen, M., Moran, D., Kanemoto, K., Geschke, A., 2013. Building Eora: a global multi-region input–output database at high country and sector resolution. Econ. Syst. Res. 25, 20–49.

Lukas, M., Rohn, H., Lettenmeier, M., Liedtke, C., Wiesen, K., 2015. The Nutritional Footprint – Integrated Methodology Using Environmental and Health Indicators to Indicate Potential for Absolute Reduction of Natural Resource Use in the Field of Food and Nutrition. Journal of Cleaner Production http://dx.doi.org/10.1016/j.jclepro.2015.02.070.

Macdiarmid, J.I., 2013. Is a healthy diet an environmentally sustainable diet? Proc. Nutr. Soc. 72, 13–20.

Macdiarmid, J.I., Kyle, J., Horgan, G.W., Loe, J., Fyfe, C., Johnstone, A., McNeill, G., 2012. Sustainable diets for the future: can we contribute to reducing greenhouse gas emissions by eating a healthy diet? Am. J. Clin. Nutr. 96, 632–639.

Macdiarmid, J.I., Douglas, F., Campbell, J., 2016. Eating like there's no tomorrow: public awareness of the environmental impact of food and reluctance to eat less meat as part of a sustainable diet. Appetite 96, 487–493.

Masset, G., Vieux, F., Darmon, N., 2015. Which functional unit to identify sustainable foods? Public Health Nutr. 18, 2488–2497.

McGowan, L., Croker, H., Wardle, J., Cooke, L.J., 2012. Environmental and individual determinants of core and non-core food and drink intake in preschool-aged children in the United Kingdom. Eur. J. Clin. Nutr. 66, 322–328.

Micha, R., Michas, G., Mozaffarian, D., 2012. Unprocessed red and processed meats and risk of coronary artery disease and type 2 diabetes–an updated review of the evidence. Curr. Atheroscler. Rep. 14, 515–524.

Monsivais, P., Mclain, J., Drewnowski, A., 2010. The rising disparity in the price of healthful foods: 2004–2008. Food Policy 35, 514–520.

Monteiro, C.A., Levy, R.B., Claro, R.M., de Castro, I.R.R., Cannon, G., 2011. Increasing consumption of ultra-processed foods and likely impact on human health: evidence from Brazil. Public Health Nutr. 14, 5–13.

Monteiro, C.A., Moubarac, J.C., Cannon, G., Ng, S.W., Popkin, B., 2013. Ultra-processed products are becoming dominant in the global food system. Obes. Rev. 14, 21–28.

Monteiro, C.A., Cannon, G., Moubarac, J.-C., Martins, A.P.B., Martins, C.A., Garzillo, J., ... Jaime, P.C., 2015. Dietary guidelines to nourish humanity and the planet in the twenty-first century. A blueprint from Brazil. Public Health Nutr. 18, 2311–2322.

Moodie, R., Stuckler, D., Monteiro, C., Sheron, N., Neal, B., Thamarangsi, T., ... Casswell, S., 2013. Profits and pandemics: prevention of harmful effects of tobacco, alcohol, and ultra-processed food and drink industries. Lancet 381, 670–679.

Nemecek, T., Jungbluth, N., Canals, L.M., Schenck, R., 2016. Environmental impacts of food consumption and nutrition: where are we and what is next? Int. J. Life Cycle Assess. http://dx.doi.org/10.1007/s11367-016-1071-3.

NHMRC, 2005. Nutrient Reference Values for Australia and New Zealand: Including Recommended Dietary Intakes. Commonwealth of Australia, Canberra (Available from: https://www.nrv.gov.au/).

NHMRC, 2013. Australian Dietary Guidelines. Australian National Health and Medical Research Council (NHMRC). Canberra, Commonwealth of Australia.

NHMRC, 2015. Obesity and Overweight. National Health and Medical Research Council (NHMRC) ([online] Available at: https://www.nhmrc.gov.au/health-topics/obesity-and-overweight [Accessed 27 Feb. 2015]).

Odegard, I., van der Voet, E., 2014. The future of food—scenarios and the effect on natural resource use in agriculture in 2050. Ecol. Econ. 97, 51–59.

Pan, A., Sun, Q., Bernstein, A.M., et al., 2012. Red meat consumption and mortality: results from 2 prospective cohort studies. Arch. Intern. Med. 172, 555–563.

Pearson, D., Friel, S., Lawrence, M., 2014. Building environmentally sustainable food systems on informed citizen choices: evidence from Australia. Biol. Agric. Hortic. 30, 183–197.

Pimentel, D., Williamson, S., Alexander, C., Gonzalez-Pagan, O., Kontak, C., Mulkey, S., 2008. Reducing energy inputs in the US food system. Hum. Ecol. 36, 459–471.

Popkin, B.M., Adair, L.S., Ng, S.W., 2012. Global nutrition transition and the pandemic of obesity in developing countries. Nutr. Rev. 70, 3–21.

Pradhan, P., Reusser, D.E., Kropp, J.P., 2013. Embodied greenhouse gas emissions in diets. PLoS One 8, e62228.

Pretty, J., Brett, C., Gee, D., Hine, R., Mason, C., Morison, J., ... Dobbs, T., 2001. Policy challenges and priorities for internalizing the externalities of modern agriculture. J. Environ. Plan. Manag. 44, 263–283.

Pretty, J., Barton, J., Pervez Bharucha, Z., Bragg, R., Pencheon, D., Wood, C., Depledge, M.H., 2015. Improving health and well-being independently of GDP: dividends of greener and prosocial economies. Int. J. Environ. Health Res. http://dx.doi.org/10.1080/09603123.2015.1007841.

Reynolds, C.J., Piantadosi, J., Buckley, J.D., Weinstein, P., Boland, J., 2015. Evaluation of the environmental impact of weekly food consumption in different socio-economic households in Australia using environmentally extended input–output analysis. Ecol. Econ. 111, 58–64.

Röös, E., Karlsson, H., Witthöft, C., Sundberg, C., 2015. Evaluating the sustainability of diets–combining environmental and nutritional aspects. Environ. Sci. Pol. 47, 157–166.

Sage, C., 2012. Environment and Food. Routledge, Abingdon.

Sanne, C., 2002. Willing consumers—or locked-in? Policies for a sustainable consumption. Ecol. Econ. 42, 273–287.

Schröder, M., 2013. Chapter 16 - food system sustainability and the consumer. In: Webb, M.R.K. (Ed.), Food Industry Wastes. Academic Press, San Diego, pp. 281–293.

Serra-Majem, L., Ribas, L., Ngo, J., Ortega, R.M., García, A., Pérez-Rodrigo, C., Aranceta, J., 2004. Food, youth and the Mediterranean diet in Spain. Development of KIDMED, Mediterranean diet quality index in children and adolescents. Public Health Nutr. 7, 931–935.

Springmann, M., Godfray, H.C.J., Rayner, M., Scarborough, P., 2016. Analysis and valuation of the health and climate change cobenefits of dietary change. Proc. Natl. Acad. Sci. 113, 4146–4151.

Stanton, R.A., 2015. Food retailers and obesity. Curr. Obes. Rep. 4, 54–59.

Swedish National Food Agency, 2015. Find your way to eat greener, not too much and be active. Swedish National Food Agency, Uppsala p. Available from http://www.livsmedelsverket.se/en/ Accessed 14 June 2015.

Temple, N.J., Steyn, N.P., 2011. The cost of a healthy diet: a South African perspective. Nutrition 27, 505–508.

Thorpe, M., Milte, C., Crawford, D., McNaughton, S., 2016. A revised Australian dietary guideline index and its association with key sociodemographic factors, health behaviors and body mass index in peri-retirement aged adults. Nutrients 8, 160.

Tilman, D., Clark, M., 2014. Global diets link environmental sustainability and human health. Nature 515, 518–522.

Tubiello, F.N., Salvatore, M., Rossi, S., Ferrara, A., Fitton, N., Smith, P., 2013. The FAOSTAT database of greenhouse gas emissions from agriculture. Environ. Res. Lett. 8, 015009.

Tukker, A., Goldbohm, R.A., De Koning, A., Verheijden, M., Kleijn, R., Wolf, O., ... Rueda-Cantuche, J.M., 2011. Environmental impacts of changes to healthier diets in Europe. Ecol. Econ. 70, 1776–1788.

Victor, P.A., 2008. Managing Without Growth: Slower by Design, not Disaster. Edward Elgar Publishing, Cheltenham, UK.

Vieux, F., Darmon, N., Touazi, D., Soler, L., 2012. Greenhouse gas emissions of self-selected individual diets in France: changing the diet structure or consuming less? Ecol. Econ. 75, 91–101.

Wackernagel, M., Rees, W., 1998. Our Ecological Footprint: Reducing Human Impact on the Earth. New Society Publishers.

Wackernagel, M., Onisto, L., Bello, P., Callejas Linares, A., Susana López Falfán, I., Méndez García, J., ... Guadalupe Suárez Guerrero, M., 1999. National natural capital accounting with the ecological footprint concept. Ecol. Econ. 29, 375–390.

Wang, Y.C., McPherson, K., Marsh, T., Gortmaker, S.L., Brown, M., 2011. Health and economic burden of the projected obesity trends in the USA and the UK. Lancet 378, 815–825.

Watson, W.L., Kury, A., Wellard, L., Hughes, C., Dunford, E., Chapman, K., 2016. Variations in serving sizes of Australian snack foods and confectionery. Appetite 96, 32–37.

Welch, N., McNaughton, S.A., Hunter, W., Hume, C., Crawford, D., 2009. Is the perception of time pressure a barrier to healthy eating and physical activity among women? Public Health Nutr. 12, 888–895.

Westhoek, H., Lesschen, J.P., Rood, T., Wagner, S., De Marco, A., Murphy-Bokern, D., ... Oenema, O., 2014. Food choices, health and environment: effects of cutting Europe's meat and dairy intake. Glob. Environ. Chang. 26, 196–205.

White, T., 2000. Diet and the distribution of environmental impact. Ecol. Econ. 34, 145–153.

Wilson, N., Nghiem, N., Ni Mhurchu, C., Eyles, H., Baker, M.G., Blakely, T., 2013. Foods and dietary patterns that are healthy, low-cost, and environmentally sustainable: a case study of optimization modeling for New Zealand. PLoS One 8, e59648.