Socio-technical innovation for sustainable food chains: roles for social science

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The article discusses the evolution of the contemporary agri-food system, charting the increasing assertion of consumer concerns along the food chain and the resultant opposition to technology-driven models of food production. It sets out a case for closer integration between social and natural science research to reflect more effectively the complexity of contemporary food systems, and to respond to demands for technological options and the basic science behind them to be opened up to public scrutiny and social choice.

Introduction

The development of a sustainable agri-food system places responsibilities on both the natural *and* the social sciences. While advances in basic and strategic biological research have greatly expanded the potential to produce nutritious food in an efficient and environmentally sustainable manner, social and economic factors will determine the uptake and value of this research, as well as its future direction (OECD, 2004). At the same time, a succession of issues related to the growing complexity of globalised food chains – including farming crises, chronic health risks, food safety scares and resource and habitat depletion – evoke widespread mistrust of the science and technologies underpinning the food system which are often portrayed as out-of-touch with public concerns and driven by narrow disciplinary or commercial logics (Food Ethics Council, 2004). In reaction, there are increasing demands from policy makers, stakeholders and public interest groups for research to adopt more integrated perspectives in pursuit of more holistic solutions (Defra, 2003; Kates et al., 2001). Integrated perspectives are particularly called for to improve understanding of the mutual interaction between technological change and the economic, social and environmental contexts in which it occurs. The promise is held out for holistic solutions combining adaptations in socio-technical systems, rather than single-minded technological responses.

This paper[1] discusses how the increasing complexity of agri-food systems has enabled and evoked the assertion of consumer concerns along the food chain, leading in turn to escalating opposition to technology-driven models of food production. It argues that new forms of analysis are needed drawing upon understandings of social as well as biological processes and a closer integration between social and natural science research. Integration is necessary to reflect the complex socio-technical character of the challenges that arise in contemporary food systems and the innovations required to address them. By way of introduction to this special issue of *Trends in Food Science and Technology*, the paper highlights the potentially multi-faceted contribution of social science to agri-food system research. A case is made for 'upfront' engagement of social science research and analysis, alongside and integrated with R&D programmes in the natural and biological sciences.

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[1] Earlier versions of the paper were presented at the OECD Conference *Opportunities and Challenges in Agri-food Research*, Rome, 18–20 May 2005; the XXIst Congress of the European Society for Rural Sociology, *A Common European Countryside? Change and Continuity, Diversity and Cohesion in the Enlarged Europe*, Keszthely, 22–27 August, 2005; and the Science Policy Research Unit's 40th Anniversary Conference, *The Future of Science, Technology and Innovation Policy*, University of Sussex, 11–13 September 2006.

Food chain complexity

Technological changes have allowed agri-food systems to become ever more complex. That increasing complexity is associated, at least in industrial societies, with a progressive shift during the past 30 years away from systems that were largely nationally-based, supply-oriented and state-regulated and supported. The sufficiency and regularity of food supplies have countered the concerns for food security that underpinned the characteristically simpler and more direct agri-food systems of the post-war years. The growth of disposable incomes and the rise of consumerism have meant that supply chains have had to become more demand oriented and food production more responsive to feedback signals from the market and from consumers who are now regarded as active agents in the food chain. The liberalisation of trade in food and agricultural products has weakened national regulation in favour of international trading regimes. Research and development are no longer so state dominated, nor so focussed on boosting primary commodity production rather than other stages in the food chain. At the same time, advances in biological technologies have opened up a multitude of new substitution possibilities and eroded the dependence of food production on specific geographical areas (Goodman, Sorj, & Wilkinson, 1987). Supply chains have become more extended and intersected as part of the process of globalisation. Supply chain intermediaries – multinational food suppliers, manufacturers and retailers, particularly global supermarket chains – have taken on a more prominent role between producers and consumers (Hingley, 2005; Morgan, Marsden, & Murdoch, 2006).

In trying to make sense of the food that he or she eats, the contemporary consumer thus faces the complexity of global agri-food systems that link together diverse people, places and processes through product flows and multiple intermediaries. Those systems, of course, open up a realm of choice (a typical large British supermarket, for example, carries 20,000 different food products) which is leading to rapidly changing and very diverse food habits. The variety of linkages and the scope for forging additional ones also opens up possibilities for alternative food networks and new solidarities (for example, between consumers with special dietary needs, direct marketing by speciality producers or Fair Trade schemes). Novel linkages, though, are disturbing in the way they seem to pose new threats or introduce additional sources of insecurity, ranging from Sudan Red to Pandemic Bird Flu. Many, therefore, find the complexity of agri-food systems bewildering. Above all, it is unclear who is in control. Whatever the specifics of national regulation and international regimes, various intermediaries are popularly perceived to be dominant whether they be 'agri-business', 'multinationals', 'the supermarkets' or simply 'Big Food' (Hingley, 2005). Despite the expanding array of choices, consumers themselves do not feel in control (Miles *et al.*, 2004; Ritson & Kuznesof, 2006). Indeed, concerns that global agri-food systems may be out of control have been aroused by high-profile food scares. Successive such events have undermined consumers' trust in the security of agri-food systems.

Extended and complex food systems are seen not only to have their own intrinsic vulnerability but also to expose consumers to distant and novel risks. Newly mandated approaches to minimise such risks, such as Hazard Analysis and Critical Control Points (HACCP) procedures, serve only to emphasise further the extensive linkages and critical interdependencies that constitute agri-food systems. Firms are required to scrutinise not only their internal processes but also their suppliers, for potential sources of risk, logically leading to demands for full traceability of food chains with all its 'farm-to-fork' rhetoric (Hobbs, 2006). Manufacturers and retailers, to limit their own liability and to safeguard their reputations, are thus impelled to pursue any potential vulnerabilities in a supply chain right back to its origins – a pursuit which may well cross countries and continents. The result is a spreading, extra-territorial 'private' regulation of food chains by downstream firms, accompanied by a proliferation of private standard setting and monitoring of suppliers, and the advent of such social technologies as supply chain management, risk assessment and logistics (Busch & Bain, 2004).

The movement towards a more complex, technology-led, globalised, privately regulated and demand-oriented food system is, however, proving to be far from smooth or uncontentious. It has met resistance from a panoply of social movements and interest groups including the anti-globalisation lobby, environmentalists, farmers, the health lobby, advocates of sustainable development, rural and countryside interests and food campaigners, as well as from consumers – on the grounds of manifold claimed impacts on the environment, health risks and social equity. Indeed, the food chain has become one of the primary sites of political resistance to globalisation (Coleman, Grant, & Josling, 2004). This resistance has been a core factor in the increasing assertion of consumer interests and concerns along the food chain. A primary area for concern has related to the consequences of the technology-driven nature of food production and its narrow scientific underpinning.

Opposition to a technology-driven model of food production

The conduct of science on agriculture and food in post-war decades and earlier was based primarily upon the concerted pursuit of technological solutions and production efficiencies. A key instrument of government policy was research and development targeted at boosting primary production. Chemical and engineering technologies were promoted, which enhanced labour productivity in agriculture, but increasingly the emphasis shifted

towards biological improvements, to enhance the productivity of the plants and animals themselves.

Challenges towards the wider ecological consequences of technological change in agriculture first emerged in the 1960s (Lowe, 1992). Concerns focussed initially on chemical pesticides, but widened in the 1970s and 1980s to cover the intensification of agricultural production and its consequences for farmland ecology, agricultural pollution and landscape change. In response, environmentalists have sought to regulate harmful technological changes and curtail production subsidies. To reinforce policy reforms and regulatory changes they have also sought to encourage consumers to buy 'environmentally friendly' products. This in turn has stimulated 'green' marketing and environmental quality assurance schemes. Through its efforts to reveal the complex ecological relations of food production, the environmental movement has thus activated debate over the wider sustainability of food systems, and has been a key force in linking up notions of environmentally-beneficial farming practices with socially-conscious consumption.

This confluence of environmental and ethical concerns up and down the food chain underpins consumer resistance to industrial agriculture expressed, for example, in the attention to food provenance (whether locally, regionally or developing country sourced) and so-called alternative foods (organic, welfare-friendly, GM-free – see, for example, Singer & Mason, 2006). Such consumer sensitivities support the proliferation of marketing schemes – 'organic', 'fair trade', 'freedom food', 'Protected Designation of Origin' etc. – that valorise particular production methods and circumstances and establish the basis for market differentiation and new niche markets for local producers and rural territories (Barnham, 2003; Ilbery & Maye, 2005; Murdoch & Miele, 1999; Raynolds, 2000). The setting of public and private standards regulating food production and supply has moved beyond traditional consumer safety preoccupations to embrace ethical and environmental concerns. More politicised responses assert a 'defensive localism' in food production and consumption, including the pursuit of food sovereignty as a counter to the globalisation of food systems, in order to protect small producers and low intensity farming (Via Campesina, 2003; Windfuhr & Jonsen, 2005; Winter, 2003).

Growing awareness of the environmental and social costs associated with the provenance and processes of food production is itself associated with broader changes in modern societies towards what social scientists term reflexive consumption, whereby people think of themselves as active, discerning consumers whose choices contribute to their sense of identity (Giddens, 1991). Indeed, the consumer focus of modern marketing epitomises the broader consumption orientation of contemporary society. The growth of affluence has led to a stress on personal development, and society too is re-oriented towards the values of individuality and self-expression. With the decline in the

defining power of old economic and political forms – associated with workplace, class and nation – self-identity forming has shifted to spheres where individuals have discretion and control. This leads to a growing personal focus on consumption and leisure activities and the cultural resources and goods that surround them. Increasingly, people consume not to fulfill their basic biological needs, but to express a sense of self and improve psychological well-being. Consumption choices take on considerable personal and social significance, while being strongly structured by marketing and retailing.

Food, for example, is accorded purpose and meaning beyond the basic nutritional function of eating (Bell & Valentine, 1997). What and how we eat are central to our sense of self, marking boundaries between social groups and geographic regions (Lupton, 1996). The greater range of choices available today contributes to processes of individualisation and fluidity in a person's sense of self. Reflexive consumption thereby reinforces quite different identities and behaviours in contemporary society, whether these are to do with hedonistic lifestyles, health and fitness preoccupations, cultural and ethical concerns or political and moral standpoints. As a consequence, there is ever growing demand for information about food and its provenance, a demand to which commercial marketing and the mass media have readily responded. Globalisation is as much about the mobility of information as it is of people and material. People thus intensely consume images and ideas as well as the basic nutritional content of food. This is captured by Atkinson's (1991) notion of food as 'a liminal substance', a substance that links humans and nature.

The pervasive worries and concerns of consumers about industrialised food systems reflect also a society characterised generally by a higher level of risk consciousness than in former times. It is argued that, partly as a result of individualisation, we have moved from 'industrial society' to 'risk society', typified by an increased recognition of the potentially negative effects of scientific and technological developments, the positive effects being increasingly taken for granted (Beck, 1992). People are more aware of risks confronting them, even ones that are distant in time (threats to future generations) or space (ones that reach beyond their locality). That may seem paradoxical but the globalisation of risk that arises from the sort of interdependence seen in global sourcing in the food chain has greatly heightened public perceptions and media attention. When food was largely sourced locally, shortcomings in its quality or supply were hardly of wider interest.

In recent years, high-profile agri-food controversies, including animal disease outbreaks and contamination scares, have thus aroused consumer concern about the safety of food and shaken public confidence in the science and technology of industrialised food systems. These large-scale scares have tended to arise from contamination of food chains at the primary level, and so have fuelled consumers'

concerns over the technological transformation of farming. For example, when asked about the food they eat UK consumers express most concern over the use of pesticides, antibiotics and hormones in food production (Fig. 1). Such worries about the safety of food are the motive for many of those who, in increasing numbers, are turning to organic food (Lockie, Lyons, Lawrence, & Mummery, 2002; Williams & Hammitt, 2001). Food controversies also reinforce public suspicions of the claims made for new technologies in the food chain. Technologies, such as GM and irradiation, have provoked considerable opposition (Gaskell, Bauer, Durant, & Allum, 1999; Grove-White, Macnaghten, Mayer, & Wynne, 1997). Agricultural biotechnology in particular has become a significant focus of contention, with broad disquiet over the possible health and wider ecological effects, but also misgivings over the threat of becoming dependent upon biotechnology corporations as well as doubts over the capacity of public authorities and the science community to understand popular concern and effectively regulate risks (Kloppenberg, 2004). Public concerns and consumer anxieties are thus influencing the markets for food products and the climate in which technological developments are now promoted and sanctioned.

In this way, public concerns over the implications of new technologies in the food chain have merged with and broadened debate on the sustainability of food production. Specific issues have been swept up into a wider preoccupation with the changing nature of the production process. That is a function of both changing perceptions of agri-food systems and emergent characteristics of those systems. What these concerns all have in common is opposition to a technology-driven model of food production (Goodman & Redclift, 1991). Implicit in the model is a sharp separation — physically, culturally, geographically — of production from consumption: with production processes subject to forces of accumulation, technological transformation and global competition; and consumption processes subject to personal choice and satisfaction, bolstered by rising incomes and backed up by national regulation of consumer welfare. In contrast, the various concerns all emphasise the connections between production and consumption and assert legitimate consumer and public interest not only in what food is produced but also how it is produced, stretching right back along the food chain — what has been called "reversed food chain thinking" (Wolf, 2002).

This is quite a profound inversion of the logic of the food chain. Most fundamentally, it undermines the artificial but potent divide between the supposedly technical (food production) and the supposedly social (food consumption). The breaking down of that distinction reveals the social relations of production as well as the technical relations of consumption, leading on the one hand to the growing interest in the provenance of food and on the other hand to increasing consumer concerns about the technical aspects of foods (e.g. transfats, vitamins, carbohydrates, additives, E-numbers, macrobiotics, nutraceuticals, antioxidants etc.). "Reversed food chain thinking" also focuses on 'demand-pull' as a driver of innovation in the food chain. It is evident, for example, that the food industry and the large retailers see in the growing consumer reflexivity
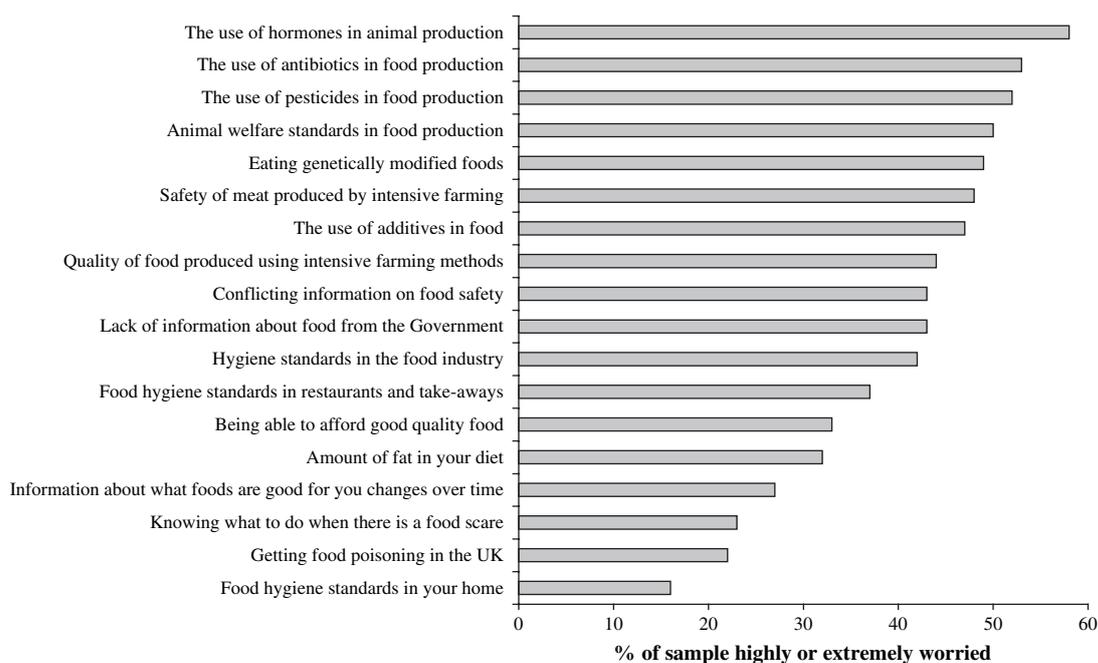

Fig. 1. Food safety concerns expressed by a UK sample (Miles et al., 2004).

increasing opportunities to segment the market, generate customer loyalty and add value through processes of product qualification. Opinion is divided as to whether that represents a cynical co-opting and deradicalisation of alternative food movements or a shift by the food sector towards a more open and consumer-focused innovation process (Du Gay, 2004; Friedberg, 2004; Gobé, 2001; Miele, 2006; Von Hippel, 2005). Undoubtedly, though, there are major implications for the way agri-food systems are regulated in terms of both locus (regional, national or international) and mode (markets, controls or voluntary). There are also implications for the type of research and knowledge needed to shape and inform the development of agri-food systems. Fundamentally, the divide between consumption as the realm of social science and production as the realm of technical science is challenged as not only artificial but also dangerously blinkered.

From 'end-of-pipe' to 'up front engagement' of social science

Many natural scientists and technologists working in agri-food R&D, and indeed many funders and users of technical research, acknowledge the need to understand better the social and economic parameters of their work (Defra, 2003; EU Advisory Board, 2004; OECD, 2004). However, drawing social scientists into natural science and technological research areas raises questions concerning the roles they might play within interdisciplinary collaborations. Traditionally, the role of social sciences under the technology-driven model of food production was cast as one of facilitating social acceptance of novel products or processes. Thus, while rural sociologists and agricultural economists focussed on understanding what characteristics of farmers facilitated or delayed the diffusion and adoption of novel technologies and production methods, consumer scientists and market researchers investigated what attributes of food and its marketing encouraged consumer acceptability. The rationale for this traditional use of social science was to induct the public into the merits of new technology-led food products in keeping with the so-called deficit model of food risk – i.e. the assumption that popular anxieties towards novel products stemmed from ignorance and unfamiliarity (De Boer, McCarthy, Brennan, Kelly, & Ritson, 2005).

Since the 1980s such an 'end-of-pipe' role for social science has been called into question (Buttel, Larson, & Gillespie, 1990; Clark & Lowe, 1992). Social scientists have taken a more detached stance, examining growing concerns over the social and environmental impacts of new technologies and investigating the interests lying behind the development of agricultural science and food and agricultural technologies. The traditional contribution of social science has been challenged for being subservient and instrumental, and displaying an uncritical view of technological change and its consequences.[2] In the words of the UK Commission on the Social Sciences (2003: p. 29):

> ''[The role of] social sciences as a 'back-end fix' to the problems arising from new scientific developments … can be parodied by 'we have invented this, now find a market for it' or 'we have invented this but it has a few unfortunate side effects. How do we get people to accept it?'''

The movement towards ''reversed food chain thinking'' radically inverts the relationships and seeks to entrench consumer demand as the impelling force in food systems, refocusing all elements of food production and distribution on the end-consumer as the ultimate object and arbiter of food chains. That would imply refocusing of research away from the dominant orientation on productivity and new food products towards questions such as consumer acceptability, food safety and health and the functionality of food (Wolf, 2002).

Recent calls for technological innovation to be opened up to public scrutiny and social choice introduce a need to reconsider the place of social science, re-engaging it in a more creative and strategic role inside the design of technological change:

> ''…technological change is often portrayed as an autonomous process deterministically driven by scientific advance and with social and environmental effects analytically separate from, rather than integral to, the process. The partitioning of scientific research in relation to technological change reproduces and reinforces this artificial separation with engineering and the physical sciences seen as sources of innovation, and social and environmental sciences as furnishing analyses of 'up-take' and 'impacts'. Clearly, this divide needs to be overcome if social and environmental factors are to be incorporated in the design, execution and regulation of agricultural and other technology.''
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> (Lowe, 1992: p. 8)

Specifically, the contemporary failings of agri-food systems pose three major demands for closer integration between social and technical perspectives in research and development. Firstly, research and innovation are required to be more closely attuned to the consumption-centered and socially constructed character of contemporary food chains (Wolf, 2002). Secondly, there is the need to avoid partial framings of, and provide integrated solutions for, problems that are both social and technical in character

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[2] Though we would broadly concur with this critique of the prevailing role of social science in technological change during this period, it should not be overplayed. Take, for example, the case of agricultural economists in the UK during the post-war period. At this time, they played a pivotal role in establishing the publicly managed farm economy that was so fundamental in framing the drivers of technological change in farm production.

(Klein, 2004; Lowe & Phillipson, 2006). The corollary is that effective innovation is likely to require coordinated socio-technical adaptations.[3] Finally, the need for an integrated perspective emerges from demands for technological options and the basic science behind them to be opened up to public scrutiny and social choice – for the technology-driven model of food production to be superseded by an emphasis on the social shaping of technology (Food Ethics Council, 2004; Russell & Williams, 2002; Williams & Edge, 1996).

If we characterise this new role for social science as 'upfront engagement' (in contrast to 'end-of-pipe'), what might it entail? Social science is, in its broadest sense, the study of society and the manner in which people behave and impact on the world around them. It encompasses many disciplines that focus on particular aspects of society or human nature. Social scientists deploy a range of approaches to gathering evidence, from the collection and analysis of statistics, to the collation of responses to surveys and interviews and to the systematic observation of human behaviour. These different approaches continue, of course, to offer a breadth of essentially instrumental roles in tackling specific problems encountered in the management of agri-food systems. However, the strategic involvement implied by 'upfront engagement' must mean additional roles that are more systemic and more generic. The systemic aspect stems from an encompassing understanding of technological change that embraces not just scientific discovery and its applications but also the setting of scientific priorities and the processes of design and adaptation that technologies undergo as they are developed, taken up or contested. Such a perspective, in turn, suggests a number of generic roles for social science in integrated agri-food system research (Defra Science Advisory Council, 2007). We would highlight three of the key contributions as relating to the representation of public and stakeholder preferences, problem framing, and the analysis of complex socio-technical systems.

Public representation

Working with social scientists can help illuminate or facilitate the expression and engagement of public, consumer and stakeholder preferences, values and motivations. For the scientist or technologist this can mean improved strategic awareness of public concerns and policy issues relating to their research, improved sensitivity to cultural and social differences between different social groups, and more effective communication with policy makers, practitioners and the wider public. In other contexts social scientists play active roles in facilitating debate, mediating

conflict, engaging the participation of stakeholders and in posing crucial choices. They can also operate as social critics within research or socio-political settings.

This role for social science is usefully demonstrated by Traill *et al.* (2008), who emphasise the need to match social and commercial needs in agri-food innovation. In a discussion of novel production methods for enhancing the nutritional content of food products, they show how commercialisation prospects and the design of interventions must be closely entwined with social science analysis revealing what consumers prefer to eat and why and at what cost, as well as their views on the impact of the new production technologies themselves.

Problem framing

Social science can help in the setting of research questions, and not just in ensuring that due account is taken of consumer demand or public preferences in orienting research to pressing societal challenges and opportunities. The potential solutions sought to any problem depend crucially on how it is characterised. A corollary of the complexity of the agri-food system is that specifying the boundary conditions for a problem is not straightforward. In consequence, problems may be open to radically different framings, and this is the case with respect to many of the contemporary issues in the management of the agri-food system. Is obesity a nutritional problem, a public health problem, or a social problem? Is bovine-TB a veterinary problem, a conservation problem, an animal welfare problem, or a public health problem? Is overfishing an ecological problem, a political problem, or an economic problem? Each characterisation points to different types of expertise, but it may be that multiple framings are appropriate to reflect the indeterminate and shifting nature of problems (Schön & Rein, 1994). The changing public priorities for agriculture – from maximising production to sustainable development, consumer health and food quality – themselves call for a reframing of research objectives and questions. An important justification for interdisciplinarity then is to bring together different disciplinary framings of a problem. Collaboration with the social sciences can bring different perspectives and methodologies to help reframe problems, or indeed reveal multiple or disputed understandings and thus expose diverse possibilities and ambivalent tendencies (Fischer, 2003; Jasanoff, 2005). The social scientist questions the norms by which a problem is characterised and considers how the problem might be viewed in other contexts or be reconceptualised. Social science can thus make more robust the shaping and prioritising of scientific research.

The critical importance of attention to problem framing is illustrated by research into the potential for reducing 'food miles' – the distances travelled by foodstuffs from farm gate to consumer – and the benefits claimed for local economies, consumers and the environment by different interests. Edwards-Jones *et al.* (2008) review the specific

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[3] The term 'socio-technical' is used "to stress the pervasive technological mediation of social relations, the inherently social nature of all technological entities, and, indeed, the arbitrary and misleading nature of distinctions between 'social' and 'technical' elements, institutions or spheres of activity" (Russell & Williams, 2002: p. 128).

claims and put forward a holistic assessment that reveals complex environmental trade-offs in switching from non-local to local food, but also ethical issues in the potential substitution of goods produced in poorer countries.

Systems analysis

Agri-food systems are complex, combining human and biological elements that link together diverse people, places and processes through multiple product flows and intermediaries. They are characterised by emergent properties and non-linear dynamics, due in part to highly articulated interactions between manifold levels (Liu *et al.*, 2007; Puu, 1993; Sawyer, 2005). On occasions small causes can produce large effects. This is no more evident than in several recent food scares. The obverse can also occur, as in the chronic failure of successive healthy-eating campaigns. Social science methods and analysis can assist in interpreting uncertainties and divergent views and understanding the social, economic and political factors determining the workings and pressures of complex socio-technical and socio-ecological systems. This analysis can inform decision-making and reveal the scope for intervention (Byrne, 2005; Defra Science Advisory Council, 2007).

Social scientists can help inform debates about the effective governance of complex systems, and how to design institutions that are more resilient and able to cope with uncertainty (Ostrom, 2005). An important area of research, for example, is how societies understand and deal with the risks and uncertainties that are intrinsic in scientific advice and technology choice. Shepherd (2008) emphasises how dealing with food risk is not a purely technical task. Technical risk management models tend to dominate decision-making, though they are not necessarily a useful guide to public responses and perceptions, especially in times of crisis or failure. Prediction becomes difficult if not impossible, which can lead to a breakdown of control systems and a legacy of diminished public confidence in the ability of government departments and agencies to tackle food hazards and in the credibility of scientific advice. Through a participatory approach in the design and implementation of risk assessment, management and communication there can be greater confidence that the right questions have been asked of science, the appropriate values and priorities applied, the relevant assumptions tested and the salient sensitivities explored.

Final remark

Agri-food systems comprise complex social, ecological and technological connections that require integrated research approaches. Interdisciplinary research offers many opportunities and challenges, but requires reflection on the role of social sciences vis-à-vis the natural sciences. We have shown how social sciences can play a variety of strategic, though not uncritical, roles within the process of technological innovation. By considering how problems are framed, offering analysis of social values and preferences and providing understandings of complex socio-natural systems and their emerging properties, the social sciences can play a part in addressing the limits of partial disciplinary perspectives.

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