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Climate Change Adaptation at the Intersection of Food and Health

Ferne Edwards, BA(Hons), MSocSci[1], Jane Dixon, MSW, PhD[1], Sharon Friel, MSc, PhD[1], Gillian Hall, MBBS, PhD[1], Kirsten Larsen, BEng/BA, MSc[2], Stewart Lockie, BAppSc(Hons), PhD[1], Beverley Wood, Regd PHNutr APD, PhD[3], Mark Lawrence, MSc, PhD[4], Ivan Hanigan, BA(Hons)[1], Anthony Hogan, MSc(Hons), PhD[1], and Libby Hattersley, BSc, MIPH[1]

Abstract

Nutritious, safe, affordable, and enjoyable food is a fundamental prerequisite for health. As a nation, Australia is currently classified as food secure with the domestic production exceeding domestic consumption of most major food groups. The domestic system is almost self-sufficient in terms of nutritious plant foods, although these foods have seen steady higher price increases relative to other foods, with nutrition equity implications. However, the viability of Australia's food security sits counter to the continued presence of a stable and supportive climate. This article reviews the current state of science concerning the interface between climate change, food systems, and human health to reveal the key issues that must be addressed if Australia is to advance human health and sustainable food systems under a changing climate.

Keywords

climate change adaptation, food security, human health

[1]The Australian National University, Canberra, ACT, Australia
[2]The University of Melbourne, Melbourne, Victoria, Australia
[3]Consultant, Melbourne, Australia.
[4]Deakin University, Burwood, Victoria, Australia

Corresponding Author:
Ferne Edwards, National Centre for Epidemiology and Population Health, ANU College of Medicine, Biology and Environment, The Australian National University, Canberra ACT 0200 Australia
Email: ferne.edwards@anu.edu.au

Introduction

Evidence is accumulating on the current and expected impacts of climate change on food system sustainability[1-5] and on human health.[6-8] This article brings together the evidence on these 2 distinct lines of enquiry, within a context of Australian government support for climate adaptation initiatives.

Domestic and global food systems depend on the continued presence of a stable, supportive biophysical environment[9] and a global trade in food commodities,[10] both of which are now threatened by climate change. Ericksen[9] highlights that to attain a sustainable and secure food system, climate change needs to be considered across the entire food chain, while also taking into account multiple scales (global, national, and local), levels (temporal, institutional, and management), and time periods (short- and long-term implications).

Climate change affects human health via the food system through the direct pathways of fluctuating temperature, rainfall, and humidity, and severe weather events, such as heat waves, floods, droughts, and storms. These climatic factors influence plant and animal health and hence, the quantity and quality of food yield, while possibly increasing foodborne disease. Indirect pathways from climate include changes to ecosystem function and quality, such as increased levels of air and water pollution, soil and nutrient degradation, with repercussions for food yields and nutritional standards.[2,5] To ensure human health, it is essential to recognize the critical connections and feedback loops existing both within and between the food system, climate, and society.[6,11]

The focus for this article is climate change adaptation, defined as the modification of current policies and practice to cope with the unavoidable impacts of climate change.[12] Climate change mitigation, on the other hand, represents actions that reduce the conditions and root causes of climate change. The first step to adaptation is to increase resilience and reduce vulnerability, by incorporating diversity and flexibility within systems. Adaptation also stands to provide co-benefits or opportunities for mitigation,[13] and we note in reference to consumers changing their food behaviors that adaptation and mitigation operate along a continuum. The identification of potential co-benefits for both climate and population health by transforming food systems is the subject of a growing literature.[14-16]

This article discusses how climate change is affecting the Australian food system and the related health effects. It also explores possible, near-term scenarios resulting from unaddressed, prolonged and more extreme, climate change impacts. Such conditions are likely to exacerbate current food system and health issues, while introducing new concerns. The article concludes by illustrating some preliminary sectoral responses to these issues in Australia and notes the implications for climate change governance.

Trends and Dynamics in Australia's Food System

In the past decade, there have been significant changes in the makeup of Australia's food supply, with implications for reliable availability, accessibility, and affordability of nutritious food. Australia's substantial food trade surplus decreased slightly with imports doubling to around $9 billion in 2007-2008. Dominant contributors to the import increase were processed foods, particularly flour mill and cereal food, wine, dairy products, beverages, fruit and vegetables, and "other" processed foods (not elsewhere classified). Reduced grain and dairy exports explained most of the decline in exports; with smaller contributions from fresh/chilled fish, live animals, and fresh/chilled horticultural produce. The decline in exports was largely as a result of climatic factors and fluctuating demand in key export markets such as Asia.[17,18]

Domestic production of most major food groups equals or exceeds domestic consumption. This production/consumption balance remained largely unchanged between 1997-1999 and 2001-2003 (Table 1). Specifically,

- production of cereals, sweeteners, pulses, meat, milk, and animal fats exceeded domestic consumption;
- production of starchy root vegetables, vegetables, fruit and eggs equaled, or nearly equaled, domestic consumption; and
- production of seafood and vegetable oils did not meet domestic consumption.[17,18]

Evidence of Climate Change Impacts on the Food System and Health

Australian agriculture is characterized by a history of adverse and variable weather conditions, as indicated by trends in rainfall over the Murray–Darling Basin: the nation's "bread bowl" and foremost fruit and vegetable growing region. Figure 1 shows that the annual trend over the first half of the 20th century was lower than the past 50 years, by about 50 millimeters on average or 1½ month's annual rainfall. The 1930-1946 period was particularly dry, as has been the 1998-2008 period.

The most recent drought in the Murray–Darling Basin coincided with record high temperatures in southern Australia.[19] Australian agriculture has changed appreciably since the "dry" early decades of the past century: most notably through the intensification of water-thirsty agriculture (lettuce, dairy, rice, and viticulture). Within a context of water cap and trade regulations for farming and commodity groups, which are more vulnerable to prolonged drying, the adaptation challenge for these farmers is at least more constrained than in the past.

A recent sign of farming being adversely impacted by seasonal conditions is demonstrated by 84% of Australian agricultural businesses reporting that they had experienced droughts, severe frosts, hail, severe storms, floods, or an increase in seasonal variability during the 2007-2008 season. Almost one third reported using financial reserves and/or taking on increasing liabilities in response to adverse seasonal conditions.[20]

Climate Change and Food Production

Food yields are being affected by adverse seasonal conditions.[1,2,17,21-27] Nearly all food products are considered vulnerable, albeit in varying degrees because of their exposure, sensitivity and capacity to adapt to changing biophysical conditions.[22] Foods that are particularly vulnerable are water intensive, heat-, climatic extreme–, or water pollution–sensitive, such as fresh fruit and vegetables, intensively reared livestock, and seafood. This vulnerability was illustrated during the 2009 Victorian heat wave, which resulted in production losses of 50% to 90% of raspberry, blackberry, and blueberry crops; 20% to 25% of orchard crops (apples and late season apricots); and 60% to 80% of strawberries in the Port Phillip region.[23] Australia, normally one of the world's largest grain exporters, has experienced 2 years (2001-2002 and 2007-2008) of net grain importing because of severe drought.[24] Each of these climate affected food sectors is required to maintain a healthy diet, although some high-consuming Australians could, in the interests of health and the environment, reduce their ruminant livestock food consumption.[25]

Climate Change Effects on Food Processing and Distribution

Processing activities are also suffering from climate change because of variable availability and quality of raw produce. Two vulnerabilities affecting distribution channels are those that are responsible for transporting food from production-processing sites to retailers, such as extreme weather events and sudden disruptions that physically prevent the movement of food or cause it to spoil or be wasted, and the system structure itself whose capacity may fail to adequately respond to the changed climatic and market conditions to the extent that reliable supply chains

Table 1. Food Balance Sheets: Supply and Consumption of Major Food Groups in Australia[a]

Food Group (Average of Years Given)	Domestic Production (kt)	Imports (kt)	Exports (kt)	Domestic Consumption (kt)	Production as Percentage of Consumption
Cereals					
1997-1999	32 478	133	22 794	9716	334
2001-2003	31 893	340	17 651	11 253	283
Starchy roots					
1997-1999	1334	84	43	1376	97
2001-2003	1300	95	64	1334	97
Sweeteners					
1997-1999	5699	43	4364	1091	522
2001-2003	4979	102	3357	1579	315
Pulses					
1997-1999	2574	12	1082	1523	169
2001-2003	2013	11	2084	390	516
Vegetables					
1997-1999	1790	189	247	1740	103
2001-2003	1969	274	236	2003	98
Fruits					
1997-1999	2786	270	476	2595	107
2001-2003	3456	478	533	3401	102
Meat					
1997-1999	3469	25	1508	1986	175
2001-2003	3847	57	1637	2266	170
Eggs					
1997-1999	145	1	1	145	100
2001-2003	144	2	1	145	99
Seafood					
1997-1999	214	402	131	486	44
2001-2003	236	501	203	534	44
Milk					
1997-1999	9842	365	5528	4759	207
2001-2003	11 045	496	5813	5545	199
Vegetable oils					
1997-1999	351	213	111	449	78
2001-2003	234	270	119	412	57
Animal fats					
1997-1999	725	20	585	160	453
2001-2003	768	40	572	215	357

[a]Data from Australian Food Statistics (2002 and 2007 editions).[17,18]

are no longer viable.[26] Products such as rice may only be available in wetter years and processing mills may not be viable with variable supplies.[27] The costs of "doing business" are already increasing under fluctuating weather conditions as experienced by rising prices for water, energy and transport, requiring higher investments in logistics systems to ensure standards of hygiene and temperature control to minimize spoilage and waste.[4,19]

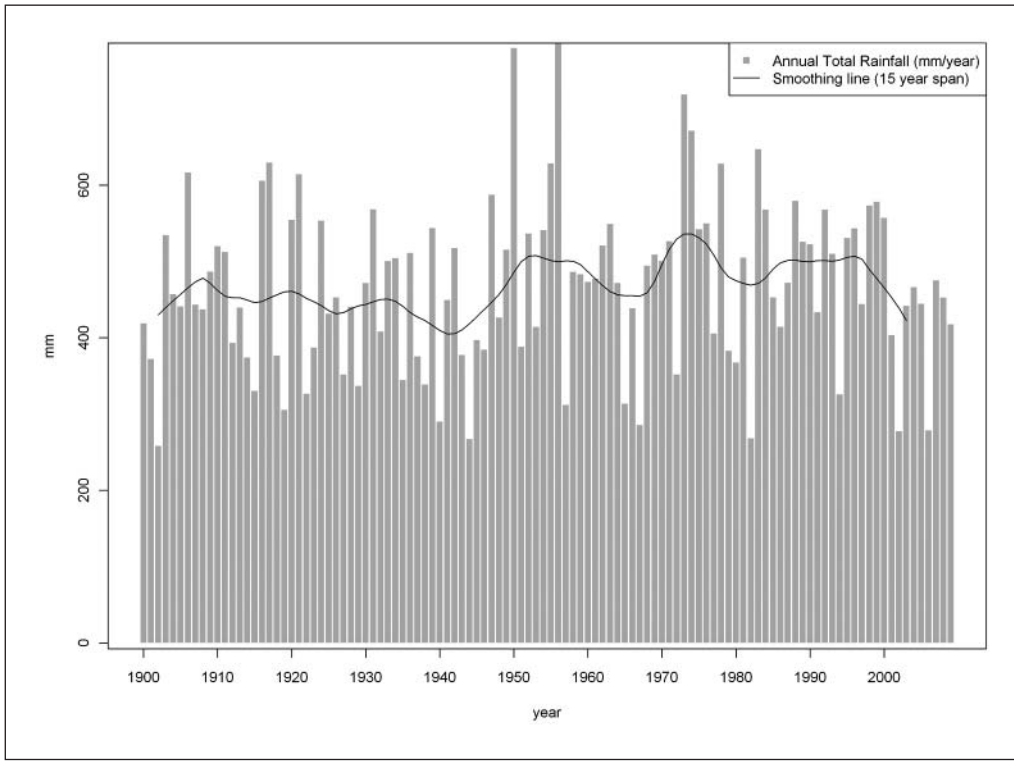

Figure 1. Murray–Darling Basin annual rainfall: 1900-2009
Source: Bureau of Meteorology. http://www.bom.gov.au/web01/ncc/www/cli_chg/timeseries/rain/0112/mdb/latest.txt.

The Impact of Climate Change on Food Price

A range of global and domestic influences has led to rising food prices in recent years affecting food manufacturing input costs and output prices. Key drivers include higher energy and other input costs, adverse climatic influences undermining agricultural production, and growing demand for food in developing nations. Although raw agricultural commodities have generally increased in price, they often represent only a small proportion of the costs of meeting first-world consumer needs for affordable, tasty, convenient, and safely processed foods year-round. As yet, there is no comprehensive assessment of climate change impacts on Australian food prices. However, modeling exercises based on the current Australian drought provide some indication that the cost of fruit and vegetables has increased more than the consumer price index, whereas highly processed foods have fallen.[28] Another report[29] indicates that drought alone is responsible for increasing prices across all food groups by 12% between 2005 and 2007, whereas vegetables showed the most pronounced increase in the consumer price index. Sheales and Gunning-Trant[30] explain recent fruit and vegetable price volatility as the result of "seasonal factors."

Climate Change Impacts on Food Consumption and Health

Climate change–related disruptions in food production, processing, and distribution will increasingly result in reduced food availability, affordability, and accessibility. Such disruptions can, in

turn, influence dietary practices, food intake, and nutritional status, with implications for food security and a range of diet-related health outcomes.[31] Moreover, climate change places additional stress on existing social system inadequacies including income and employment.[6]

Numerous factors—such as sufficient money for food; access to retail outlets that offer desirable, affordable commodities; the possession of adequate food storage and cooking facilities; access to culinary practices appropriate to one's cultural identity; and having the personal skills, knowledge, and time to prepare nutritionally balanced meals—all influence the social distribution of food, nutrition security, and chronic disease risk.[32,33]

Like other risk factors for chronic diseases, food insecurity is most prevalent among socially disadvantaged groups. Energy-dense, highly processed foods, with their hidden salts, sugars, and fats, are major contributors to dietary imbalances that result in diet-related disease.[34] Australian evidence suggests a strong link between poverty, food insecurity, and obesity in developed countries—the risk of obesity is 20% to 40% higher for women who are food insecure.[35] In Australia, the cost of a diet adhering to the national health guidelines consumes about 40% of the disposable income of welfare-dependent families, compared with 20% for an average income household.[31] Climate change–related food price increases will hit the poorer households hardest. Indigenous and non-Indigenous rural and remote Australians often source their food from the community store, where available food is expensive relative to the national average and to the incomes of community members**.** Transporting food to remote regions also increases prices while reducing fresh food availability, and possibly, nutritional standards.

Nutrition Quality and Foodborne Disease

In terms of nutrition, degraded soils and lack of water may reduce the quality of produce, particularly affecting perishable, fresh foods. These foods contain micronutrients, which with insufficient consumption lead to acute deficiencies of vitamin C, folate, and other B vitamins, with significant negative health impacts for pregnant women.[36] In relation to the macronutrient composition of certain foods, it is reported that increasing atmospheric carbon dioxide levels could reduce crop protein content by 20% as plants lose the ability to absorb nitrate from agricultural soils.[37]

Climate change also increases the incidence of foodborne diseases. The most common foodborne disease in Australia is infectious gastroenteritis, which is caused by different pathogens. About one third of all gastroenteritis cases in Australia is caused by food, numbering a total of about 5 million cases each year. Deaths are rare but can occur in the elderly and the immunocompromised.[38]

Pathogens can enter the food system at any point between paddock and plate. Some pathogens then replicate in food, especially under warm conditions. At the primary production stage pathogens may appear because of use of manure, irrigation, or runoff. For seafood, changes in sea temperature can affect plankton and algae growth and consequently cause the growth of microorganisms such as *Vibrio cholerae*.[39] Natural toxins are already found in fish in warmer, northern parts of Australia, including the ciguatoxins and histamines, and this reach is likely to extend southward with climate change.[40] As the climate warms and as weather patterns become more erratic, liver cancer through aflatoxin contamination[41] may become an increasing problem. These fungal metabolites contaminate cereals and pulses, with dry, hot conditions increasing risk of contamination during crop growth, whereas the harvesting and storage of mature crops are at risk of contamination during wet conditions.[42] Industrial chemical contaminants of food can also be a human health issue because of increased use of pesticides required as plant and animal diseases change in response to changed climate.[43-46] Fertilizers are also likely to be increasingly used as

soil nutrients are depleted in part through overgrazing, and also through soil loss because of hot winds and torrential rains.[44]

Possible Future Scenarios

The future possibility of a significant change in, or lack of, a consistent Australian based food supply is endorsed by Sheales and Gunning-Trant,[30] who forecast falls between 2006 and 2050 in wheat (up to 13%), sheep, beef, dairy (up to >18%) and sugar, if no planned mitigation or adaptation measures are put in place. Other examples of food sources that could significantly be affected include seafood, with studies[45-47] predicting that the next 50 years will see coral reefs and mangroves—the major fish breeding grounds—altering rapidly.

Producers whose agricultural systems depend on the kind of rainfall they have been getting since 1946 will experience enormous adjustment pressures if the dry conditions of the 1930s and 1940s return (Figure 1). One response to declining productivity is to relocate production and processing sites to more suitable growing areas. It is important to remember that such investment and reinvestment is a feature of Australia's agricultural system. During the relative moistness of the late 1860s and 1870s, farmers went north of Goyder's Line in South Australia, only to find the dryness return in the 1880s, forcing them back south again. However, with modern agricultural systems being more heavily reliant on fossil fuels than in the past, the prospect of peak oil poses future constraints on agricultural production.[48] In other countries, water privatization is driving up the cost of water with implications for food security.[49]

Disruptions to distribution systems because of flooding in Queensland and northern New South Wales and South Australia over the 2009-2010 summer prevented citizens from accessing food for up to a week.[50] As Australia's 2 largest supermarket chains hold only a few weeks' food supplies at any one time, there is little margin in the event of a disaster.[51,52] All Australians are affected during severe weather events, although it is the lower income households who are less likely to have stockpiles of food or be easily able to restock. These are households who are presently unable to afford a healthy diet.[31]

In the short term, consumers may respond to a changed climate in a range of ways. In a context of price rises associated with climate pressures on food yields, and as a consequence of spending more on energy consuming climate adaptive services (such as household cooling and the use of air-conditioned motor cars), people on low incomes may shift consumer purchasing toward produce that has a lower cost per calorie. These are likely to be foods that are high in fats, salts, and sugars thus exacerbating health risks. A move away from home prepared foods in favor of meals prepared by the food services sector, may also take place in the interests of saving money, using less energy and water in food preparation. Householders may also choose to save water by not having vegetable gardens, although there is evidence that those who grow their own are more likely to consume more fruit and vegetables.[53] Each response poses greater dependence on market availability, with implications for nutrition equity.

There are other potential early responses to increasing temperatures, storms, and other "wild weather" events that may not be healthy. For example, shopping routines may change favoring one-stop shopping at major supermarkets, Internet shopping, or more home delivery of pizzas and other fast foods.[54] Any motor vehicle–dependent shopping option—that is those involving consumers' cars, and supermarket and fast food chain delivery vans—reduces opportunities for incidental physical activity. These food procurement decisions will affect people's health differently according to their gender, age, lifestyle, and for those with special needs, for example, people who are ill, migrants, or elderly.

However, there are also more healthy plausible responses. Where there is enough land and rainfall, householders may return to, or start to, grow their own foods, either individually or as

part of community schemes. Environmentally friendly foods—those that emit fewer greenhouse gases, and/or require less water, industrial feed, and fertilizers—may become popular; for example, kangaroo, poultry, and pigs, which feed on organic waste and forage, and vegetarian farmed fish.[22,55] Likewise, locally produced food may be further advocated as a way to reduce oil dependency and promote greater sustainability.[3,56]

In relation to climate change and food safety concerns, a number of business decisions are also conceivable. Moving to new locations may compromise safety during storage and transport, especially if refrigeration is less available or fails due to overload of the electricity grid. Some growers may choose to store products if the supply chain is disrupted, leading to loss of product quality, shelf life, and possible spoilage. More chemicals may be used to counter changed plant and animal diseases, or alternatively, increased prices of chemicals may inhibit their use, instead encouraging the application of organic inputs. In addition, a shift to acquiring food from offshore locations may introduce subsequent health risks because of less stringent food regulations and monitoring in other countries. Shortage of fertile land could lead to planting on toxic soils, increasing the risk of people eating food of lesser quality that may be contaminated. Gready et al, in this issue, identify the current and foreseeable problems with water quality, posing additional risks to food safety. All these circumstances necessitate stringent and comprehensive measures to ensure food safety in times of climate change. These tentative scenarios highlight the variety and degree of interconnectedness and complexity of feedback loops between climate change, the global and Australian food systems and health. Understanding the interrelationships between producer and consumer behaviors and structural reform drivers is critical if Australia is to foster a sustainable and healthy food system.

Sectoral Responses to Climate Change

In general, Australian responses for addressing food-related health adaptations to climate change are in their infancy and are uncoordinated. At the national government level, there are federal programs concerning climate change in general (the Department of Climate Change and Energy Efficiency and the National Climate Change Adaptation Research Facility), and agricultural issues more specifically (such as Australia's Farming Futures program, the Water for the Future program, and various CSIRO initiatives). Regarding health and food specifically, the Australian Dietary Guidelines are currently being revised with the new version expected to reflect dietary recommendations that are based on principles of not just nutrition but also of environmental sustainability and social equity. The Victorian government's Sustainability Fund established the Victorian Eco-Innovations Lab in 2007, in part to advise the government on sustainable food systems.[3] In 1999, the South Australian Food and Health Policy[57] recognized that "a high quality food supply is dependent on ecologically sustainable agricultural practices . . . The quality and variety of food produced has an impact on the health of the population."

At the same time, public health coalitions and cross-sectoral coalitions have released visions for a national food and nutrition policy with a focus on sustainability and health at its center.[57-59] Nongovernment agencies, most notably the Australian Conservation Foundation and Doctors for the Environment, have sponsored research into climate change and sustainable food systems.[2,60,61] Local government, particularly in Victoria, is beginning to show interest in municipal planning for community food security.[62] The National Heart Foundation is currently supporting a food sensitive urban planning and design initiative, which will include reference to the impacts of climate change.[63]

Food and beverage processing is Australia's largest manufacturing sector.[64] Industry has responded to climate change impacts in the food area by advocating for genetically modified and

functional (nutritionally enhanced) foods, and the application of nanotechnology, which can embed both natural and manmade materials with characteristics to adapt to climate change conditions.[65,66] The resulting products are presently expensive and rely on consumer acceptance if they are to address nutritional deficiencies,[65] although their contribution to environmental toxicity is yet to be determined.[61] Fundamentally, a reliance on highly industrial foods does not tackle the underlying structural problems or nutritional equity of the current food system.[15]

Improvements in transport, processing, and preservation technologies now enable food retailers to source a growing range of products from large global suppliers. At the same time, supermarkets are positioning themselves as industry leaders in social and environmental sustainability through corporate social responsibility policies, triple bottom line reporting and ethical traceability schemes.[67] Supermarkets are among the earliest adopters of the novel global audit, the Hazard Analysis Critical Control Point measures, intended to monitor the management of food safety hazards along commodity chains.

Farmers are on the frontline of climate change. According to Kurukulasuriya and Rosenthal (2003, cited in Heyhoe et al[68]), agriculture's track record of adaptation to climatic variability allows a measure of confidence that continued adaptation is possible. Furthermore, there is political support for climate risk management as part of usual business practice with government programs promoting farmers' capacity to manage risks.[69] Existing farm-level practices and technologies are already available that suit low-end adaptation purposes. The options include changes to the timing or location of cropping activities, shifting to varieties or species with increased heat and drought tolerance, water harvesting and conservation, integrated pest management, and enterprise diversification and climate forecasting.[70] Stokes et al[71] suggest these adaptation practices work best under low to moderate warming conditions (<2°C), and are likely to be less effective under greater temperature rise. Given that climate change related challenges are likely to intensify over time, questions are raised regarding how much variability can be accommodated using existing farm management strategies and technologies. More profound structural adjustment or technological change may well be required.

Finally, grassroots community responses have begun to emerge in urban areas, with householders and communities establishing new forms of production and distribution[72] (also F. Edwards, unpublished data, 2010). Although seemingly meagre set against the sheer scale of the formal economy, these pockets of change reveal patterns of community understanding and concern, ideas and innovation that have potential to grow (F. Edwards, unpublished data, 2010). Domestic and community food gardens also underscore the bidirectional nature of climate change at the intersection of food systems and health: Not only is climate change a threat to the viability of food systems with implications for human health, but the threat of climate change is leading citizens to change their food procurement behaviours which in turn may contribute to mitigating greenhouse gas emissions.

The Limits to Adaptation

Climate change poses risks to many things of importance to people, including their health, employment, families, communities, and food preferences. For adaptation to be effective, individuals' and communities' diverse goals, needs, values, cultures, capacities, and institutions, need to be understood and aligned to enable or constrain responses. However, there are biophysical, economic, social, health, and governance limits to adaptation.[13]

Water shortages are probably the key biophysical limiting factor for Australia, as exemplified by the near collapse of the Murray–Darling Rivers system to the detriment of the dairy and horticulture industries reliant on it for irrigation.[73] With state governments asserting their rights over

the river system to supply urban households with drinking water, there is likely to be a high level of disputation between jurisdictions and between alternative land uses.[74]

Farmers have to be in good health themselves to practice adaptive strategies.[75] In a recent analysis, women and young farmers were the farmers more likely to report poor health, isolation from support and social systems, and low social capital. These factors combine to create reduced capacity to adjust to climate change pressures.[71]

Adapting to climate change will also be costly. Current assessments are likely to substantially underestimate costs because of overlooking some sectors, only partially covering others, and because of unforeseen costs from maladaptation.[76] If agricultural systems do not adapt in time or to an appropriate extent, the costs of production will increase, competing against other business opportunities,[77] and placing greater reliance on overseas sources of food—many of which are also affected by climate change.

Good governance is essential if an effective and equitable approach to adaptation is to be realized. For example, UK research shows that consumer capacity to respond to climate change is limited without industry and government support.[78] As Hatfield-Dodds et al[13] recognize, regardless of the risks, places, and groups involved, adaptation is at its core a social issue.

The *Social, Economic and Institutional Dimensions* National Climate Change Adaptation Research Proposal Discussion Paper encourages the implementation of both adaptation and mitigation plans because "if no efforts were made to address climate change through mitigation actions, then eventually the impacts of climate change would become so great that adaptation would be impossible." In one of his addresses to the United Nations, Ban Ki Moon noted that food security is climate security, and hence it is critical that climate change mitigation becomes a central component of food and health policy. Effective mitigation will save Australia money, time, health, energy, resources, sociopolitical stress, and prevent the loss of unique natural resources. A dual strategy requires federal government leadership nationally and internationally, with strong input from business, nongovernment sectors, and citizens.

Conclusion

Both climate trends and variability are affecting the food system—from production, processing, and distribution through to consumption. Particularly vulnerable foods include fresh fruit and vegetables, intensive livestock and dairy, and seafood. Potential health impacts include compromised nutritional status because of modified food availability and affordability and higher incidences of foodborne diseases. These issues particularly threaten the poor, Aboriginal people, and non-Indigenous Australians living in rural and remote regions.

The science and policy of climate change, food system, and health remains disconnected across a range of institutions and government portfolios. Competing economic, health, social, and environmental agendas for the development of the food system persist. This has the effect of muting the critical complexities that are essential for understanding and addressing the synergistic impacts of these interlinked systems that are essential when identifying coherent policy solutions.

Although the article's authors support more research, particularly to avoid maladaptive responses, we also agree that action must be taken immediately to avoid potentially catastrophic consequences for Australia's health and productivity. Thus, we support the immediate development of adaptation and mitigation plans that prioritize vulnerable food industries and populations to increase resilience, while trialing mid- to long-term transformational strategies to enhance the opportunity to secure a sustainable and healthy food system overall. With its unique natural resources, history, global position, and culture of innovation, Australia is in an excellent position

to become a leader in addressing climate change through advancing strategies that offer multiple health, environment, and social co-benefits and opportunities.

Authors' Note

The article represents a collaborative work bringing together expertise from leading researchers and policy makers in the fields of health and food from across Australia as part of a series being developed by the National Climate Change Adaptation Research Network for Human Health and builds on the recently published National Adaptation Research Plan on Health.[79] Those who have provided advice at various stages include Colin Butler, Ryan Wilson, and Andreas Lopata.

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