Air pollution: carrots, sticks and private initiatives to improve food quality assurance in India

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Summary

The levels of air pollutants are rapidly increasing in many 'megacities' of the developing world. Air pollution reduces both the yield and nutritional quality of crop plants, and is also a major source of particulate contaminants which can accumulate at toxic levels in the edible portion of crop plants grown in urban and peri-urban (UPU) areas. This paper reviews knowledge of the impacts of UPU environmental pollution on food safety in India, explores the policy environment in India and the appropriate balance between public and private initiatives, and develops a framework for introducing public and private mechanisms to improve food safety and quality assurance.

Keywords

food safety, India, institutions, air pollution, central government, State/city government, private sector

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1 Introduction: peri-urban air pollution and food quality

"… behind the rising prosperity in the developing world lurks the shadow of lethal air pollution from motor vehicles, smokestacks and hearths" (World Bank, 1998: 99).

Almost 3000 million people live in urban areas. Most of the growth in the world's population is taking place in developing countries, and most of the projected increase of 1000 million people between 1999 and 2010 is likely to be absorbed by developing country cities. The 'ecological footprints' of cities can be vastly greater than their physical area because of the demand for energy, food and other resources, and the regional impact of their wastes and emissions to air, soil and water. Among the most serious environmental problems in the developing world is air pollution, which is reaching crisis dimensions in many 'megacities' - urban populations greater than 10 million (United Nations Environment Programme, 1999).

Respiratory hazards from air pollution in urban areas are widely acknowledged. Another reason for concern is the major threat posed by air pollution to crop production in urban and peri-urban (UPU) areas, where the livelihoods of urban inhabitants are dependent on access to cheap and safe food of high nutritional quality. The contribution of UPU production to urban food demand throughout the world, particularly of perishables, can vary from 25-100%, and may involve a high percentage of families (Birley and Lock, 1999). The majority of highly perishable products, including many vegetables that are consumed in cities, are produced in UPU areas.

Air pollution reduces both the yield and nutritional quality of crop plants, with important implications for consumers and producers, particularly the poor. Air pollution is also a major source of heavy metals which can accumulate at toxic levels in the edible portion of crop plants (Marshall and Wildig, in press). Compared with degradation of the physical environment, the management of health hazards associated with environmental contaminants has been accorded some neglect. Nevertheless, public awareness of the health, education and economic implications of unsafe food systems in developing economies is growing fast. According to Motarjemi, "it should be remembered that the developing countries bear the heaviest burden of foodborne diseases in the world" (1996: 82). For lifestyle reasons, poor populations are more susceptible to environmental metal poisoning (Nriagu, 1992).

There is currently little information on the integrity of supply chains for horticultural produce in UPU areas of developing countries. Pre- and post-harvest contamination is likely to be widespread. For example, initial results of research in Varanasi, India, indicate that post-harvest contamination results in highly toxic levels of cadmium in fresh vegetables (Marshall, 2000). Data are scarce, but levels of morbidity and economic losses affecting poor people are likely to be considerable. Knowledge of best practice in food production and handling, and of the availability of appropriate technologies, is thin and unevenly spread. Moreover, the regulatory regime for environmental pollutants, and for hazardous technologies and production practices is likely to be weak.

This paper reports the first stage of an interdisciplinary study of the impacts of air pollution on urban food quality in the developing world, and suggests mechanisms to improve quality assurance. The focus for this work is India – Delhi and Varanasi - but it draws on research elsewhere and will have implications for poor people in other regions.

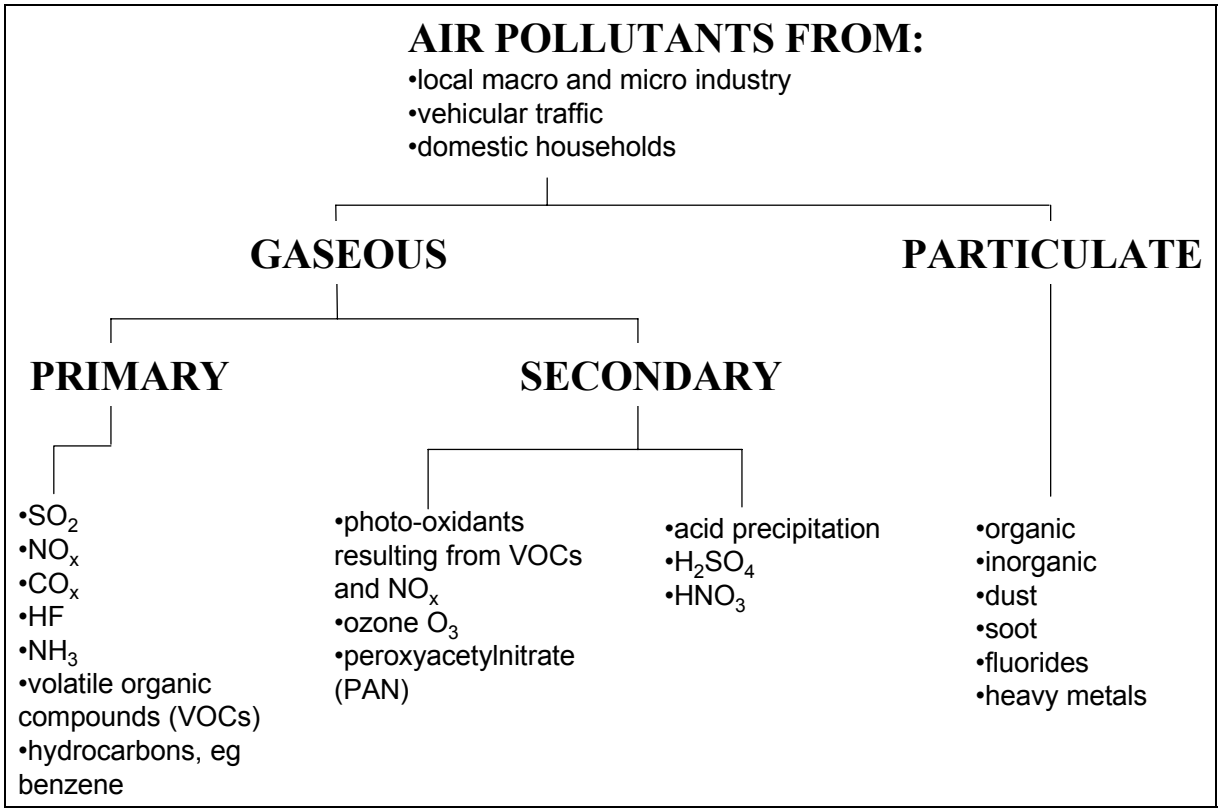
The next two sections discuss air pollution impacts on UPU food systems, and the quality assurance concepts associated with these hazards. Section four is a literature-based account of QA in practice: the science, economics, institutions and policy environment concerning food safety. Section five discusses the elements of the policy environment in India that bear on food safety and QA. The final section presents a framework for developing mechanisms to enhance the integrity of the UPU vegetable systems in India.

2 Air pollution impacts on UPU food systems

Sources of pollution

The adverse effects of air pollution have been associated with three major sources. They are sulphur oxide and solid particulates from fossil fuels; photochemical oxidants and carbon monoxide from motor vehicles; and miscellaneous pollutants such as hydrogen sulphide, lead and cadmium emitted by smelters, refineries, manufacturing plants and vehicles (Birley and Lock, 1999). Population pressures leading to increased numbers of motor vehicles, power generation, domestic fuel use, refuse burning and other sources all contribute to the problem. Particular cities present particular problems: India's economy relies heavily on coal, which contributes high levels of SO_2 emissions. In Delhi, where the population is growing at 3.8% per annum - and in Mumbai - levels of particulate matter exceed World Health Organization recommended levels by a factor of three (United Nations Environment Programme, 1999). Sources and types of air pollutants are summarised in Figure 1 and Table 1.

Figure 1 Major air pollutants



Derived from Davies (2001)

Table 1 Sources and types of urban air pollution, Varanasi, India

Industry	Pollutants
Metal products	Fluoride, SO_2, NO_2, heavy metals
— Aluminium, steel, brass, copper	
Chemical products	Organic vapours, SO_2, NO_2
— Soaps and detergents	
— Pharmaceuticals	
Textile printing	SO_2, NO_2
— Saris	
— Hosiery thread	
Coal and products	SO_2, NO_2, ash (heavy metals)
— Bakeries	
— Household use	
— Commercial food preparation	
— Textile dying	
— Other small scale industries	
Transportation & vehicle servicing	SO_2, NO_2, HC, CO, heavy metals
Miscellaneous	Fluoride, SO_2, NO_2, organic vapours, heavy metals and other particulates
— Plastics and ceramics	
— Carpets	
— Jari work	
— Brick kilns and construction	

Compiled from Agrawal (2000) and Marshall (2000).

Impacts on crop output and value

Primary pollutants such as sulphur dioxide can cause significant crop yield losses in the vicinity of urban industries, whilst ozone is the pollutant of greatest concern for crop production on the outskirts of cities (Ashmore and Marshall, 1999). Elevated levels of ozone have been found to have both yield and quality effects on crop production in field experiments in the UK and elsewhere (Wilbourn, Davison and Ollerenshaw, 1995; Ollerenshaw and Lyons, 1999; Ollerenshaw, Lyons and Barnes, 1999). Crop damage has been found to be more severe in countries with greater solar intensity because strong sunlight accelerates the series of chemical reactions that leads to ozone formation in the lower atmosphere. There are also indications that some tropical crop cultivars and agricultural systems may be particularly sensitive to ozone (Ashmore and Marshall, 1999).

Phytotoxic gases have been found to cause major yield reductions on a range of important crops in the developing world (Ashmore, Bell, Marshall and Milne, 2000). For example, yield reductions of 40% or more have been recorded at ambient levels of air pollution for rice and wheat on the outskirts of Lahore, Pakistan (Wahid, Maggs, Shamsi, Bell and Ashmore, 1995a; Wahid, Maggs, Shamsi, Bell and Ashmore, 1995b); and on spinach and mustard in Varanasi, India (Marshall, Wildig, Stonehouse, Bell, Ashmore and Batty, 2000). Air pollution also has the potential to reduce the nutritional quality of crop plants, with important implications for consumers, particularly the poor (Marshall, Ashmore and Hinchcliffe, 1997; Ashmore and Marshall, 1999). Air pollution can cause visible damage to the edible portion of the crop (Taylor, Ashmore and Bell, 1987), increase susceptibility to post-harvest pest and disease attack (Bell, McNeill, Houlden, Brown and Mansfield, 1993), and reduce shelf life, with important economic losses throughout the market chain.

Impacts on crop safety

There are also major concerns over toxicity in food crops caused by emissions of fluorides (particularly associated with brick kilns that are prevalent in peri-urban areas) and heavy metal deposition (for example lead, cadmium, zinc and copper) from a wide range of industries. These can accumulate at toxic levels in the edible portion of crop plants.

Exposure to heavy metals has been linked with developmental retardation and reduced IQ among children, various cancers, kidney damage, and the development of autoimmunity. Children appear to be especially vulnerable (United Nations Environment Programme, 1999: 31):

> "There is particular and growing concern about the threats that chemicals pose to children's health. The main problems include both acute exposure leading to poisoning, and chronic, low level exposure causing functional and organic damage during periods of special vulnerability, when neurological, enzymatic, metabolic and other systems are still developing. Exposure of unborn children to toxic chemicals may produce irreversible effects… Recent research suggests that these chemicals may affect the ability of children to learn, integrate socially, fend off disease, and reproduce".

3 Pollution hazards and QA concepts

'Quality' is a complex of properties of a good or service that satisfy a customer's implicit and explicit needs. Food safety is a subset of the broader concept of food quality, and includes a number of dimensions:

- product safety: freedom from environmental and other contaminants and sources of toxicity (chemical and biological) injurious to health;

- product attributes: both objective (nutritional and other physical characteristics such as shelf life, appearance, flavour, texture, and other presentational aspects including labelling), and subjective (utility in respect of economic value, consumer preferences and satisfaction, including range of choice….);
- production and post-harvest handling techniques: process, or 'best practice' in respect of technology and inputs including choice and application of agrochemicals and/or organic fertilizers, processing and storage; labour practices also might be included here.

Food safety can be a 'search' or 'experience' good (Nelson, 1970). QA systems for such safety hazards are likely to use market-mediated incentives (Segerson, 1999). Other safety attributes are 'credence' goods, for which information cannot be discerned even after repeated consumption (Darby and Karni, 1973), and QA may involve control, reduction or elimination by regulation. However, even in the absence of market-driven incentives, regulation or controls may not be necessary if firms can be induced by incentives or constraints. These food quality attributes, incentives and potential QA mechanisms for hazards resulting from airborne contaminants are resumed in Table 2.

Table 2 Food quality attributes, quality incentives and potential assurance mechanisms for air pollution effects

Attributes	Example	Incentive framework	Assurance mechanisms
'Search' goods	Physical appearance — freshness — variety — size and shape — colour — maturity — visible injury	Market-mediated	Information — inspection
'Experience' goods	Organoleptic characteristics — freshness — flavour — texture — smell	Market-mediated	Information — behaviour and reputation effects — repeat purchase — labelling & branding — provenance
'Credence' goods	Production and post-harvest technologies, and nutritional value — freedom from environmental contaminants such as heavy metals — nutrient content, especially vitamins and minerals	Public sector initiatives — mandatory interventions — facilitatory incentives and constraints — public information provision	Control — testing and implementation of accepted standards — (self-) certification — self-regulation through market organisation — institutions creating and enforcing liability Information — 'best practice' production technology, post-harvest and household handling

Food quality and safety: demand and supply considerations

Assuring food safety is a complex task involving a range of stakeholders and disciplines throughout the food chain. Swinbank (1993) has reviewed the complexity of the economic issues surrounding food safety. Poorer societies characterised by food scarcity, lower life expectancy and lower levels of education, are likely to demand less food safety than richer societies. "Poverty will affect the perception of rewards and dangers and can induce people to take extra risks" (Adams, 1995: 66). Unnevehr and Jensen (1999) link the demand for food safety to growing affluence, among other things. In short, in economic terms, food safety is a 'luxury' good. Thus, the demand for food safety probably depends on income and prices; on perceived risk, which is a function of the level and value of available information and individual attributes such as age and education; and on risk tolerance.

Where incentives and information flows are imperfect, the market alone may fail to supply the level of food safety demanded by society. According to Bunte (2000) product demand grows when perceived quality rises due to improved health and safety measures. Efficient markets and cooperative trading relationships signal demand changes and enhance the flows of information and incentives. However, firms in non-cooperative vertical supply chains may under-deliver safety improvements: individual profit-maximising firms will not consider the positive externality of increased output and profits accruing to other firms, nor the broader socioeconomic benefits resulting from improved health and safety.

Approaches to regulation: public or private?

Market failure to deliver the level of safety to meet public health requirements and consumer demands constitutes economic grounds for public policy intervention (Unnevehr and Jensen, 1999). However, the existence of market failure does not mean that intervention can necessarily improve the performance of unregulated markets. Even where there are positive net benefits, the distributional consequences of regulation need to be understood (Antle, 1999), as do the structural effects, and the technological and scale barriers to market access.

Approaches to public food regulation range from low to high levels of intervention: from the provision of information, through the development and enforcement of standards, to prior approval. Unnevehr and Jensen (1999) distinguish between information-based incentives for private market solutions and direct command and control interventions. The former may be provision of information to consumers, lowering information costs through improved testing mechanisms, branding, labelling, (self-)certification schemes, and laws creating enforceable liability. Reputation effects and trust are additional private mechanisms which are of considerable importance in advanced economies, and probably no less important in developing economies: "in India you do business with people with whom there is prior mutual trust" (Basu, 1992: 344).

Interventionist regulations can take two broad forms, according to Hilmer, *et al.,* (2000). Performance standards specify a quality level that a firm's output must meet, involving enforcement through testing, but allowing the firm autonomy over its production process. Process standards specify procedures required to produce output of the desired quality – the prior approval previously referred to.

Under a light regulatory regime one might expect differing levels of voluntary compliance to high sanitary standards, or 'sanitary propensity' (Hilmer et al., 2000). High levels of intervention create the potential for firms to 'capture' the regulatory process and thereby attempt to co-opt the regulatory system to gain competitive advantage. This phenomenon,

together with the enforcement problems that arise from a heavy regulatory approach - evident, for example, in the case of India below (Harriss-White, 1995) – suggest that where the institutional framework is weak regulation must be approached with caution.

The public-private balance

Analyses of QA mechanisms in the US and the UK have highlighted the importance of the appropriate balance between the 'carrot' and 'stick' approaches (Fearne and García, 1999; Segerson, 1999). In advanced economies, there are increasing concerns about the costs to the industry of regulatory compliance. The costs to the regulatory authorities are those of the enforcement of performance measures through product testing, and to firms are the costs of conforming to industry-wide standards that may not be appropriate. HACCP (Hazard Analysis Critical Control Points) process standards are becoming widespread because they are considered to be less costly.

Whether or not food chain stakeholders engage in private QA activities depends in part on the mix of incentives. Incentives may be positive, resulting in voluntary adoption of appropriate QA mechanisms. They may be negative, either purposive (in the form of policy-mediated sanctions for non-compliance such as fines), or consequential (in the form of declining market share and exclusion from the market).

Consensus is growing that both public and private sector initiatives are necessary in enhancing the integrity of food systems. Regulatory initiatives to impose 'due diligence' requirements and legal liability cannot work alone. Nor can the task to secure the integrity of the supply chain be left to individual or firm initiatives in response to market forces.

The public-private balance in India?

Drèze and Sen argue that the contrast between market-based and government-based economic decision making requires a clear understanding of the context (1995). As Basu argues, "In reality, an effective market is one which operates freely, but *within* a structure of norms and legal institutions" (Basu, 1992: 341). At the state level in India, Drèze and Sen note among other things the essential role of three factors for successful public policy implementation. There must be: a) well-functioning public (ie state-provided) services; b) public (ie democratic and participative) action; and c) a particular type of public action – the political organization of deprived sections of the society.

In the context of food safety, consumer pressure might be the form of public action expected to play a role in bringing about improved QA. "Public action can also affect outcomes without having to work through swaying government policy" (Drèze and Sen, 1995: 89). These assertions are consistent with the climate of economic adjustment that seeks to find an efficient and effective balance between intervention and regulation by the state, and private sector activity in response to incentives created by the market.

4 QA in practice

Science, economics and institutional development

Food quality assurance is a multidisciplinary endeavour. The literature provides pertinent examples of the interplay of a range of factors contributing to food quality assurance. In the UK, for example, historic improvements in food quality were not just a matter of genuine scientific achievement, but also of institutional development and an enhanced regulatory framework, improved commerce, more efficient market organisation and changes in business

culture (Collins, 1993). Above all, advanced food industries are driven by the need for control of the food chain in order to satisfy consumer demands in respect of product quality – including food safety - and value-for-money (Poole, 1997).

Further evidence of the evolution of technological and institutional approaches comes from Brazil. Resende (1993) shows how food safety in Brazil is associated with the level of socioeconomic development, and how consumer protection was enhanced by measures in the 1988 Constitution that established the municipalisation of food control services. Salay and Caswell (1998) highlight the coalition of stakeholders in food safety issues.

The relevance of institution-building to food safety in India is worth noting. Commenting on the economic restructuring that was initiated in India during the last decade, Basu (1992) asks: "Do we have the institutions for markets to function effectively? Suitable social norms and a legal framework are a prerequisite for an efficient market. Do we have this base?" (p. 338-9).

Efficient and effective vertical transmission of information and incentives is an important constituent of the mechanisms for QA. Information and incentives are likely to play a part in QA mechanisms at least as important as policy, especially where the regulatory environment is weak. Even in advanced food systems, deficiencies in the flow of information through market systems have been found to be a source of market imperfection in matching market intermediaries' perceptions of quality to consumers' preferences and demand characteristics (Poole and Baron, 1996; Poole, 1997b).

Contractual relationships and even written contracts are an important mechanism to address agency problems in food systems (Poole, Del Campo Gomis, Juliá Igual and Vidal Giménez, 1998) and these issues are directly relevant to the establishment of QA mechanisms (Compés López and Poole, 1998). Basu envisages that written contracts, or "a limited contract-enforcing regime" may even have a part to play in reducing transaction costs in the agricultural sector in India (1992: 347). Contracts may serve to enhance trust in the trading community (Poole, Kydd, Lynch and Poulton, 2000; Poole, Seini and Heh, 2000). Basu continues: "The inability to sign contracts and have them enforced through the government is, I think, one of the main factors behind the inefficiency of the Indian economy" (p. 344).

The wider policy environment

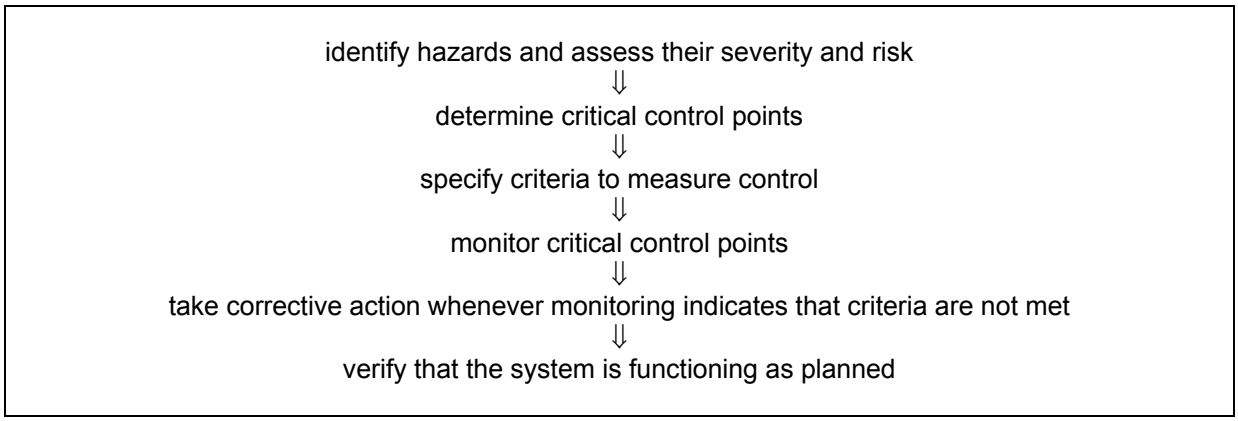
In the international arena, the priority of the Codex Alimentarius Commission (CAC) is to protect the health of consumers and ensure fair practices in the food trade. The significance of the CAC food code for consumer health protection was underscored in 1985 by the UN Resolution 39/248 in which guidelines were adopted for the development of consumer protection policies. In the 1997 biennial meeting of the Codex about 75% of delegations were from developing countries (Codex Alimentarius Commission, 1999).

In the CAC (CAC/RCP 1-1969, Rev.3 (1997)) food safety is defined as assurance that food will not cause harm when it is prepared and/or eaten according to its intended use. A positive approach to food quality and safety will embrace also the production, marketing and distribution practices that impair nutritional and economic quality characteristics of food, such as nutrient levels and shelf life.

HACCP (Hazard Analysis Critical Control Point)

The HACCP procedure for food products is the most widely disseminated mechanism for enhancing food chain integrity. HACCP was advocated by the World Health Organization as long ago as the early 1970s, and is regarded as "the universally recognized and accepted method for food safety assurance" (Motarjemi et al., 1996: 77). The HACCP procedure (Figure 3) substitutes easily monitored control processes for costly testing, targets specific hazards, and can be linked to system-wide risk assessment. Most commonly, the safety hazards are conceived as microbial in nature. Properly the concept of hazard should cover any biological, chemical or physical agent with the potential to cause an adverse health effect – including inferior nutritional content and heavy metal contamination.

Figure 2 HACCP: the sequential steps

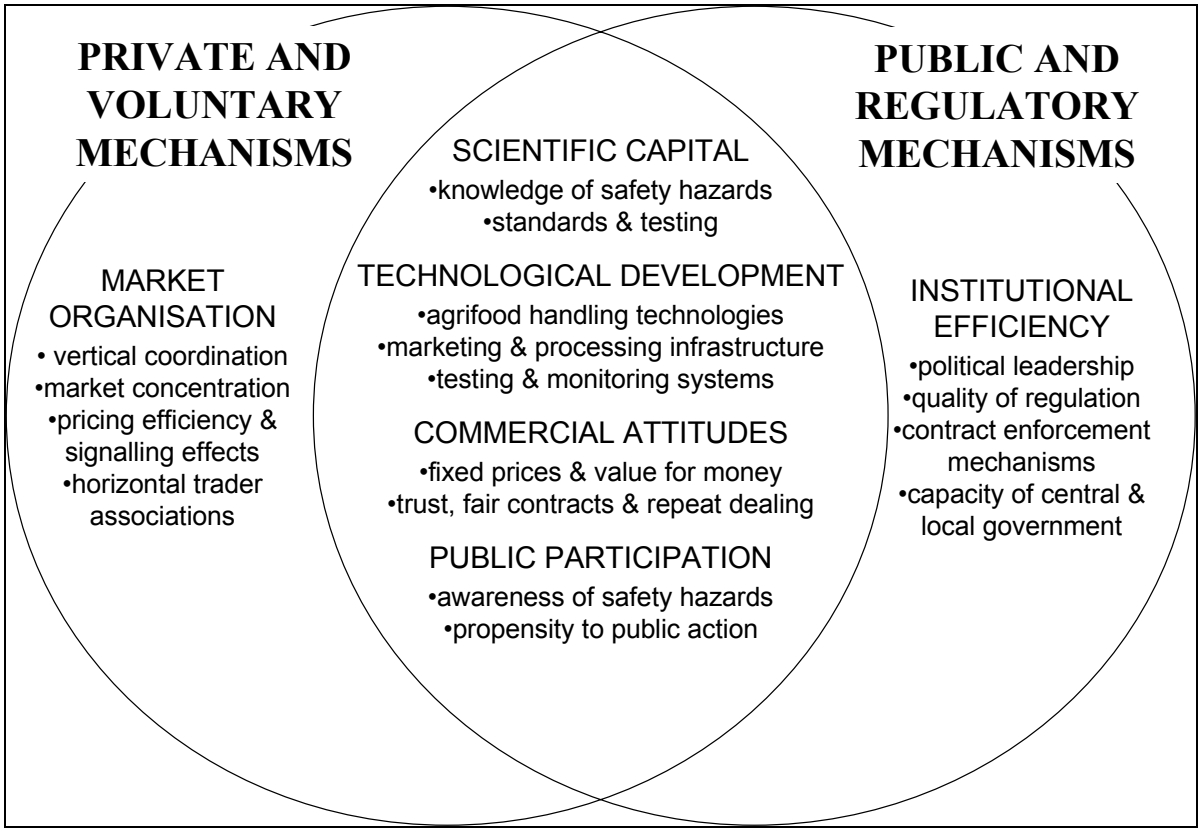


System-wide HACCP procedures should encompass the food chain from production, through harvesting, processing & manufacture, distribution, preparation, to the consumption of agrifood products. According to Motarjemi, "in view of the high prevalence of food-borne diseases in the developing world, and the limitation of resources, the potential benefits that the application of the HACCP system may afford in comparison to the problems faced are more important for developing countries…" (1996: 82).

HACCP approaches to food safety have been used in the WHO Healthy Cities Project, begun in 1986, and which emphasised the importance of health linkages to peri-urban marketplaces. The main hazards to food safety arising from the marketplace were due to contamination during transport, lack of quality control standards, improper handling, storage and environmental conditions, and misrepresentation or adulteration leading to health, nutritional or economic problems for the consumer (Birley and Lock, 1999).

Thus there is a range of factors which will determine the feasibility of different approaches to QA, and hence the appropriate blend of market-mediated mechanisms and public intervention. These are summarised in Figure 3. In summary, efficient, effective and relevant food QA mechanisms in developing countries are likely to involve improved scientific knowledge, accompanied by technical and institutional responses through both regulatory and market mechanisms, and commercially propitious business attitudes. Information and incentives are likely to play a part in QA mechanisms at least as important as policy, especially where the regulatory environment is weak. The next section evaluates the regulatory environment for food safety in India.

Figure 3 Factors conditioning the effectiveness of QA mechanisms



5 The policy environment in India

The Indian Constitution

Bhagwan's review of the Indian Constitution (1999) furnishes important contextual detail concerning the institutional framework and the potential for regulatory efficiency in India. The Constitution creates a federal state with powers distributed between the Central Government and the constituent units (25 States and 7 Union Territories), and enshrines the notion of 'vigilant public action' in the governance of the country. The complex multisectoral issues underlying food safety and the multiplicity of stakeholders mean that legislative responses to food safety hazards will not be simple, but can be targeted. An example is the 'Prevention of Food Adulteration Act', which is a national law, the result of an Act of Parliament, whose implementation is the responsibility of the State governments.

Food and nutrition policy

India's economy has been described as one of the most closed and regulated economies in the world (Ahluwalia, 1993). Intervention in agricultural and food markets in the 'modern era' can be traced at least back to the 19th century (Bhupal, 1979). In fact, since 1991 there have been serious attempts at reform, meaning a policy shift towards liberalisation, although reforms have not moved as fast as anticipated (Drèze and Sen, 1995).

Since independence in August 1947, there has been one dominant food policy intervention, the Public Distribution System (PDS). The PDS is a long-standing general entitlement scheme, exemplifies intervention in Indian markets, and has been a focus of much debate in recent years because of the high cost, and allegations of inadequate targeting and imperfect

administration (Ahluwalia, 1993; Howes and Jha, 1994; Srinavasan, 2000; Swaminathan, 2000). The significance of the PDS extends beyond food policy issues, and its performance exposes the limitations of food market regulation In India. Mooij (1999) argues that food policy is embedded in social relations and shaped by processes 'on the ground' rather than a logical result of official statements and intentions. Echoing Drèze and Sen (1995), his position is that effective change is likely to result from public action and popular participation rather than from within the state itself.

The potential for regulation in India

Drawing on case material for food markets in India, Harriss-White (1995) has explored the apparent incongruity of the need for market regulation in the current environment of economic reform dominated by the themes of deregulation and privatisation.

From a theoretical starting point, in the tradition of North, she employs New Institutional Economics concepts to explain the existence of institutions which have the functions of enabling, disciplining and constraining market exchange. A framework may have **micro** (firm level), **meso** (collective action) and **macro** (state level) elements. She comments that laws are hardly ever implemented, may be ignored, may be creatively reinterpreted, flouted by the powerful, imposed on the weak, used as threats... and thus informal collective institutions have tended to evolve in the place of ineffective formal regulation.

Notwithstanding the vested political interests, efforts to implement combative policies in India have not proved totally ineffective. In a discussion on the contentious subject of 'judicial activism' in India, Bhagwan (1999) cites various cases in which the judiciary and Parliament have clashed, sometimes leading to the prosecution of top politicians and bureaucrats. Two prominent environmental cases argued by the judiciary involved the exoneration of the Union Carbide officials from the charge that they had prior knowledge about the Bhopal industrial disaster; and "strict enforcement of environmental laws resulting in closure or relocation of a large number of industries in the Capital which were responsible for spreading pollution" (p. 262). The latter case is particularly instructive in considering the enforceability of 'good laws' to the disadvantage of vested political interests.

Evidence suggests that there is potential in India for public sector institutions to verify the quality of food products. An example is Operation Flood, launched in the early 1970s by the National Dairy Development Board (NDDB) to combat milk adulteration. The measures involved the formation of cooperatives, the adoption of quality standards, improved product testing, provision of technical assistance, subsidies for improved processing facilities, and the adoption of branding by the cooperatives. There was a significant improvement to the quality of milk and incomes of a million producers in the target area were doubled by 1979 (World Bank, 1998: 73).

In examining the agricultural sector, Saxena argues that there is not a lack of resources for poverty reduction in India, and that poor performance of central and State governments is a more important constraint. The direct involvement of the public sector in the economy is too intrusive and costly, and administrative capacity is limited. Notwithstanding examples of commendable work at the lowest tiers of local government - see for example, Gustafsson *et al.* (2000), higher level local government is perceived as indifferent to the interests of wider society, and patronage and corruption divert resources away from productive policies.

However, Swaminathan argues for continued public sector involvement in food policy (2000). She notes that the PDS in the state of Kerala is in a class of its own in terms of effectiveness, citing the critical importance of intense public pressure in the 1940s, and good governance in Kerala. She proposes a full public sector role in food policy, envisaging a strong and effective food security policy. Among her recommendations are reform of the Food Corporation of India rather than privatisation, greater decentralisation, and genuine participation by the poor in organisations at the local level. She reiterates that strong political support and political awareness are prerequisites for public sector performance.

The weight of evidence about the public sector suggests that it would be wrong to entrust food quality assurance to strong regulatory control through Central or State governments. Private initiatives must form part of the framework of incentives and controls.

The potential for commercial initiatives

Sivamohan (1997) has undertaken a study of the evolving institutional arrangements in high value horticultural marketing in India. Traditionally, private wholesale merchants, retailers and street vendors have been the mechanism linking producers and consumers, but the development of cooperative societies in states such as Gujarat and Maharashtra since Independence has opened up alternative marketing channels. Latterly, newer marketing arrangements have evolved in response to the rapid rate of population growth, urbanisation and the consequent increased dependence on formal transport systems from rural to urban areas. Another important factor has been the increasing demand in export markets.

The commercial organisation Mother Dairy is well known in Delhi, and has its roots in the NDDB. Latterly there has been extension into fruit and vegetable marketing and the private limited company. The Fruit and Vegetable Project (F&VP) was set up in 1986 by the NDDB, initially as a pilot project to market fruit and vegetable products to consumers in Delhi. The organisation is now a sophisticated business enterprise. F&VP retails through the 250+ outlets under the brand name of Safal. F&VP also markets elsewhere in India.

Procurement occurs preferably through formal or informal producer organisations at rural procurement centres. Important functions that are integrated within the organisation are technical support to producers, transport, cold storage and ripening, product grading, some processing (washing and freezing) and quality control functions. Storage, processing and distribution are centred in Delhi. Incentives are paid to suppliers of produce above specified standards. Sivamohan attributes the success of F&VP to the farmer-support system and the integrated nature of the handling and distribution system.

In a recent interview, Sharma (2001) stressed the dynamic nature of the fruit and vegetable industry. As many as seven purely private food marketing initiatives have arisen recently in response to the liberalising economic environment and wealthy consumers' expressed quality preferences. Although evidence is purely anecdotal at this stage, apparently these new enterprises surpass Safal in quality and efficiency.

6 Developing a framework for horticultural QA in UPU India

Within this broad scenario, there are lessons for food safety. The foregoing discussion of QA issues and the policy environment serves to highlight areas which must be considered in tackling critical food safety hazards associated with air pollution in Delhi and other UPU areas.

Identification of hazards

A measured policy approach must be predicated on a better understanding of the hazards within UPU horticultural markets. The HACCP procedures provide the starting point for a system-wide multidisciplinary approach to assessing horticultural product quality. The first stage is to identify the sources and nature of industrial contaminants – a task more difficult than apparent in cities whose industries are characterised by a multitude of small firms.

There is a place for targeted industry and national initiatives. Direct public intervention is likely to be necessary for implementing emission controls in line with national and international standards. Concerning environmental policy, the industrial relocation enacted in Delhi in November 2000 has removed certain industries from within the city limits (although the pollution problems may not have been substantially attenuated). The subsequent policy (early 2001) to force public transport vehicles in Delhi to shift from petrol and diesel to compressed natural gas has contributed to discernible but as yet unquantified improvements in air quality.

Critical point determination

Subsequently, the determination of critical points employs a range of techniques involving scientific testing for contaminants and objective nutritional quality, quantitative surveys of consumer perceptions, and participant observation of technology, handling practices and exposure to hazards (Table 3). Quantification of hazards and identification of critical points is to be conducted in relation to accepted national and international standards.

Table 3 Critical point determination

Quality and safety characteristics	Method of determination at respective market system stages field production ⇓ wholesale handling and marketing ⇓ retail handling and marketing ⇓ household-level consumption
Safety and contaminant levels	• Monitoring ambient pollutant levels • Product testing
Other objective & subjective attributes	• Product testing • Quantitative surveys of stakeholders
Technology & product handling practices	• Quantitative surveys of stakeholders • Observation and appraisal

Incentive and constraint mechanisms

At this point, system-wide analysis involving a multiplicity of stakeholders departs from the firm- or plant level HACCP procedure. Moreover, the context, or 'reality', of Indian food markets will temper the appropriateness of specification and monitoring of system-wide criteria and controls (Mooij, 1999). Mechanisms such as large scale testing, correction and verification are ruled out on the grounds of unfeasibility and high cost that apply to QA systems even in advanced economies.

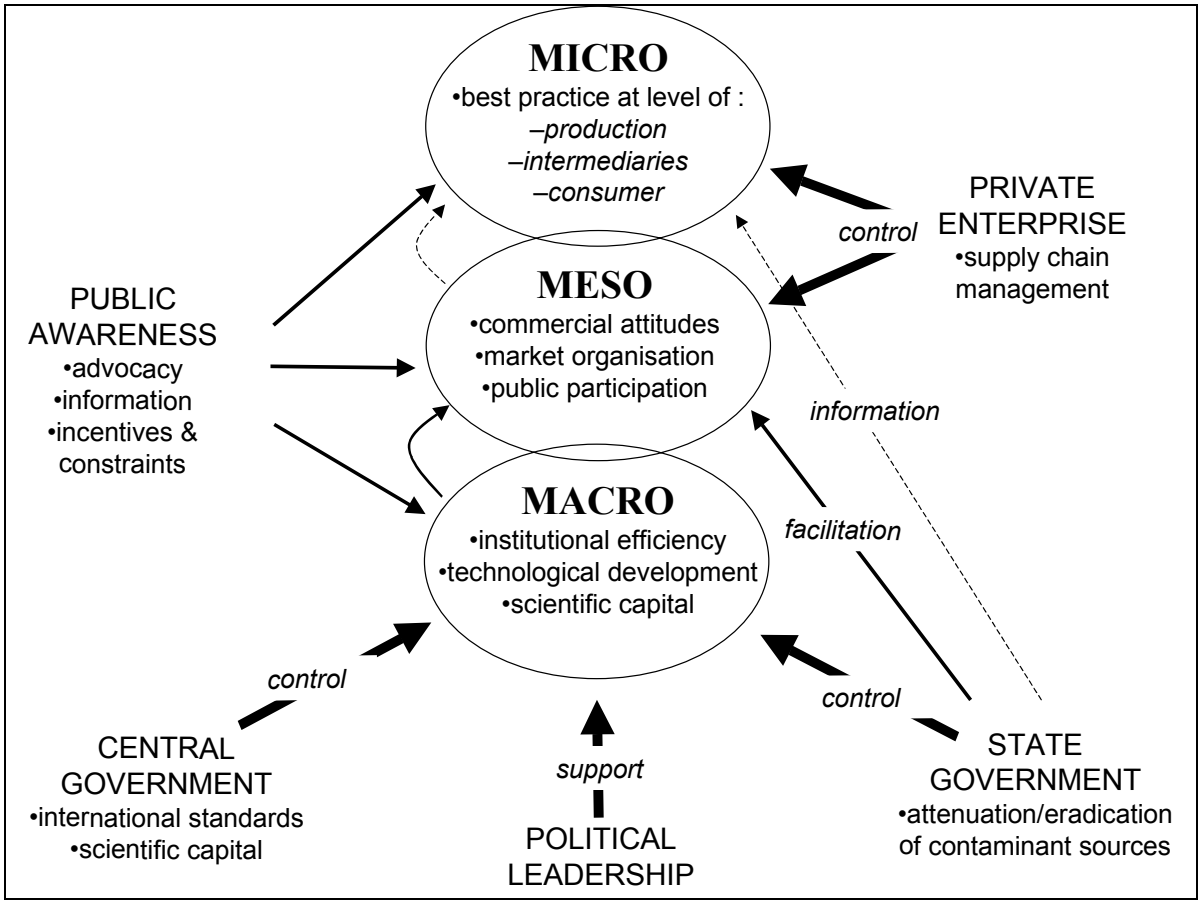
Low levels of health hazard awareness and high rates of poverty mean that effective demand for food safety is probably low, except among the wealthy. For the majority, market failure is

likely and public intervention is necessary to tackle the social costs. However, micro-interventions necessary to provide the precision to tackle food chain-specific problems should take the form of incentives rather than controls. They must account for a range of stakeholder interests (in particular consumer interests, but also those of poor labourers, producers and intermediaries). The objectives should not just fall within the narrow confines of food policy interventions but take into account also the broader health and education imperatives. Strong political support and public awareness and action are essential for an effective state role in food policy.

Framework of mechanisms to assure food quality

The vastness of the 'ecological footprints' of cities such as Delhi, the atomistic structure of agricultural and industrial production in UPU areas, and sectoral interactions such as the need for urban employment may prevent the elimination of sources of contaminants. A framework is necessary for identifying measures to reduce the consequent health hazards. The different stakeholders and the mechanisms at the **macro**, **meso** and **micro** levels proposed by Harriss-White for assuring food quality are presented schematically in Figure 4.

Figure 4 Regulatory and incentive framework for UPU horticulture in India



Direct intervention, ie controls targeted by the central and State/city governments - are necessary to improve institutional efficiency, technology and infrastructure in the macro environment. Emulating the successes of Operation Flood, the public authorities at the level of cities such as Delhi can implement standards and introduce limited scale testing. Direct investment in national and local scientific capital is likely to require central government support. Political leadership at central and State/city levels is a precondition for effective intervention while heightened public awareness also will facilitate improvements in these

elements. This is likely to lead to better safety performance at the meso level through stronger incentives and constraints.

At the meso level, for example, the proposed removal of the Azadpur *mandi* to a larger site with the possibility of better facilities is also an opportunity for the Produce Marketing Committee to initiate quality control improvements. Together with heightened public awareness, these changes have the potential to provide incentives for institutional innovation by improving market-place organization and adopting best practice technologies throughout the horticultural chain.

Improved market organisation, commercial attitudes, and efficient vertical coordination are likely to be fundamental to improve the flow of incentives and information. '**Facilitation'** by State/city governments targeted at the meso-level is a creative alternative to direct controls. In an environment such as that in which the NDDB-created Mother Dairy cooperative structure is flourishing, and Safal is sourcing and delivering quality-controlled produce to the (better-off) Delhi population, evidently there is an enabling role for the governments to facilitate horticultural market re-organization in order to exploit the benefits of market scale, concentration and ease of vertical coordination. The State/city governments can promote associative organisations involving producers and traders which will enable mechanisms such as branding, labelling and self-certification to become feasible for the mass market.

Creative action by State/city governments can address the **information** issues that are preconditions for stimulating effective public participation and disseminating best practice among producers, intermediaries and consumers at the micro level. The development of consumer power is likely to be one of the most powerful forces for impelling improved standards, and may take two forms. Dissemination of knowledge about health hazards, standards and mitigating practices throughout the food system through the appropriate organisations will create **awareness. A**wareness creates the possibility of advocacy by informed local and national consumer organisations, and empowers the decisions of consumers, even those of limited purchasing power, to demand enhanced quality.

The challenge of achieving fruitful public sector coordination can only be highlighted here, however: among the constraints affecting healthy city initiatives generally are significant difficulties in implementing an integrated approach, and also securing political leadership by central backing of local decision-makers. Consistent information should be provided through the range of different government entities involved in horticultural production and extension, market regulation, food policy initiatives and consumer organisations.

Finally, there is evidence that **commercial responses** from the private sector are feasible: the liberalising economic climate provides both opportunities for, and threats to, domestic supply. Regarding opportunities, private capital is being invested in agrifood marketing in Delhi and controlled food supply systems are developing to satisfy the demands of the wealthier sector of the population for high quality produce. There will be much that can be learnt from these systems that could benefit the mass markets in India. Regarding threats, fresh produce imports are increasing, and high specification produce and quality-controlled systems will provide undoubted challenges to domestic production and marketing, but also the possibility of transferring commercial expertise to the domestic sector.

References

Adams, J. (1995). *Risk.* London: UCL Press.

Agrawal, M. (2000). Personal communication.

Ahluwalia, D. (1993). Public distribution of food in India. *Food Policy,* **18**(1): 33-54.

Antle, J.M. (1999). Benefits and costs of food safety regulation. *Food Policy,* **24**(6): 605-623.

Ashmore, M.R., Bell, J.N.B., Marshall, F.M. and Milne, E. (2000). Air pollution impacts on agriculture: a global issue? Ch. 4. In M. Yunus, K.J. Ahmad, N. Singh and L.J. De Kok, (Eds.) *Plants and Environmental Pollution*, Dordrecht, Netherlands: Kluwer Academic Press.

Ashmore, M.R. and Marshall, F.M. (1999). Ozone impacts on agriculture: an issue of global concern. *Advances in Botanical Research,* **29**: 32-49.

Basu, K. (1992). Markets, Laws and Governments, pp. 338-355 in. In B. Jalan, (Eds.) *The Indian Economy: Problems and Prospects*, New Delhi: Penguin.

Bell, J.N.B., McNeill, S., Houlden, G., Brown, V.C. and Mansfield, P.J. (1993). Atmospheric change: effect on plant pests and diseases. *Parasitology,* **106**: S11-S24.

Bhagwan, V. (1999). *Indian Constitution: An Appraisal.* Delhi: Atma Ram and Sons.

Bhupal, D.S. (1979). *Working of Regulated Markets in Rajasthan*. Department of Economics, University of Jodhpur, India.

Birley, M.H. and Lock, K. (1999). *The Health Impacts of Peri-Urban Natural Resource Development.* Liverpool: Liverpool School of Tropical Medicine.

Bunte, F.H.J. (2000). The vertical organization of food chains and health and safety efforts, ch. 17, pp. 285-300. In L. Unnevehr, (Eds.) *The Economics of HACCP: Costs and Benefits*, St. Paul, Minnesota: Eagan Press.

Codex Alimentarius Commission (1999). *http://www.fao.org/es*/esn/codex*.

Collins, E.J.T. (1993). Food adulteration and food safety in Britain in the 19th and early 20th centuries. *Food Policy,* **18**(2): 95-109.

Compés López, R. and Poole, N.D. (1998). Quality assurance in the maritime port logistics chain: the case of Valencia. *Supply Chain Management: An International Journal,* **3**(1): 33-44.

Darby, M.R. and Karni, E. (1973). Free competition and the optimal amount of fraud. *Journal of Law and Economics,* **16**: 67-88.

Davies, C. (2001). *Air pollution and agricultural insect pests in urban and peri-urban areas of India: a case study of Varanasi*. Unpublished PhD thesis. Imperial College, University of London.

Drèze, J. and Sen, A. (1995). *India: Economic Development and Social Opportunity.* New Delhi: Oxford University Press.

Fearne, A. and García, M. (1999). The Assured Combinable Crop Scheme in England and Wales: carrot or stick? *Farm Management,* **10**(5): 243-261.

Gustafsson, G., Singh, R.P.B., Lejonhud, K. and Vålvik, K.I. (2000). Change and continuity in village India: crisis and prospects in Chamaon. *Fennia International Journal of Geography,* **178**(2): 203-214.

Harriss-White, B. (1995). The changing public role in services to food and agriculture: the legal regulation of food markets in India. *Food Policy,* **20**(6): 585-596.

Hilmer, C.E., Thurman, W.N. and Morales, R.A. (2000). The distributional effects of food safety regulation in the egg industry, ch. 9, pp.133-148. In L. Unnevehr, (Eds.) *The Economics of HACCP: Costs and Benefits*, St. Paul, Minnesota: Eagan Press.

Howes, S. and Jha, S. (1994). Public distribution of food in India: a comment. *Food Policy,* **19**(1): 65-68.

Jukes, D. (1993). Regulation and enforcement of food safety in the UK. *Food Policy,* **18**(2): 131-142.

Marshall, F.M. (2000). *Workshop report. DFID Crop Post Harvest Research Programme project R7530: Enhancing food chain integrity: quality assurance mechanisms for air pollution impacts on fruit and vegetable systems. New Delhi, 18-19 December.*

Marshall, F.M., Ashmore, M.R. and Hinchcliffe, F. (1997). *A Hidden Threat to Food Production: Air Pollution and Agriculture in the Developing World. Gatekeeper Series.* **No. SA 73**. London: International Institute for Environment and Development.

Marshall, F.M., Wildig, T.D., Stonehouse, J., Bell, J.N.B., Ashmore, M.R. and Batty, K. (2000). *The Impacts and Policy Implications of Air Pollution on Crops in Developing Countries. Final Technical Report. Department for International Development Environment Research Programme R6992*. London: Imperial College.

Marshall, F.M. and Wildig, Z. (in press). Social and economic policy implications of air pollution impacts on crops. Ch. 6. In M.R. Ashmore, F. Murray and L.D. Emberson, (Eds.) *Air Pollution Impacts on Vegetation in Developing Countries*, London: Imperial College Press.

Mooij, J. (1999). *Food Policy and the Indian State: The Public Distribution System in South India.* New Delhi: Oxford University Press.

Motarjemi, Y., Käferstein, G., Moy, G., Miyagawa, S. and Miyagishima, K. (1996). Importance of HACCP for public health and development: the role of the World Health Organization. *Food Control,* **7**(2): 77-85.

Nelson, P. (1970). Information and consumer behaviour. *Journal of Political Economy,* **78**: 311-329.

Nriagu, J.O. (1992). Toxic metal pollution in Africa. *Science of the Total Environment,* **121**: 1-37.

Ollerenshaw, J.H. and Lyons, T. (1999). Impacts of ozone on the growth and yield of field-grown winter wheat. *Environmental pollution,* **106**: 67-72.

Ollerenshaw, J.H., Lyons, T. and Barnes, J.D. (1999). Impacts of ozone on the growth and yield of field-grown winter oilseed rape. *Environmental pollution,* **104**: 53-59.

Poole, N.D. (1997a). Change in the European food industry: a research agenda for marketing economists. *Journal of International Food and Agribusiness Marketing,* **9**(1): 1-17.

Poole, N.D. (1997b). Conocimiento y cualidades de los frutos cítricos en el mercado británico. *Investigación Agraria: Economía,* **12**(1, 2 & 3): 89-101.

Poole, N.D. and Baron, L. (1996). Consumer awareness of citrus fruit attributes. *British Food Journal,* **98**(1): 23-28.

Poole, N.D., Del Campo Gomis, F.J., Juliá Igual, J.F. and Vidal Giménez, F. (1998). Formal contracts in fresh produce markets. *Food Policy,* **23**(2): 131-142.

Poole, N.D., Kydd, J., Lynch, K. and Poulton, C. (2000). *Summary Report - Overcoming informational constraints: improving horticultural marketing and technical information flows to smallholders. DFID Crop Post-Harvest Programme Project R7151*. Wye, Kent, Wye College: 39 pp.

Poole, N.D., Seini, A.W. and Heh, V. (2000). *Ghana Country Report - Overcoming informational constraints: improving horticultural marketing and technical information flows to smallholders. DFID Crop Post-Harvest Programme Project R7151*. Wye, Kent, Wye College: 69 pp.

Salay, E. and Caswell, J.A. (1998). Developments in Brazilian food safety policy. *International Food and Agribusiness Management Review,* **1**(2): 167-177.

Segerson, K. (1999). Mandatory vs. voluntary approaches to food safety. *Agribusiness,* **15**(1): 53-70.

Sharma, R. (2001). Personal communication. 22 May.

Sivamohan, M.V.K. (1997). *Institutional Arrangements for Marketing High Value Horticultural Produce. Consultancy report for DFID Crop Post-Harvest Programme*. November: Administrative Staff College of India.

Srinavasan, T.N. (2000). Poverty and undernutrition in South Asia. *Food Policy,* **25**(3): 269-282.

Swaminathan, M. (2000). Consumer food subsidies in India: proposals for reform. *Journal of Peasant Studies,* **27**(3): 92-114.

Swinbank, A. (1993). The economics of food safety. *Food Policy,* **18**(2): 83-93.

Taylor, H.J., Ashmore, M.R. and Bell, J.N.B. (1987). *Air Pollution Injury to Vegetation*. London: Institute of Environmental Health Officers.

United Nations Environment Programme (1999). *Global Environmental Outlook.* London: Earthscan.

Unnevehr, L. and Jensen, H.H. (1999). The economic implications of using HACCP as a food safety regulatory standard. *Food Policy,* **24**(6): 625-635.

Wahid, A., Maggs, R., Shamsi, S.R.A., Bell, J.N.B. and Ashmore, M.R. (1995a). Air pollution and its impacts on wheat yield in the Pakistan Punjab. *Environmental Pollution,* **88**: 147-154.

Wahid, A., Maggs, R., Shamsi, S.R.A., Bell, J.N.B. and Ashmore, M.R. (1995b). Effects of air pollution on rice yield in the Pakistan Punjab. *Environmental Pollution,* **90**: 323-329.

Wilbourn, S., Davison, A.W. and Ollerenshaw, J.H. (1995). The use of an unenclosed field fumigation system to determine the effects of elevated ozone on a grass-clover mixture. *New Phytologist,* **129**: 23-32.

World Bank (1998). *Knowledge for Development. World Development Report 1998/99.* New York: Oxford University Press.