CROP POST HARVEST PROGRAMME

Enhancing food chain integrity: quality assurance mechanisms for air pollution impacts on fruit and vegetable systems

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FINAL TECHNICAL REPORT

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Many other people have made valuable contributions to this work; either directly through engagement with the research process, or indirectly as colleagues, family and friends providing encouragement and support at difficult times. Unfortunately the names are far too numerous to mention.

We do feel particularly privileged to have had the support and engagement of communities involved in participatory work in 16 villages around Delhi and Varanasi and the many of hundreds of households who took part in our consumer studies and other surveys.

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CASE STUDY CITIES

1. DELHI.

Delhi is situated on the western bank of the river Yamuna, and the eastern side of the Delhi Ridge. Haryana State surrounds Delhi on three sides - north, south and west, while on the east it is bounded by Uttar Pradesh.

Delhi Union Territory (UT) also known as National Capital Territory, covers an area of 1483 square kilometres. The estimated 1999 population is 13 million (pers. comm. Chief planner NCRPB) and a third of these people are reported to be living in poverty in slums, often located in urban fringe areas.

Delhi is both the capital and main administrative centre of India, and in the last 50 years since independence has attracted industries and people on a large scale. Decadal growth rates for populations have been as high as a startling 50% in the seventies, eighties and nineties as per the Census of India. It is in the Southern, Southeastern and Eastern parts of the city, areas which extend, along major transport routes such as the national highways and railways, that this urbanisation is occurring at the fastest pace. This means that the urbanised areas are not confined to the Union Territory.

The total number of industrial units in the UT increased from 81,000 in 1990 to 126,000 in 1996, an increase of more than 9% per annum[1] and the number of people employed has risen from 729,000 in 1990 to 1,100,000 in 1996. The main growth sectors are: electronics; garments; leather; engineering goods; chemical products; domestic appliances; automobile parts; sports goods and a large number of consumer goods.

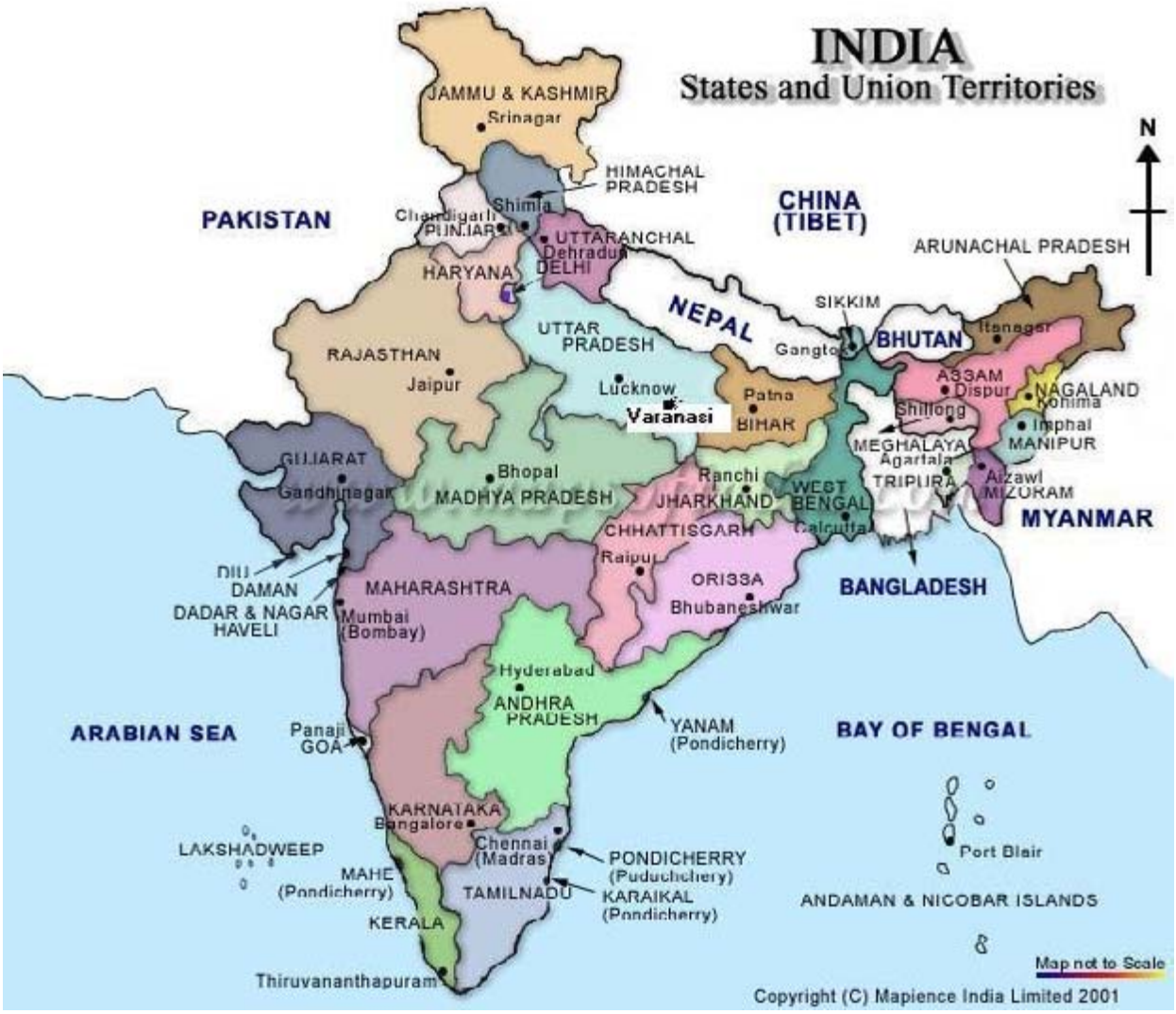
The Masterplan for Delhi 1962 aimed to divert the increasing population and industrialised areas to the towns which surround Delhi. These towns include Faridabad, Ballabgarh, Gurgaon, Bahadurgarh (all Haryana state) and Ghaziabad, Loni and Noida (U.P.) and even Narela within the UT. Thus between 1951-1981 Faridabad registered a growth of 774 percent, Gurgaon 380 percent, Ghaziabad 567 percent, against Delhi's 300 percent (NCRPB, 1996).

With Delhi at its core, these towns almost form a continuous zone of urbanised areas, crossing borders of the UT, which may be called 'Greater Delhi'. These towns principally are located within the area of the six districts adjacent to Delhi. Faridabad district to the Southeast of Delhi, is reported being one of the most rapidly growing urbanised area and industrialised districts in India. In 1990 there were 1,398 operational registered factories, providing employment to 125,000 people (Mukherjee). Furthermore in addition to the number of registered industries that are generally large or medium scale, there are also a large number of unregistered small scale industries.

2. VARANASI.

Varanasi is a regional centre, which clearly does not have the same economic and political status of Delhi and its population is only a tenth of the capital's. However Varanasi is a major pilgrimage destination for Hindus, as it lies on the left bank of the holy Ganges river. The

[1] Statistical Handbook of Delhi, Directorate of Economics and Statistics, New Delhi, pp. pp.86-87, 1998.



city's spiritual qualities and architectural heritage henceforth also attracts a large stream of Indian and foreign tourists, as much as a quarter of a million annually.

Varanasi Urban Agglomeration within Varanasi District, Uttar Pradesh is situated at 82º 56'E–83º 03'E and 25º 14'N–25º 23.5'N. Like Delhi, the urban areas of Varanasi have grown beyond the boundaries of the municipal corporation. The urban agglomeration thus consists of the municipal corporation area plus some of the contiguous urbanised area, including for instance a large railway colony, campus of Banaras Hindu University, industrial areas and a cantonment area (see table 3). Areas including Lahartara and Maruadih, Banaras Hindu University and the Cantonment area now form an integral part of the city.

Varanasi's status as India's holy city means that it is characterised by a strongly floating population. Its static population amounted to almost 600,000 in 1971, 780,000 in 1981and grew by 35% to just more than one million in 1991.

In contrast to Delhi, in Varanasi (also known as Banaras or Kashi) industries have developed at a slower pace. In total 3,505 industries are registered in and around Varanasi. An important industry is the Diesel Locomotive Works factory in West Varanasi. Other industrial activities include manufacturing of metal products, chemicals and chemical products, electricals, food and food products, spinning weaving and finishing textiles, printing of sarees and coal and coal products.

CONTENTS

A. Executive Summary

Recognising the need to address food security for rapidly increasing urban populations in developing countries, this project sought to enhance food chain integrity for selected horticultural foods important to the urban poor in Indian cities. The impacts of air pollution on both food safety (through heavy metal contamination) and nutritional quality were examined, and recommendations for appropriate and feasible public sector and market-mediated approaches to food quality assurance were made. The impact on the livelihoods of horticultural system stakeholders was assessed.

The core research was carried out by a coalition of eight research teams, including environmental scientists, geographers, agricultural economists, participatory researchers and policy advocacy groups. In addition to poor communities themselves, there was extensive consultation and engagement with other public and private sector bodies (micro-meso and macro level).

The study found that consumers are purchasing vegetables with heavy metal contamination levels that greatly exceed prescribed limits. High levels of Lead (Pb) and cadmium (Cd) in spinach were a particular concern. Spinach (palak) is grown predominantly by poor small scale producers in peri-urban areas, and is widely consumed by the poor. Washing of vegetables resulted in a significant reduction of heavy metal contamination.

Enhanced conusmer awareness will be a key driver for boosting demand for food safety. We found that poor consumers who are more likely to be subject to environmental health hazards, are not only less able to pay a price premium, but are also less aware of the potential health hazards of food contamination. Demand for food safety increases amongst the higher income groups. Producers are more aware of hazards, but currently have limited means of expressing concerns to influence policy. Suggestions were made for entry points for enhancing quality-awareness, and supporting appropriate production and post-harvest practices.

Many specific pathways for promoting awareness of hazards, and of safer food preparation practices were explored. For example Government programmes that work with poor communities to enhance *nutritional awareness.* Key potential exists in the Anganwadi/Integrated Child Development Services and the Community Food and Nutrition Education Scheme, although there are recognised operational problems. We also studied complementary programmes run by non-government organisations; a participatory work in a slum colony in Delhi highlighted innovative ways to successfully reach out to poor consumers.

The study is a pointer to the inefficacy of current approaches towards ensuring safety of food to the consumer. Clearly food contamination can take place at various stages of the food chain, and food safety needs to be ensured throughout for it to be safe for consumption. Various interventions must be made from cleaner production sites, to transport and marketing (both wholesale and retail) and consumer practices. Current policy relates to food standards, environmental standards, industrial siting, peri-urban agriculture and consumer rights separately and is inadequate to tackle the issue comprehensively. The project played a major role in creating a wider appreciation and demand for combined technical and institutional approaches for a more integrated approach to food safety in India.

B. BACKGROUND

The interest in systems for assuring the safety of food products has increased dramatically since the beginning of the 1990s, notwithstanding earlier safety scares in the food systems of both developing and advanced countries. In the latter, consumer awareness of the incidence of contaminated food products and the associated health risks has boosted demand for safety as a food quality attribute. Change has mostly resulted from contamination crises. In the former the effective demand for food safety and quality assurance is less evident, but public awareness of the health, education and economic implications of unsafe food systems is growing fast.

B.1. QUALITY ASSURANCE (QA) IN THE FOOD CHAIN

Quality is a complex of properties and characteristics 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:

- Production and post-harvest handling techniques: process, or 'best practice' in respect of technology and inputs including choice and application of agrochemicals and organic fertilisers, processing and storage;
- 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 appearance, and other presentational aspects including labelling) and subjective (utility in respect of economic value, consumer preferences and satisfaction, including flavour, texture, range of choice□.)

Assuring food safety in respect of these dimensions is a complex challenge involving a range of stakeholders throughout the food chain. Different environments, production practices and food products present different challenges, and the different dimensions vary in importance among food systems and cultures.

B.2. FOOD SAFETY AND THE POLICY ENVIRONMENT

The interests of the food industry are related to the regulatory environment for international production and trade in food products. It has been argued that international food safety assurance standards are – or should be - converging (Caswell and Hooker 1996). The concept of critical limits of contaminants is relevant to both health and trade purposes. The concept of Hazard Analysis Critical Control Points (HACCP) for food products is widely disseminated and increasingly practised in advanced food markets, where firm-operated HACCP-based quality assurance is an important mechanism for ensuring production and product integrity. HACCP also feeds into quality assurance for business management processes.

HACCP was advocated by the World Health Organisation as long ago as the early 1970s. It was endorsed much later, in 1993, by the Joint FAO/WHO Codex Alimentarius Commission as the most cost-effective current approach for ensuring food safety. Sanitary and phytosanitary (SPS) measures were introduced into the international policy environment at the end of the Uruguay Round of multilateral trade talks in 1994, by means of the SPS Agreement, in order to regulate the use of such measures as non-tariff barriers to trade. At

the country level, regulations to control hazardous substances in the food chain are being formulated, in developing countries as well as advanced economies, notwithstanding the difficulties of implementation.

There is a growing consensus that both public and private sector initiatives are necessary in enhancing the integrity of food systems. Commercial considerations and government policy together have led the global food industry to introduce assurance mechanisms throughout the food chain. National and international 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. These assertions are consistent with the climate of economic and policy adjustment that seeks to find an efficient and effective balance between public intervention and regulation by the state – be they voluntary or mandatory approaches (Segerson 1998), and private sector activity in response to incentives created by the market.

B.3. Economic and institutional development

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. But food safety is probably income-elastic, so that as incomes rise, more food safety is demanded.

Bad food unquestionably was a major contributant to the poor quality of life in the industrial towns of early 19th century Britain. The review by Collins (1993) of the improvements in the British food system in the 19th century is probably instructive for developing countries and illustrates how economic factors played as significant a part as improved science.

Food standards in Britain had fallen from the mid-18th century because of a range of factors: low incomes, high distributive costs which failed to keep pace with urban development, fraud on a massive scale, congestion and lack of structure in food retailing, absence of legislation, and the difficulties of detecting adulteration and link adulteration with impaired health.

The regulatory framework was improved from 1860 onwards by establishing public analysis, penalties for adulteration, and clearer descriptions of punishable offences. Improvements in food quality were not just a matter of scientific achievement. There were major changes in the structure and organisation of the food industry, accompanied by a fall in real food prices and growth in real incomes.

B.4. MARKET STRUCTURE AND CONDUCT

Concentration of supply, particularly through greater reliance on imports, and improved transport, infrastructure and food handling and conservation technologies improved supply conditions. Distributors were increasingly concerned with securing greater control of their suppliers, even to the point of integration with overseas production. Changes in business culture also played a part, with the development of ethical approaches such as fixed prices, fair dealing and value for money: By late 19th century 'firms now traded on their reputation for honesty, integrity and quality' and trade associations developed. The Provision Trade Association, founded in 1887, 'had regulations covering every aspect of the conduct of the provision trade, from transactions between members to the grading of produce'.

Concentration in manufacturing also led to higher standards through the application of improved technology, greater standardisation of products, and the generation of steady profits. Increased competition played a part in increasing market concentration, not just in manufacturing but also in retailing.

Loss of specialisation of food handling trades, and the increased dependence on merchandising forced moves towards assured quality: 'Sainsbury, for example, was obsessed with quality; he bought only on the basis of detailed information about the product and its provenance, and searched relentlessly for producers who were the best in their field and who could deliver at speed'. As incomes rose, distributors competed more on quality, service and freshness than on price. Branding evolved 'in response to the anarchy of the marketplace with its multiplicity of products of unknown origin and doubtful quality.'

B.5. THE CHALLENGE IN DEVELOPING COUNTRIES

Problems of food safety and quality assurance in advanced economies are prominent at the moment precisely because they have not been resolved. Information is an important dimension. Uncertainty about the fundamental science is important, but information problems arise not just because of lack of information but have much to do with the abuse of information, or dissemination of misinformation, and the existence of asymmetric information between stakeholders and the attendant agency problems.

Measures leading to improved food QA in developing countries are likely to bear some similarity to the British experience outlined above. In more recent history, Resende (1993) states that the level of food safety in Brazil is associated with the level of socioeconomic development. His case study shows how consumer protection was enhanced by the measures in the 1988 Constitution that established the municipalisation of food control services. The more dynamic and modern food control mechanism introduced then have been associated with improved primary health care and a unified health system. At the time of Resende's work, the appropriate balance of responsibilities between central and decentralised administration was unclear. Moreover, it was suggested that considerable technical and financial assistance and institution-building would be needed to implement the new system.

Efficient, effective and relevant QA mechanisms are likely to involve improved scientific knowledge, accompanied by technical and institutional responses through both regulatory and market mechanisms. Analysis of QA mechanisms in the UK by Wye researchers has highlighted the importance of the appropriate balance between the 'carrot' and 'stick' approaches (Fearne and García 1999; Fearne and García 1999). Therefore, 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. This insight is particularly relevant to developing countries.

The appropriate approach to QA will depend on the type of hazard or quality imperfection and also the potential technological and institutional solutions. Interpreted as a quality attribute, food safety has been disaggregated into a) 'search' or b) 'experience' goods if the consumer is able to either obtain information a) through inspection or access readily available information (eg labelling), or b) through repeated purchases or reputation effects (eg branding) (Segerson, 1999). QA systems for such safety hazards are likely to use market-mediated incentives, or 'carrots'.

For other hazards, in respect of which safety attributes are 'credence' goods, for which information cannot be discerned even after repeated consumption, QA may involve control

or elimination by regulation – 'sticks'. Even in the absence of market-driven incentives, mandatory regulation or controls may not be necessary if firms can be induced by policy 'carrots' or 'sticks'. Alternatively, and if feasible, the provision of information through the introduction of labelling, branding or certification can convert credence goods into search goods.

B.6. FRUIT AND VEGETABLE PRODUCTION AND MARKETING IN PERI-URBAN AREAS OF INDIA

The livelihoods of inhabitants of urban and peri-urban areas are dependent on access to cheap and safe food of high nutritional quality. In rapidly growing populations, food insecurity is becoming more of an urban problem, with poor families in developing countries spending as much as 60 to 80 per cent of their income on food (FAO, 1998).

It is particularly important to encourage the consumption of highly nutritious fruit and vegetable (F&V) crops, but as the income elasticity of demand for these products tends to be high, there is a clear need to increase supply and maximise the nutritional quality of these products to benefit the poor.

The cultivation of vegetables is labour intensive, and in India is carried out mainly by small scale, marginal and migrant farmers. Vegetables are high value cash crops, but there are considerable problems associated with lack of adequate information and support for growing, and little organisational set up for packing, storage, transport and marketing. Over the past 3-4 decades, production of fruit and vegetables has increased considerably in India, although average farm yields are still low compared with potential production, and post-harvest losses are high (estimated at 25-30%).

The majority of highly perishable products, including many vegetables that are consumed in Indian cities, are produced in peri-urban areas. For example, current work being carried out by the Imperial College applicants (ERP 6992) supports the evidence that 50-70% of cauliflower and 70-90% of spinach that is marketed in Azadpur (the largest fruit and vegetable market in Asia) is produced in Delhi and the six surrounding peri-urban districts. Mother Dairy, the main co-operative providing produce to Delhi consumers, also procures 70% of its produce from these urban and peri-urban areas.

The peri-urban interface represents areas of dynamic institutional and environmental change, with problems that are often not addressed adequately by existing institutional structures and established thought. In particular, the role of urban and peri-urban agriculture has not been well recognised, researched or supported in India. However, recent activities (eg DFID funded projects lead by Imperial College, and others led by the University of Birmingham and NRInternational) have begun to raise the profile of the issues associated with food production and supply in urban and peri-urban areas for Delhi, Varanasi and the Hubli-Dharwad city region. There is now interest from the Indian Council of Agricultural Research and elsewhere to collaborate in pursuing these activities (G B Singh pers. com.)

A team led by the project leader of this current initiative have been working in partnership with research institutions and farmers (project R6992) in Delhi and Varanasi. Activities included an investigation of the role of agriculture in the livelihood strategies of the urban and peri-urban poor; an examination of the major constraints faced by urban and peri-urban producers; a preliminary assessment of the contribution that crops grown in these areas make to food supply in the cities, and an analysis of the price spread of some major vegetable crops. The farming communities, and other stakeholders involved have indicated that there is a serious lack of institutional support and a lack of timely and appropriate advice to overcome production and marketing problems.

B.7. IMPACTS OF AIR POLLUTION ON CROP PRODUCTION

There are a number of specific environmental threats to vegetable yield, quality and safety in urban and peri-urban areas. These issues need to be considered in the context of the existing recognised constraints on agricultural production, and systems for marketing, environmental monitoring and quality control, in order that policy recommendations can be made that will be realistic, effective and appropriate.

The Imperial College applicants have been working in partnership with Indian scientists, NGOs and planners since August 1995, examining issues associated with air pollution as a constraint to crop production (ERP R6289 and R6992). This work has included a scientific programme, which is carried out in parallel, and closely linked with, participatory and policy research activities. The aim is to quantify and understand the significance of air pollution impacts on crop yields in India, with particular emphasis on the livelihoods of the poor. The team raised awareness of air pollution as a threat to crop productivity and made policy recommendations, largely based on links with ongoing air pollution control initiatives in India. These previous activities provided a sound basis for the current work.

B.7.1. IMPACTS ON CROP PRODUCTIVITY

The production of crops in urban and peri-urban areas is subject to a range of constraints not applicable to the rural situation. A major threat to crop production is provided by gaseous air pollutants - notably sulphur dioxide, nitrogen oxides and the secondary pollutant, ozone. Emissions of both sulphur dioxide and nitrogen oxides and ozone precursors are increasing in the developing world caused by industrialisation and population growth, which results in increased traffic and domestic emissions (Marshall et al., 1997; Ashmore and Marshall, 1999). These phytotoxic gases have important and increasing impacts on the livelihoods and wellbeing of producer and consumers through effects on urban and peri-urban crop production

The direct impact on crop yield are already the focus of current and recent work by the Imperial College applicants. Yield reductions of 40% or more have been recorded as a result of ambient air pollution on rice and wheat on the outskirts of Lahore, and on spinach and mustard on the outskirts of Varanasi. Clearly there are major implications in terms of the livelihoods of producers and food security for the urban and peri-urban poor.

B.7.2. IMPACTS ON CROP QUALITY

Air pollution also has the potential to reduce the nutritional quality of crop plants, with important implications for consumers, particularly the poor (Marshall et al., 1997; Ashmore and Marshall, 1999). Effects on carbohydrate metabolism, allocation and storage within plants have been studied (Koziol, et al., 1988) as has amino acid, amines and proteins production (Rowland et al., 1988 and Pell, 1988). Exposure to O_3 has been shown to cause significant decreases in non-structural carbohydrates, and protein content (Pell, et al., 1997) and in the nitrogen content of some fruit and vegetables. Some research into the biochemical changes associated with this issue have been carried out in India, but there is a need to link these theoretical studies with measurements of nutritional quality of vegetable crops grown in the field, and marketed output. There is also a need to develop simple techniques to monitor the magnitude of this phenomenon.

Air pollution can also affect the quality of F&V products by causing physical defects. Consequent reductions in income for vegetable producers and suppliers arise from visible damage to the edible portion of the crop (Taylor, Ashmore and Bell, 1987), reductions in the shelf life, and by making the products more susceptible to post-harvest pest and disease attack (Bell et al, 1993).

B.7.3. IMPACTS ON CROP SAFETY

There are major concerns over toxicity in food crops caused by heavy metal deposition (for example lead, cadmium, zinc and copper). These can accumulate at toxic levels in the edible portion of crop plants. Both industrial sources and motor vehicle derived sources are likely to be important for urban and peri-urban agriculture. The nature and extent of this issue has not been examined in relation to vegetable production in India. There is an urgent need to research this issue, comparing measured levels of these pollutants with recognised health standards from elsewhere in the world.

Improved livelihoods through increased yield, quality and safety of food production in peri-urban areas can be achieved by addressing threats from environmental pollution. Indeed, there is potential to ameliorate the impacts described above, through agricultural measures such as changes in crop cultivars, and fertiliser regimes. However, effective solutions will only be achieved through a combination of rigorous scientific research, improved information systems to support production and marketing of food crops, increased consumer awareness and the facilitation of policies and programmes that can provide integrated approaches to tackling these emerging threats to food safety. This is likely to include a range of regulatory and voluntary measures to tackle pollution at source,

B.8. QUALITY ASSURANCE, FOOD SYSTEMS AND CONTRACTUAL RELATIONSHIPS: A FOOD SYSTEMS APPROACH

Researchers from Wye have been involved in analysing market systems that are primarily rural in origin. These have concerned livelihood and other studies of market systems for inputs and products, domestic staples, other edibles including vegetables and fruit, and other cash crops, in advanced and developing economies. It has been noted by Wye researchers that in well integrated and more populous areas, the boundaries between rural, peri-urban and urban regions are at best indistinct (Poole, Kydd et al. 1998).

Similarly the distinction between production and post-harvest stages in the food chain needs to be handled with caution. Regarding the safety of food at the time of consumption, due recognition needs to be given to sources of contamination and critical points from the primary factors of production and inputs, through production and post-harvest handling, transport, storage and processing, to domestic food preparation and consumption.

The marketing system from the supply of inputs to the point of final consumption is the channel for the physical flows of produce and finance. Marketing economics is concerned principally with the technical and economic efficiency of marketing functions and organisations of the system - which is not the focus of this study (Scarborough and Kydd, 1992). The marketing system is also the mechanism whereby information and incentives are communicated among participants. The economics of institutions is concerned primarily with the coordination efficiency of the interpersonal and interfirm transactions. Thus, understanding the production and marketing chain or system is a prerequisite for analysing the form and terms of transactions that communicate incentives and information to market

participants. Efficient and effective vertical transmission of information and incentives is an important constituent of the mechanisms for quality assurance.

Furthermore, analysis of QA mechanisms in the UK by Wye researchers has highlighted the importance of the appropriate balance between the carrot and stick approaches (Fearne and García 1999; Fearne and García 1999). 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. This insight is particularly relevant to developing countries.

B.8.1. INFORMATION PROBLEMS: THE NIE CONTRIBUTION

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 1996; Poole 1996; Poole and Baron 1996; Poole 1997).

Insights from New Institutional Economics (NIE) have been used to analyse the often interlinked contractual relations between input suppliers, producers and first buyers in agrifood systems in developing countries (Dorward, Kydd et al. 1996; Dorward, Kydd et al. 1998; Dorward, Kydd et al. 1998). Work in progress on vegetable markets in three Sub-Saharan African countries (DFID project R7151) focuses on informational imperfections as a constraint to market efficiency, and assesses the importance of production, producer and product characteristics on market access (Poole, Kydd et al. 1998).

The importance of the vertical coordination mechanisms between suppliers, producers and marketing intermediaries, and the differential impacts on livelihoods of stakeholders, underlie the NIE approach used in these studies. Thus, contractual relationships are an important mechanism to address agency problems in food systems (Poole and Del Campo Gomis 1998; Poole, Del Campo Gomis et al. 1998) and these issues are directly relevant to the establishment of quality assurance mechanisms (Compés López and Poole 1998).

B.8.2. INCENTIVE PROBLEMS: THE COSTS AND BENEFITS OF FOOD SAFETY

Whether or not food chain stakeholders engage in quality assurance activities depends in part on the mix of incentives to which they are subject. Incentives may be positive, and result in the 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).

Efficient, effective and relevant safety mechanisms are likely to involve both regulatory and market mechanisms. The policy framework, or stick approach, is an important element of a QA system. Experience gained from studies in advanced economies suggests that, the carrot approach, or market- or contract-mediated incentives may be more important.

B.9. EVIDENCE OF DEMAND FOR THE RESEARCH

The project team had been working on urban and peri-urban environmental issues in Delhi and Varanasi for a number of years prior to this study.

Demand for the proposed research was clearly expressed by collaborators and other organisations involved in our current research in India, including NGOs, governmental

bodies, research institutions and farming communities. For example, Local producer-consumers in many of the case study villages for our participatory research (R6992) were very keen to understand more about the impacts of the industries in the vicinity of their homes on food crops. Senior officials in the ministry of agriculture discussed the fact that whilst the focus of toxicity research and regulation at the ministry of agriculture is concerned with pesticide contamination, heavy metal contamination is recognised as an important issue that had been neglected so far, and interest in linking with the proposed research was expressed.

There was also demand expressed from the CPHP South Asia office. Dr Andrew Hall was, at the time we submitted the project beginning to develop the CPHP country framework document for India. One of the broad themes was to be contamination of the food chain. He suggested that the project could act as a focus or starting point for a cluster of projects on this issue – possibly laying the groundwork for promoting our approach in other market sectors. He also recognised the project had strong elements of the other key country theme which concerns emerging patterns of institutional linkages and the opportunities these present for servicing the needs of the poor.

C. PROJECT PURPOSE

The project addressed the following CPHP programme output, which was defined as the project purpose in the logical framework:

> *Strategies developed which improve food security of poor households through increased availability and improved quality of horticultural foods and better access to markets.*

The project will contribute to the purpose of improving food security of poor households in urban and peri-urban areas through:

1. *Improved quality* – by recommending feasible technical and institutional approaches to address specific threats to the quality of horticultural products important to the poor.

2. *Improved access to markets and availability of produce* – Through extensive consultation with stakeholders, the information flows in current marketing channels will be examined, highlighting the specific problems faced by the poor and ways in which they might be addressed.

The specific project objectives were:

- To assess air pollution effects on vegetable quality and safety, and implications for poor people in urban and peri-urban India;
- To examine information flows in current marketing channels, through extensive stakeholder consultation, to highlight the specific problems faced by the poor and ways in which they might be addressed.
- To identify and recommend feasible technical and institutional approaches to improved product quality assurance of selected horticultural food

The importance of 'Process'

Whilst the project focuses on specific well defined development 'issues'– such as understanding the impacts of environmental pollution on the poor, and recommending the feasible technical and institutional measures for improving food safety. There is an additional underlying purpose, of (at least) equal importance in terms of a long term contribution to development. This is to explore, at a very practical level, how we can develop appropriate partnerships and networks that will enable us to understand and prioritise environmental threats to the livelihoods of the poor whilst learning appropriate means of addressing these in the context of a wider and economic and political environment. One important and demanding aspect of this approach is bringing together actors (both research and non-research organisations) in entirely new types of dynamic partnerships, finding effective means of sharing perspectives, defining common goals, and developing new working practices on a day to day basis. These new partnerships must not create undue clashes with the existing institutional demands of individual collaborators, but at the same time must find appropriate means to challenge them in favour of a more holistic approaches to involvement in 'development' related initiatives.

These objectives are in many ways in line with the emerging literature on 'evidence based policy' and innovations systems perspectives, but evolved, in this case, simply from practical project management experience and a desire to explore ways of ensuring that science and

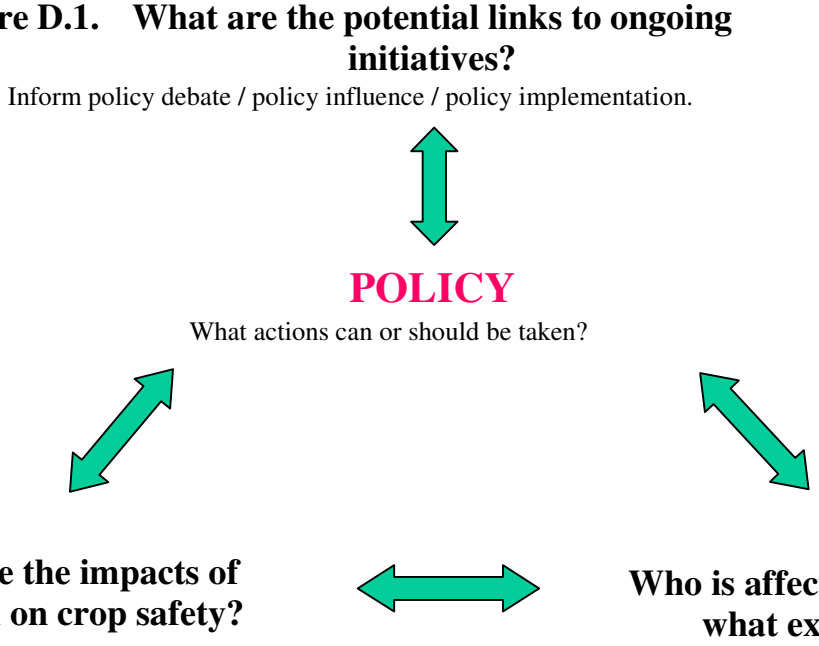
technology can have a more integrated, more effective role in the process of development. The basis of this was to try to create an enabling environment for new roles and relationships to evolve, which challenged traditional boundaries .We were well aware that these vital 'process' elements are often not recognised or supported in formal evaluations of initiatives that are perceived as 'traditional science and technology' based projects. The fact that we were producing the first real evidence that environmental pollution was indeed a threat to food safety, in parallel to developing the appropriate partnerships and approaches to address it, added an additional challenge to the work.

D. ACTIVITIES AND OUTPUTS

Introduction

The project activities can be represented in the context of two very simple representations of the task at hand. The first (figure D.1) indicates that the team must devise means of developing a shared understanding (between themselves and the wider stakeholder group) of appropriate policy responses to addressing the impact of environmental pollution on fresh vegetable produce. In order to do this, we devise means of involving grassroots stakeholders in the process of investigating threats to food safety and the associated implications for livelihoods. The team also identifies policies and programmes with potential relevance to this issue, and engages the stakeholders involved by identifying common interests. Strategies are established for informing relevant policy processes, influencing them as appropriate, and recognising aspects of the implementation process that can be utilised in our particular context. Potential technical interventions which might be required to improve food safety, can then be matched up with a realistic assessment of the institutional mechanisms by which this could be achieved.

Figure D.1. What are the potential links to ongoing initiatives?



For the purposes of this project we are considering the entire production – consumption chain, and the factors that influence the behaviour of those directly involved in it, as a 'system'. This system includes the 'external' influences determined by current social, political and economic priorities. In the manner described above, the project activities are designed to understand how that system operates, and how it might most appropriately be utilised to monitor and address the risks associated with contamination of local vegetables with heavy metals. Thus, distinct clusters of project activities focus on parts of the system, but there is a constant cross-referencing to the context of these activities within the wider system.

A simplified diagram of the food production- consumption chain is provided in Figure D.2, and D.3. and the clusters of major activities that are associated with it can be summarised as follows:

- Research to understand the nature and organisations of the vegetable marketing system and its significance to the livelihoods of the poor (micro level level analysis)
  Described in section D1 of this report

- Research into 'horizontal' relationships between stakeholders in the marketing system – identifying the level of coordination and potential entry points for conveying food safety messages (micro level analysis)
  Described in section D1 of this report

- Research into the nature, extent and source of heavy metal contamination at various points in the marketing chain, and technical means of addressing it. (micro level level analysis)
  Described in section D2 and D3 of this report

- Research into the functioning of 'vertical' relationships between stakeholders in the vegetable marketing systems and the policies and programmes with potential to convey food safety messages or actively address food safety concerns. This will include, for example: formal and informal processes to improve the nutritional status of the poor; the role of traders associations; the functioning of consumer rights organisations; current industrial pollution control measures.
  (meso-macro-micro level analysis and engagement)
  Described in section D4 and D5 of this report

- Identification of the most appropriate institutional mechanisms for influencing the activities of stakeholders - in order that the consumption of heavy metals (via contamination of fresh produce in urban areas) is reduced. (micro-meso-macro level analysis)
  Described in sectionD4, D5 and section E (contribution of outputs) of this report

Figure D.2. Interventions for improved food safety

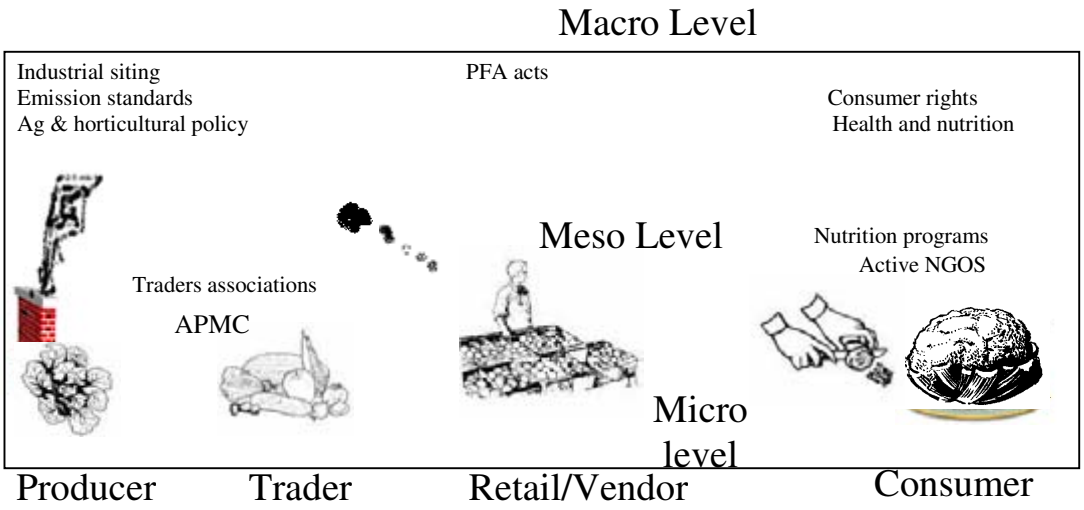
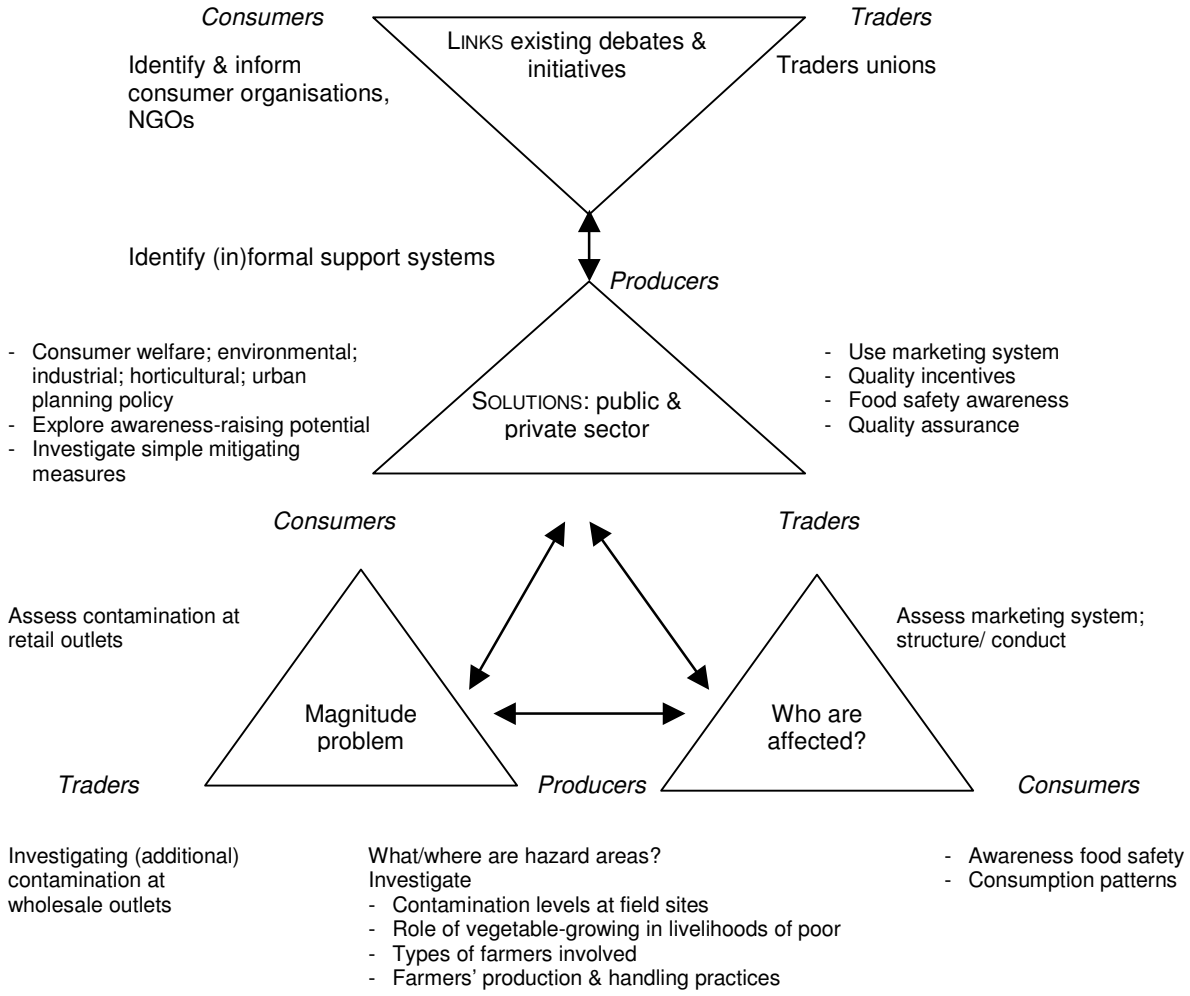


Figure D.3. Enhancing food chain safety



D.1. VEGETABLES AND THE LIVELIHOODS OF THE URBAN AND PERI-URBAN POOR - IMPLICATIONS FOR FOOD SAFETY STRATEGIES.

This section discusses our research into the structure and function of the peri-urban food chain with regard to the provision of fresh vegetables from farm gate to consumer. It includes our assessments of the importance of the vegetable system for the livelihoods of key stakeholder groups. These assessments, along with an understanding of food safety awareness amongst producers, market intermediaries, retailers and consumers enabled us to:

1. Examine how vegetable handling practices can impact on the safety of vegetable crops, and how the relationships between stakeholders in the food supply chain, and with those implementing relevant policies and programmes, could influence these practices.

2. Identify potential interventions in the supply chain, which might enhance the safety of produce, and implications for these interventions to the livelihoods of the poor people involved in production, marketing and retailing of vegetables

The information presented in this section is a summary of a series of major research activities including extensive market surveys, mapping activities and participatory research in 15 villages. All of these activities have separate, and more detailed reports available, which include full details of methodologies, questionnaires utilised etc.

There was, in addition, and extensive literature review of food quality and quality assurance systems. This included background information on nutritional concerns in India relating to the poor and vegetable consumption. This report was submitted to DFID during the first year of the project and is available on request.

For the purposes of explanation, the research activities and outputs are presented in the following sections, and are followed by a more integrated discussion of the results in the context of issues 1 and 2 above:

i) Marketing surveys and additional field surveys to determine where urban vegetables come from (in terms of geographic locations, types of farms and producers)?

ii) Participatory research to assess the importance of vegetable cultivation to support the livelihoods of the poor (including an assessment of food safety awareness amongst producer-consumers)

iii) Marketing research to understand the organisation of the vegetable marketing system from production to consumption, to assess the level of coordination, and to identify policy entry points for improving performance.

iv) Consumer surveys to assess nutritional awareness, vegetable consumption patterns, food safety awareness, and food handling practices that might impact on food safety.

D.1.1. WHERE DO URBAN VEGETABLES COME FROM?

I. ACTIVITIES

I.a. Varanasi

A previous DFID funded research project conducted by the research coalition (ERP 6992) provided satellite imagery indicating areas with dominance of arable land uses in and around Varanasi in 1999. These images could be used as base maps for further investigations, but did not enable accurate identification of specific crops grown. Therefore the Imperial college team worked with the geographers and agricultural economists and others to determine the main production areas of vegetables such as okra, spinach, beet and cauliflower which are commonly consumed by the poor (this assumption of produce consumed by the poor is based on evidence from our participatory research and extensive field surveys from our previous DFID funded research).

In the current study, the four largest wholesale and retail markets in Varanasi were surveyed using questionnaires targeting farmers and traders, as they arrived at the markets, to determine the origin of produce. Surveys were undertaken in different seasons to obtain an accurate picture of peak seasons for each of the produce.

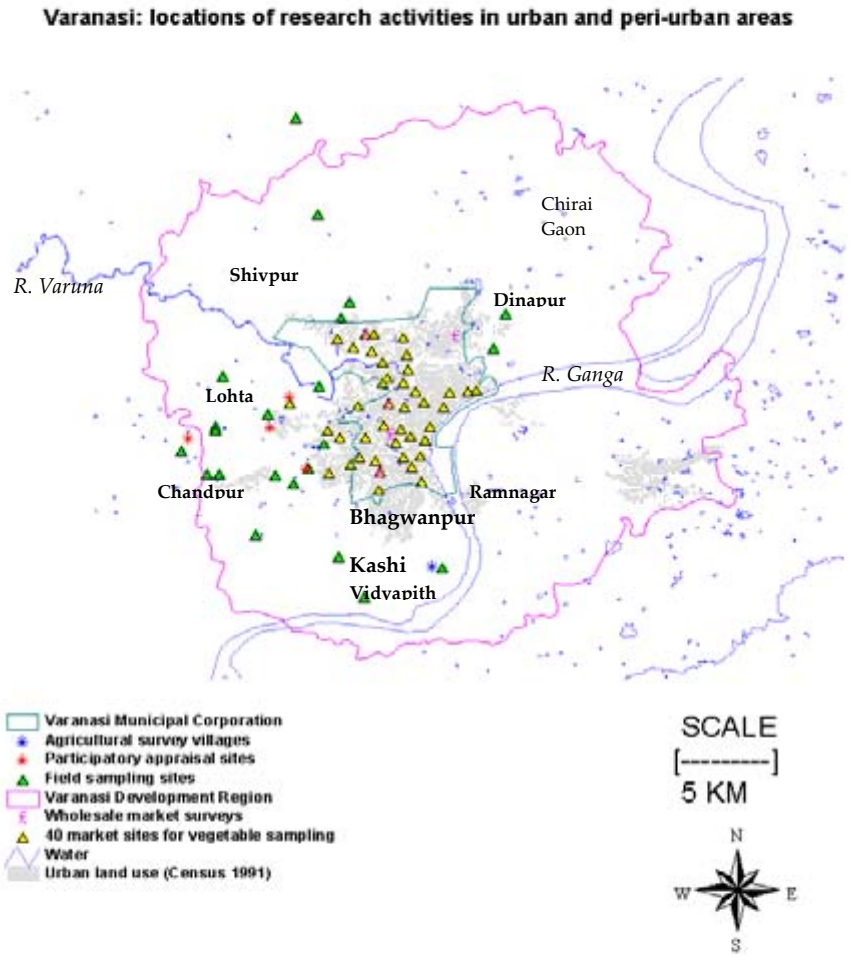
In the early stages there were some difficulties in verifying the market data gathered. For example, the first survey results of October 2000 indicated peak supply villages which were intended as a guide to select crop field sampling locations for heavy metal analysis. Thus the intention was that the extent of heavy metal contamination at time of harvest could be determined for the crops from villages that were key suppliers to local markets. However during field visits in May 2001, few okra cultivating sites could be located in the villages that had been indicated from the market survey. It became clear that farmers do not consistently cultivate okra in both rainy and summer season as suggested by the survey work.

From May 2001 new rounds of market surveys were organized, and followed up by immediate field visits to the villages to verify the data. The method applied was to interview all traders in each of the markets during peak hours of trade, 8-12am spending 3-4 subsequent days in each market, to determine the source village of okra, palak, and cauliflower supply. Another round was conducted in October 2001 for all three crops, however it was too early in the local cauliflower season to obtain a good picture of supply and therefore this crop was resurveyed in November 2001. The October round also highlighted that little supply was noted for the area to the north-east of the city. Accordingly, the Koniya market was included - the results highlighted that its 'cauliflower command area' lay precisely to the northeast of the city.

Simple frequency counts of supplying villages were made. Villages that were mentioned by 5 or more traders were immediately visited and the number of plots sized 2 bishwa (a local unit of measurement amounting to 252.9 sq. metres or about $1/16^{th}$ of an acre) growing the respective crop were counted. Researchers decided to use this unit as it appeared to be a very common size of plots in the area of survey, especially for palak.

Finally, the location of villages with high frequencies of produce arrivals were mapped in hard and digital formats providing a picture of important vegetable supply zones to the major wholesale markets in Varanasi. The zones are indicative rather than exhaustive. Only the high frequency villages are shown, widely scattered villages with low frequency of supplies are not represented in the maps. Under- representation can also have been caused by the selection of 4 major markets, excluding smaller but locally important markets, as highlighted by the survey of Koniya.

Figure D.1.1

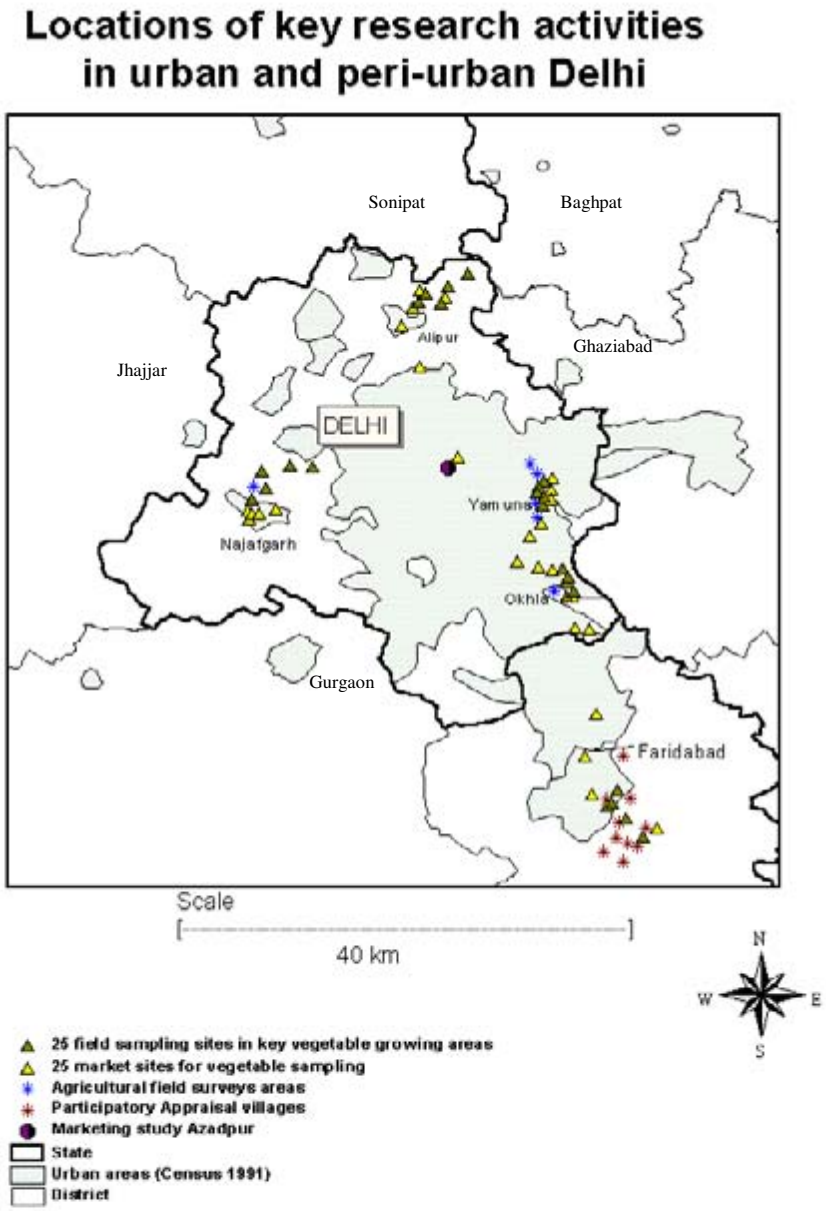


Satellite image: February 1999, IRS 1-C, 25 meter resolution, swath 140 x 127 km.
Map digitised by RMSI, adapted by D. te Lintelo (Imperial College)

I.b. Delhi

Analysis of key vegetable production builds on the knowledge generated in a previous project carried out by the research coalition and funded by DFID (ERP 6992). This previous project had conducted in depth studies to identify the origin of produce in Azadpur wholesale market for potato, aubergine and palak. This data was supported by new research activities, which combined investigation of the origin of produce with other research into the functioning of the vegetable marketing system.

Figure D.1.2



As part of the pilot survey of okra, palak and cauliflower marketing in Azadpur wholesale market that was carried out from 6-11 November 2000, enquiries were made with a range of market functionaries concerning the source of produce (Table D.1).

Table D.1.1. Number of respondents in the November 200 vegetable marketing pilot study Azadpur, Delhi

	Assembly wholesalers	Commission agents	Mashakhores
Okra	15	15	24
Cauliflower	15	15	24
Palak	15	15	24

Cauliflower was selected for further in depth surveys with market actors. Most relevant here were the interviews of 150 farmers delivering cauliflower that were carried out from 2-8th of February 2001 in Azadpur market.

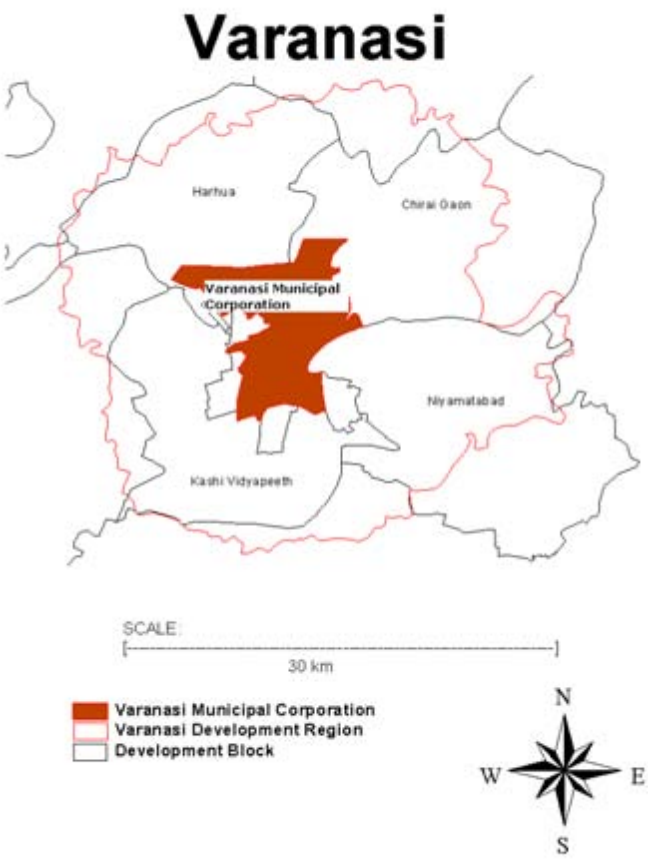
II. OUTPUTS

II.a. Varanasi

Production areas have been identified through surveys of farmers and traders in 4-5 key wholesale markets in Varanasi. Generally, it was observed that those villages that dominate supplies had good access to metalled roads, therewith facilitating access to urban markets. Each of the markets surveyed also appears to have its own geographic hinterland that primarily supplies it with the vegetables.

The supply of palak appears generally to be widespread, with no particular villages dominating the trade in summer season. Over 100 villages were registered as supplying palak and 210 supplying okra and in about three quarter of cases, only one or two respondents arrived from one particular village indicating the widespread cultivation of the vegetables. However, in some markets particular villages could be quite dominant; this was the case in Sunderpur where half of its supplies were received from 14 (out of 65 recorded) villages. Also in the winter season, the great majority of villages supplying to the wholesale markets are located within an 8-10 km radius, accordingly source areas correspond roughly to the Varanasi Development Region.

Figure D.1.3.

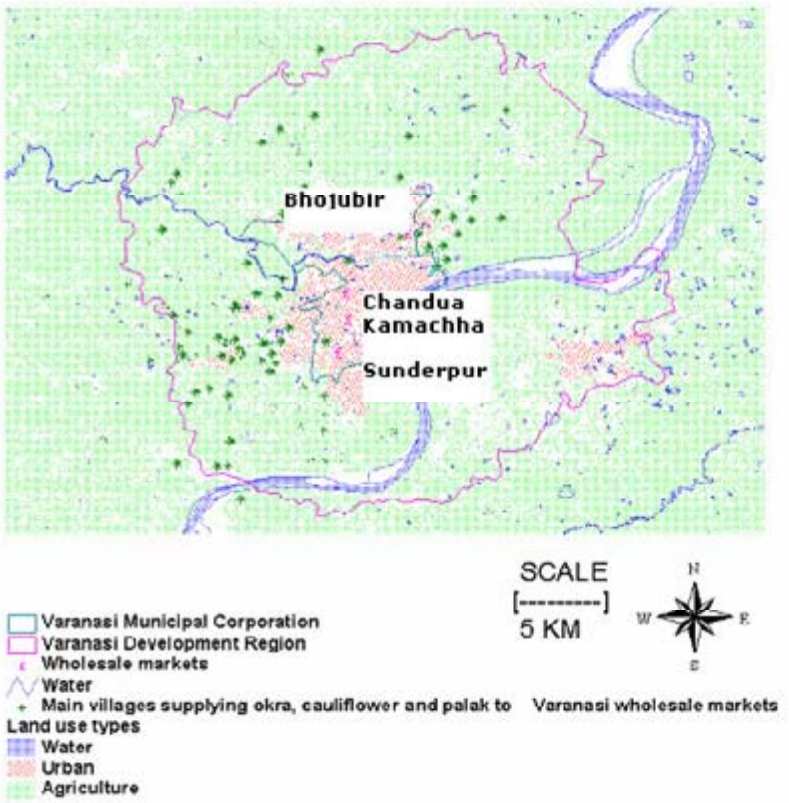


Our initial maps suggested that very little produce originated from the Niyamatabad District, the area southeast of the city across the Ganges, a rapid field survey was carried out in July 2001 to investigate this further. 5 Villages were visited in and around Ramnagar industrial area. These visits confirmed that few vegetables were cultivated for marketing purposes, due to poor irrigation facilities as well as infertile soils, attributed by the farmers themselves to the dumping of industrial effluents in irrigation canals.

In the Table D.2, a summary is given for cauliflower, palak and okra supply villages, for which the frequency of arrivals and percentage of produce volumes during the market survey are given. Also presented is the number of plots counted larger than 2 biswa (253 square meter) during visits to the villages in question immediately after the market survey was completed. Similar tables with information regarding important source villages in other seasons have also been prepared for market surveys in the months of May/June 2001 and October 2000. However, these are presented as a map in Figure D.1.4 below and summary notes for each of the surveys are provided.

Figure D.1.4.

Locations of important urban and peri-urban villages supplying vegetables to Varanasi markets



Satellite image: February 1999, IRS 1-C, 25 meter resolution, swath 140 x 127 km.
Map digitised by RMSI, adapted by D. te Lintelo (Imperial College)

Table D.1.2. Villages supplying vegetables (Bhindi, Palak, Gobhi) to Varanasi markets, October 2001

Market	Village	Frequency of supply	Plots No. >253 Sq.m.	Locational reference (Census/Revenue Village Code), Se No. VDR Map
Sundarpur	Dayapur (*Bhindi*)	9	53	~ 4km W from Lohta, near Ramareypur (1095), 384
Sundarpur	Ghamhapur (*Gobhi*)	8	26	12km NW from Sundarpur, Kashi VP DB (1224), 346
Sundarpur	Karnadandi (*Gobhi*)	8	31	~ near Mohansarai, GT Rd meeting at diversion (1199), 380
Sundarpur	Saraidangri Kalan (*Palak)*	4	37	~ 4km SW from BHU, adjacent to Tikari (1313), 447
Kamachha	Banpurwa/ Ramna (*Bhindi*)	4	25	2.5km SE from BHU & 2.3km W of RIE (Ramanagar) (1327)
Kamachha	KANPUR (*Gobhii*)	6	----	~ 600km W of Varanasi, a big Satti & metropolis
Chandua	Allauddinpur (*Bhindi*)	5	8	~ 4.5km W from Lohta on Bhadohi Rd (1247)
Chandua	Bhaidpur (*Bhindi*)	4	23	~ 7km W from Lohta (1103)
Chandua	Kapar Forwa (Khetari)(*Bhindi*	4	28	~ 10km NW from Chandua (1054), 282.
Chandua	Bharthara (*Palak*)	7	46	~ 2km NW from Lohta (1220), 347
Chandua	Bharthara (*Gobhi*)	4	27	~ 2km NW from Lohta (1220), 347
Chandua	AGRA (*Gobhi*)	5	----	~ 563km W of Varanasi, a big Satti and a metropolis
Bhojubir	Murdi (*Bhindi*)	4	31	16km N from Bhojubir Satti on Sindhora Rd (238)
Bhojubir	Surwan (*Palak*)	10	62	~ 9km W from Bhojubir Satti, near Jaunpur Rd (693)
Bhojubir	Laskaria (*Palak*)	8	41	~ 16.5km SW from Varanasi Rly Stn in Araziline Block at Mirzapur border (1184)
Bhojubir	Ahmadpur (*Palak*)	5	38	~ 3km N from Shiopur (664)
Bhojubir	Chuppepur (*Gobhi*)	5	28	~ 2.3km N from Shiopur (747)

Notes: RIE, Ramanagar Industrial Estate; CIE, Industrial Estate Chandpur; DLW, Disel Locomotive Works; LT, Lahartara industrial area; SV, Shivpur industrial Area

Winter:

- The market and field surveys of October and November 2001 make it clear that the great majority of villages supplying to the wholesale markets are located within an 8-10 km radius, accordingly source areas correspond roughly to the Varanasi Development Region.
- The maps showing the location and catchment areas of Gobhi supplying villages to Sattis clearly reveal the western affinity around Sundarpur, Kamchha and Chandua; northern affinity around Bhojubir; and northeastern affinity around Koniya.
- Whilst normally palak is a popular crop in October, few villages were reported with high frequencies of supply to the markets. The researchers attribute this anomaly to heavy unseasonal rains in the period August to early October 2001 resulting to loss of vegetable yields.

Table D.1.3. Important villages supplying cauliflower to Varanasi markets, November 2001

Satti / Mandi	Source Village	% of total supply	Frequency of supply	No. of plots >253 Sq.m.	Locational reference (Census/Revenue Village Code), Se No. VDR Map
Sundarpur	Darekhu	29.56	25	121	~ 1km N of the GT Rd, 11km W from Varanasi Rly Stn (1116), 364
Sundarpur	Madhaon	27.32	22	115	~ 1km W of DLW, 1km S of Bhullanpur (1284), 389
Sundarpur	Ghamhapur	7.50	7	39	~ 12km NW from Sundarpur, Kashi VP DB (1224), 346
Sundarpur	Karnadandi	6.74	7	41	~ near Mohansarai, 1km from the GT Rd meeting at diversion (1199), 380
Sundarpur	Bikapur (Hardattpur)	4.63	5	42	~ Near Jagatpur on GT Rd, 13km W from Varanasi Rly Stn (1121), 381
Kamachha	Kesharipur	33.11	18	93	~ 9km W of Vns Rly Stn, along the GT Rd (1234), 372
Kamachha	Madhaon	18.77	10	71	~ 1km W of DLW, 1km S of Bhullanpur (1284), 389
Kamachha	Nakain	14.07	7	53	~ 1km SW from Madhaon, the neighbouring village (1270), 388
Kamachha	Ghamhapur	9.72	4	37	~ 12km NW from Sundarpur, Kashi VP DB (1224), 346
Kamachha	Tanria (~Bairwan)	9.77	3	21	~ 15km W from Vns Rly Stn, on the GT Rd, (a hamlet of Bairwan)
Kamachha	Darekhu	7.01	4	29	~ 1km N of the GT Rd, 11km W from Varanasi Rly Stn (1116), 364
Chandua	Bharthara	35.94	38	241	~ 2km NW from Lohta (1220), 347
Chandua	Naraur	16.43	13	87	~ 5km W of DLW along the GT Rd (1260), 384
Chandua	Lakhanpur	6.86	6	45	~ 1km W of DLW, 0.5km N of Bhullanpur on the GT Rd (1238), 375
Chandua	Jagatpur	4.78	5	41	~ 10km W of Vns Rly Stn, on the GT Rd (1122), 382
Chandua	Karnadandi	4.26	4	37	~ near Mohansarai, 1km from the GT Rd meeting at diversion (1199), 380
Bhojubir	Chuppepur	28.75	15	103	~ 2.3km N from Shivpur (747), 223
Bhojubir	Parmanandpur	15.88	11	79	~ 3km NW of Bhojubir, 1km SE of Chuppepur (754)
Bhojubir	Bhusaula	17.29	9	68	9km N of Bhojubir Satti on Sindhora Rd, 1km N of Murdaha (756)
Bhojubir	Bhatauli	10.45	5	43	~ 8km NW of Shivpur along Jaunpur Rd, left side (691), 80
Bhojubir	Duniyapur	7.52	5	39	~ 1.5km S of Bhatauli, i.e. 7km NW of Shivpur (697), 139
Koniya (Purana Pul	Panihari	9.76	7	49	~ 8.5km N of Pandepur crossing on Azamgarh Rd (507), 63
Koniya	Kotwan	10.92	4	33	~2km NE from Varana confluence, linked to Panchakroshi Rd (604), 326
Koniya	Rustampur	7.07	4	29	~ 13km NE of Pandepur, on Ghazipur Rd , border of VDR (588), 269
Koniya	Kamauli	6.42	2	18	~ 4.5km E of Koniya, 1km S of Balua Ghat Rd (602), 330

Source: Primary survey Rana P.B. Singh, November 2001

Notes: RIE, Ramanagar Industrial Estate; CIE, Industrial Estate Chandpur; DLW, Disel Locomotive Works; LT, Lahartara industrial area ; SV, Shivpur industrial Area

II.b. Delhi:
Clearly, it is during the peak season that a particular vegetable will be at its least expensive and therefore most accessible to poor urban consumers. It is in these periods that we focused our market survey work.

- Palak: cultivated annually but peak season generally covers November – February.
- Cauliflower: is cultivated mainly in winter (a little production also takes place during hotter months using a few select cultivars)
- Okra: is cultivated from March till November during the hot and rainy season.

Important vegetable production areas are located inside Delhi NCT, and in its neighbouring districts, whilst some ,less perishable, produce is transported to Delhi's main wholesale market, Azadpur, from much greater distance, (Table D.4 summarises the results of our origin of produce survey for cauliflower, palak and okra. Some results of a previous survey we had carried out at Azadpur for potato and aubergine are included for comparison, although this is only very indicative, as the season number of respondents etc differed from the current work.

Table D.1.4. Produce arrivals at Azadpur Market Originating from Delhi NCT, adjacent districts and outside areas (%)

Vegetable	Delhi NCT	6 adjacent districts	Outside	Number of respondents
Cauliflower**	58 95	35 5	7 0%	54 (a) 150 (b)
Okra**	17	82	1	54 (a)
Spinach** beet/palak	57 72	43 22	0 6	54 (a) 559*
Potato	0	2	98	896*
Aubergine	10	47	43	410*

* DFID 6992 (April 1999)
** Data from current project (November 2000 (a) and January 2001(b))

Details of the 150 farmers delivering cauliflowers to Azadpur in January 2001 show that not only are the large majority of farmers from the northern (Alipur) and western parts (Najafgarh) of Delhi NCT, but also that particular source villages (such as Hiranki and Dichaun Kalan) dominate supplies. (Table D.5)

Table D.1.5. Origin of farmers selling cauliflowers in Azadpur wholesale market

Delhi NCT			Haryana	Total
	Blocks		District	
Village	Alipur	Najafgarh	Sonepat	
Khera Kalan	18	-	-	18
Khera Khurd	7	-	-	7
Khergarh	3	-	-	3
Holambi Kalan	13	-	-	13
Hiranki	21	-	-	21
Kushak	13	-	-	13
Bakhtawarpur	17	-	-	17
Dichaun Kalan	-	30	-	30
Jharonda Kalan	-	19	-	19
Mitrau	-	1	-	1
Nangli Sahrawat	-	1	-	1
Kumaspur	-	-	3	3
Mathepur	-	-	2	2
Badh Khalsa	-	-	1	1
Pithopura	-	-	1	1
Total	92	51	7	150

D.1.2. WHAT IS THE IMPORTANCE OF VEGETABLE CULTIVATION TO SUPPORT LIVELIHOODS OF THE POOR?

A major objective of the participatory research activities was, from a perspective of food safety, to understand, the role of the selected vegetable produce in the livelihood strategies of the urban and peri-urban poor. This helps tp provide a basis for understanding the impact of food safety hazards, and potential means of addressing them, on poor vegetable producer-consumers.

The participatory research also explored other issues such as food preparation and consumption practices, in the context of food safety, among urban and peri-urban poor. This contributed to our understanding of awareness of food safety issues, and pointed to appropriate means of addressing food safety hazards.

A final objective was to examine existing information, advice and support systems available to, and utilised by, horticulture producers. This was matched by a review, from the perpective of policy makers and programme managers, of the types of support systems available and used by producers. The purpose here was to compare the formal process with the actuallity of advice provision, with a view to understanding what types of information systems would be appropriate for exchanging information and ideas on food safety in an effective manner with producers. This final aspect of the work is not written up in the current report, but further information is available on request. A similar exercise for urban consumers, which became a greater focus within the constraints of this current study, are written up within this report (section F).

I. ACTIVITIES

I.a. Delhi and Varanasi:
Field surveys in vegetable production areas were conducted using several research techniques, particularly Participatory Rural Appraisal. This process that was planned collaboratively but was led in the field by Dr Neela Mukherjee and her team. Exploratory overviews and topical probing were undertaken in a total of 15 villages with 9 study villages in Faridabad and 6 study villages in Varanasi. Interactive sessions were conducted with groups of women, men and mixed groups, totalling 358 participants (200 men, 158 women). Visits to Faridabad area took place in March, April 2001, April 2002 and February 2003, whilst Varanasi was studied in October 2001 and November 2002. As women groups had little time to spare during the day, field researchers conducted many sessions during the evening, an approach also practical during the hot months of March and April.

Relevant villages were identified using research outcomes from the activities of Varanasi partners (Botany Department of BHU and geographers at the SHPEH) showing villages where cauliflower, okra and spinach beet are grown as part of the livelihood strategies of the poor. In Delhi, villages close to the industrial belt of Faridabad where vegetables were known to be grown were selected, building on research conducted there during the earlier ERP6992 project on air pollution impacts on crop yield. Only those hamlets within the villages which practice vegetable cultivation were selected.

Table D.1.6. Case study villages in Varanasi and Delhi

Varanasi	Delhi/Faridabad
Maraon	Unchagaon
Lohta	Chandawali
Sundernagar	Machchgar
Chandpur	Malerna
Bharthara (Kashi Vidyapith development block)	Sahupura
Parampur (Arazi lines block)	Sahapur Kalan
	Sumper
	Badoli
	Budhayna

Though the principles of Participatory Rural Appraisal (PRA)/Participatory Learning and Action (PLA) were the foremost in deciding the basis of research, the approach adopted for field research was that of Participatory Rapid Rural Appraisal (PRRA). "PRRA is a variation of PRA, which is widely used where information is required by external agencies but must be expressed by the communities themselves in their way and with their own emphasis" (UNDP's 1996 Report on Human Development in Bangladesh, A Pro-Poor Agenda, volume 3, UNDP, 1996). Some of the field methods and the aspects probed are indicated below.

Table D.1.7. participatory research methods employed

Methods Applied	Aspects probed
Participatory mapping	Locations, setting of the village, social groups, crops/vegetables grown, infrastructure etc.
Semi-structured interviews	Conducted on all aspects of the check list
Historical transect of selected vegetables	Provided an historical background of cultivation of crops and vegetables
Crop calendar	Provided an overview of the crops/vegetables grown throughout the year
Seasonal calendar of food consumption	Provided seasonal picture of food/vegetable consumed in different months
Daily food calendar	Provided picture of food/vegetable consumed on a daily basis
Gender workload calendar	Calendar depicted women and men's workload in terms of different activities
Criteria listing for selected vegetables	A set of criteria was used for comparing different vegetables produced/consumed
Matrix scoring of selected vegetables	Different vegetables/crops produced/ consumed were compared against a set of criteria including discussion related to "why", "how", "how much", by which group etc.
Preference ranking/scoring of selected vegetables	Selected vegetables ranked/scored according to preferences of producers/consumers
Pie charts on vegetable production/consumption	Share of selected vegetables in production or consumption
Oral history	The participant narrated orally the history of producing selected vegetable/crop
Case studies	Case study of a household/group producing selected vegetables/crops and their experience and lessons learnt

In addition to the PRA, both in Delhi and in Varanasi, the geographers in the research team studied a small number of peri-urban villages that were identified by the market surveys as important vegetable supply villages, using questionnaires and gathering village level statistical records.

In Delhi, 102 respondents from villages in Najafgarh (Dichaon Kalan, 32 respondents), Okhla (Aaligaon, Madhanpur Khadar and Jaitpur, 33) and the Yamuna Floodplain areas (37) were

surveyed in March 2001. For the Yamuna Floodplain (which is not classified as a village by the government due to its uninhabitable nature) the areas surveyed lie to the north and south of Nizamuddin Bridge. Selection of villagers was done at random. In Varanasi, 10% of households from different land holding categories in village Ramana were surveyed in in March 2002, totalling 72 respondents. Questions addressed issues such as: family size; caste; education; place of origin; area under and quantity of production, home consumption, quantity and value of sales for vegetables, cereals, fruits.

II. 'LIVELIHOODS' OUTPUTS:

a. Role of vegetable cultivation in livelihood strategies of the poor

Local communities in the peri-urban areas of Faridabad and Varanasi pursue a range of activities to sustain their livelihoods, of which cultivation of vegetables is an important part.

Table D.1.8. Sources of livelihoods in peri-urban areas

	Delhi/Faridabad	Varanasi
Cultivation of cereal crops	✓	✓
Cultivation of vegetables	✓	✓
Daily labour	✓	✓
Rearing dairy animals	✓	✓
Government jobs	✓	✓
Private sector jobs	✓	✓
Shopkeeping, business	✓	✓
Saree weaving		✓
Self-employed: bangle, necklace, bead, bidi (cigarette) making		✓

Vegetables are widely grown in the peri-urban areas of Delhi and Varanasi, as indicated the table below, differences may be significant between villages, a phenomenon in line with earlier reports by Te Lintelo et al (2001). Vegetable cultivation suits local conditions of small landholdings and provides regular income, employment, nutritious food, fodder and in some cases fuel (like dried okra stems).

Table D.1.9. Importance of vegetable Cultivation in villages around Faridabad and Varanasi

Hamlet/ Village	No. of households, proportion growing vegetables, other activities	Area under vegetable cultivation as proportion of total cultivable area
Faridabad		
(1) Unchagaon	Total number of hh: 845	Total cultivable land: 600 acres Seasonal vegetable cultivation: 80 %
(2) Chandawali	Total hh: 795	Total cultivable land: 2400 bighas: 60% vegetable farming; 30% for vegetable-cereal mix and 10% for cattle feed, barseem, etc.
(3) Majhgar	Total hh: 260	Total cultivable land: Not available
(4) Malerna	Total hh – 350 in agriculture: 50%	Total cultivable land: 500 acres Vegetable cultivation: 10 %
(5) Sahupura	Total hh: 350 in agriculture: 45%	Total cultivable land: 650 acres Vegetable cultivation: 10 %
(6) Sahapur Kalan	Total hh: 163 in agriculture: 70 %	Total cultivable land: 400 acres Vegetable cultivation: 10 %
(7) Budhaina	Total hh: 412 In agriculture: 248 hh Vegetable cultivation: 35 hh Daily labour: 90 hh	Total cultivable land: 352 acres Cauliflower – 69 % Spinach – 25 %
(8) Badoli	Total hh: 431 In agriculture: 320 hh Vegetable cultivation: 4 migrant hh	Total cultivable land: 422 acres Vegetable cultivation - Negligible
(7) Sumper	Total hh: 320 in agriculture: 50 %	Total cultivable land: 600 acres Vegetable cultivation: 60 %
Varanasi		
(1) Rajbhar Hamlet, Parampur Village	Total hh: 130 Vegetable cultivation: 100% Daily labour 30 hh Saree weaving: 20 hh	Total cultivable land: 145 acres Okra – 28 % Spinach – 1.4 %
(2) Bangla Tola, Parampur	Total hh: 58 Vegetable cultivation: 58 hh Daily labour: 18 hh Saree weaving: 30 hh	Total cultivable land: 31 acres Okra – 42 % Spinach –23 % Cauliflower – 0.5 %
(3) Morya Hamlet, Lohta	Total: 83 hh Vegetable cultivation: 83 HH General cultivation: 83 hh Saree weaving: 25 hh Daily labour: 10 hh	Total cultivable land: 35 acres Cauliflower – 0.2 % Spinach – 4%
(4) Morya Hamlet, Bharthara	Total of 53 households Vegetable cultivation: 53 hh General cultivation: 53 hh Daily labour: 13 hh	Total cultivable land: 81 acres Cauliflower – 53.09 % Spinach – 4.9 % Okra –1.2 %
(5) Pal Hamlet, Bharthara	Total hh: 64 In agriculture: 64 hh Vegetable cultivation: 64 hh Daily labour 20 hh	Total cultivable land: 55 acres Cauliflower – 18.2 % Spinach – 18.2 % Okra – 3.6 %
(6) Patel Hamlet, Maraw	Total of 80 Households Vegetable cultivation: 80 hh General cultivation: 80 hh Daily labour: 50 hh	Total cultivable land: 165 acres Cauliflower – 37 % Okra – 0.6 % Spinach – 2.4 %
(7) Morya Hamlet, Maraw	Total of 26 Households Vegetable cultivation: 26 hh General cultivation 26 hh Saree weaving 26 hh	Total cultivable land: 57 acres Cauliflower – 32.3 % Okra – 3.2 % Spinach – 8.1 %

Note: HH stands for households.

In village Ramna (Banpurwa) located 5 km to the southeast of B.H.U. agriculture is the dominant source of livelihoods of its 719 households. Almost two third of the total area of 215 hectares is used for agriculture and about 80% of the working population is engaged in farming, including 135 landless labourers. More than 65% of the total farmers have less than

2 hectares of land. These marginal and small farmers spend on average more time 4 to 6 hrs/per day on their vegetable fields. The farmers with larger landholdings however, hire labourers for this purpose.

Agricultural labourers also derive important livelihoods from vegetable cultivation. Annually, labourers on the Yamuna floodplain reported to receive around 180 days of employment. In Varanasi this was less, but still most engage on average 20 to 40 days per season. Most of the work takes place in the hot Zaid season, when 40 to 50 days of labour are done. Both in Delhi and Varanasi all the payment to labourers are made by cash.

Table D.1.10. Village Ramana, Varanasi: Average seasonal number of days engaged in Vegetable farming, 2001-02

Season	10-20 days	21-30	31-40	41-50	51-60	+60 days	Total Hh
1. Kharif	10	2	1	--	--	--	13
2. Rabi	4	9	--	--	--	--	13
3. Zaid	--	3	3	4	2	1	13
TOTAL	14	14	4	4	2	1	39

(Source: RPB Singh, March 2002).

b. Choice of vegetables cultivated

Though a range of vegetables is grown in all the study villages[2] the volume of production for each differs widely amongst the villages. Typical vegetables grown in summer and rainy season are okra, gourds, turai and bora, whilst in winter tomato, spinach beet, radish and cauliflower are commonly grown. In some areas the main vegetable grown is okra in 3 cycles, while in other areas spinach is grown year round in 3 cycles and in still other areas it is cauliflower grown in 5 or 6 cycles. The majority of farmers active on the floodplain has strong seasonal preferences and grows palak mainly in the period September- March. Of course, they do not have access to land during the monsoon flooding.

Farmers from the peri-urban areas of Faridabad stated that vegetable cultivation requires relatively more inputs and labour compared to paddy and wheat. Though such production yields more income, it also involves higher risks from pest attacks, weather changes and market gluts affecting prices. Hence, all groups grow a mix of crops and cultivars. For instance, for cauliflower different varieties are planted in different parts of the fields.

Box 1
Changing livelihoods of landless labourers in Unchagaon

Around 25 per cent of the population of Unchagaon are landless labourers. Out of this 15 per cent of households are engaged in cultivating land acquired on lease. Earlier, there was intense agricultural activity in the village, mainly vegetable cultivation and therefore labour was required for 8 months in a year and on average, 20 days in a month. However, Haryana Urban Development Authority has acquired 90 per cent of village land and agricultural land is dwindling in size and the scope of sustaining livelihoods through farm labour is diminishing. (Source: From the PRA field notes of Saraswati)

Farming communities in Delhi and Varanasi descrined the various characteristics of okra, cauliflower and palak that affect farmers' crop choice. Okra is cultivated from April-October in three cycles and therewith provides prolonged, high yields. Twice or thrice a week the

[2] Okra; cauliflower(ghobi); spinach beet(palak); tomato; potato; radish, carrot, bitter gourd; bottle gourd; cucumber, green peas, turai; bora; etc.

crop is harvested, providing handsome prices in the summer markets otherwise deprived of many vegetables. However large amounts of fertiliser and much pesticides must be applied. Okra is a sturdy crop and not much affected by the climate but requires continuous access to reasonably large landholdings and irrigation water, an asset often not available to marginal farmers. Cauliflower also requires larger tracts of land and high investments in agro-chemical inputs as it is perceived as the crop most affected by pest attacks. The advantage of palak is its low input character: less fertilisers, less pesticides but more labour intensive and therewith well-suiting marginal farmers. Palak is however prone to weather changes and requires a lot of irrigation, but this is offset by a regular flow of income as cuttings can be made on a daily basis.

Table D.1.11. Village women scoring risks, yield & costs of cultivating vegetables

	Okra	Spinach	Cauliflower	Potato
High cost	: : 4	.. 2	: : : 6	: : : : 8
More pesticides/herbicides	:.: 5	: . 3	: : : 6	: : . 5
High risk	: : 4	: 2	: : : 6	: : : : 8
More fertilizers	: : 4	: . 3	: : . 5	: : : 6
More insect attack	: : 4	: . 3	: : 4	: : . 5
Need more water	: : . 5	: : : 6	: : . 5	. 1
High yield	: : : : . 9	: : . 5	: : : 6	: : : 6

Village: Unchagaon, Date: 19.03.2001, Researcher: Saraswati. Note: 10 is the highest score and 0 the lowest score.

Availability of key production factors such as land and labour also determine the crop cultivated. The farmers prefer family labour for vegetable production since employment costs of outside labour for vegetable fields offsets additional income gains. Many of the poorest farmers prefer annual cultivation of vegetables, whilst farmers with more cultivate vegetables to supplement their income from the main crop.

Box 2
Water pollution affecting livelihoods

In village Badoli, vegetable-growers informed that for over 10 years, sewage water has been used for vegetable cultivation and was beneficial. However in the last 2-3 years, chemical factory waste was being dumped into the sewers affecting their crops:

- In summer, plants withered way following irrigation
- Discouloration of the vegetable.
- Higher requirement of pesticides/herbicides adding costs

Two affluent farmers stopped vegetable farming in this village and obtained land in a nearby village where clean water could be applied. Some poorer households however abandoned vegetable farming altogether in favour of vegetable trading earning Rs.100-150/- on a daily basis.

The availability of irrigation water is also increasingly a concern for farmers. Whilst currently many cultivators have tube wells, farmers in Faridabad recognise that a rapid fall in the water table is going to have a negative impact on (vegetable) cultivation in the near future. Irregular electricity supply is another major constraint to vegetable cultivation. As per the farmers they do not get enough electricity for cultivation while the hotels in Faridabad waste electricity on neon signs and pompous decorations. This makes the farmer communities feel discriminated against the urban lobby in terms of meeting their needs.

Nearly 95 per cent of the producers sell vegetable to the nearest market on a wholesale basis. Only 5 per cent of the vegetables get sold in the retail market. Generally cauliflower, spinach and okra are harvested one day in advance of sending them to the wholesale market, however, for transport to evening retail markets vegetables are harvested on the same day before noon.
The spinach is cut and tied into small bundles in the field. To look fresh, immediately after harvest and bundling/packing the vegetables are immersed for about 10 minutes in a small water tank “kundi”. The

kundi also serves other purposes such as irrigation reservoir linking with irrigation furrows, for washing clothes, for bathing, for washing livestock. For protection during market transport harvested cauliflower retains covered in its leaves.

Table D.1.12. Comparative cost and returns from Spinach, Cauliflower and Okra cultivation (Rs per acre land)

	Spinach	**Cauliflower**	**Okra**
Income –Unchagaon Income – Majhgarh Income – Chandawali	14000 - 20000	20000 12000 19000	20000 20000 20000
Cost – Unchagaon Cost – Majhgarh Cost – Chandawali	3000 - 4000	5000 4000 7000	5000 5000 7000
Net Returns – Unchagaon Net Returns – Majhgarh Net Returns - Chandawali	11000 - 16000	15000 8000 12000	15000 15000 13000
Return to investment ratio Unchagaon Macchgarh Chandawali	DT to calculate		

Note: Collated from field notes on Faridabad villages.

c. Social perspectives on vegetable farming

The different communities living in peri-urban villages such as Saini, Jat, Gujjar, Dalit, Yadav etc do not all cultivate the same vegetables, reflecting social as well as economic conditions –when economic efficiency dictates marginal farmers to opt for certain crops-. For instance around Faridabad, low caste Sainis cultivate spinach, methi, coriander, radish, chukander and cauliflower as they have small landholdings. Despite difficulties in cultivation of okra, many Dalit households cultivate this crop. The vegetable growers in Jat community derive good profits from cultivation of chilly and potatoes. The Gujjars pursue extensive cultivation of tomatoes. In village Badoli however, vegetable cultivation is frowned upon as a low status activity and is only undertaken by a handful of migrant families.

Surveys by the geographer teams showed the strong preponderance of migrant cultivators in Yamuna Floodplain and Okhla areas (up to 85% of respondents), where temporary land tenure was often based on lease contracts. In contrast in Najafgarh area in the west of Delhi, local farmers used migrant agricultural labourers. These migrant communities came often from the ‘scheduled caste’ or ‘other backward caste’ communities, were in half of all cases illiterate and catered to large families, in the large majority of cases having 5-8 mouths to feed.

In Varanasi, market studies also showed a strong profile of low status social groups cultivating particular vegetables. For instance, village Ramna was founded by the Kurmi caste (which still makes up 84% of its population) and their traditional occupation of vegetable growing still heavily influences the choice of crops. Nowadays, vegetables cover more than half of all cultivated land, with great preference for okra.

Table D.1.13. Caste background of cauliflower sellers/suppliers in 5 Varanasi markets

Caste (traditional profession)	Sund-arpur	Kama-chha	Chan-dua	Bhoj-ubir	Koniya	Total	% of total
Rajput / Kshatriya (Landlord)	---	---	---	---	2	**2**	0.65
Sonkar/ Svarnakar (goldsmith)	3	4	5	---	3	**15**	4.84
Kurmi/ Patel (vegetable growers)	62	23	44	55	13	**187**	60.32
Maurya/ Kushwaha (vegetable growers)	18	3	25	2	9	**57**	18.39
Ahir/ Yadav (milkmen)	1	2	---	1	9	**13**	4.19
Pal/ Gareriya (shepherd)	2	---	9	1	4	**16**	5.16
Rajbhar (servant to king)	1	4	---	---	1	**6**	1.94
Pasi (toddy caretaker)	---	---	---	1		**1**	0.32
Bind/ Bin/ Kewat (fisher/ boatman)	---	---	---	---	1	**1**	0.32
Gonr (parcher)	---	2	---	---	---	**2**	0.65
Total Respondents	**87**	**38**	**83**	**60**	**42**	**310**	**100.00**

Source: survey conducted November 2001 by SHEPH.

Within households, all family members are involved in the vegetable cultivation: men, women and children. Many women have detailed knowledge about ways of cultivating vegetables. They have been involved in such cultivation since their childhood. Asha, a women participant remarked with confidence, “We were cultivating cauliflower and spinach as children before getting married and coming to this village”.

Men and women reported to have different specialist areas of knowledge, reflecting their major activities towards farming.

Table D.1.14. Knowledge specialisation of women and men regarding vegetable cultivation

Women	Men
Timing of weeding	Selection of appropriate vegetables to be cultivated
Timing of irrigation	Selection of high yielding seeds
Assessing daily wagers labour inputs	Selection of chemical fertilisers
How to harvest most efficiently	Amount of seeds and fertilisers to be applied
Timing of harvest	Trends in market prices of vegetables
	Techniques for repairing tractors, motors, sprayer etc

Men appear to be in charge of business decisions regarding inputs and sales, whilst the women are more knowledgeable regarding the agricultural day to day operations, which they conduct together with children. Therewith women have an important role, but are also carrying the extra burden of responsibility for the daily household chores (*there are tables available regarding gendered roles however they seem internally contradictory*).

Table D.1.15: Division of labour in vegetable farming families

Activity	Time required	Faridabad			Varanasi		
		Women	Men	Children	Women	Men	Children
Buying inputs	No daily activity		*			*	
Ploughing	Supervising only		*	*		*	
Preparing field (inc. weeding)	Whole day	*	**	*	*		*
Sowing	Whole day	**		*	*	*	*
Draining	Whole day	**		*			
Applying pesticides, herbicides	1-2 hours		*			*	
Applying fertiliser	1-2 hours		*			*	
Irrigation	2-4 hours	*	**	*	*	*	*
Harvesting/bundling/grading	3-4 hours	**		*	*	*	*
Sales at markets[3]	3 hours		*	*		*	
Cooking	4 hours	*			*		

Note: an asterisk denotes the relative heaviness of burden (this data is available for Faridabad villages only)

d. Producer practices and levels of food safety awareness

Farmers in Faridabad felt that whilst consumers are concerned about the safety of cooked food items there is no concern about vegetables, which are judged on the basis of

- freshness (crisp okra, spinach with green/tight leaves, fresh cauliflower)
- price
- colour (naturally green okra and white cauliflower)
- size (small tender okra and small spinach leaves)
- freedom of insects in cauliflower and okra

Food safety issues related to farming/household practices that farmers relate to regard:

- spoiled food
- pesticides
- crop growth boosting chemicals
- post harvest application of pesticides on vegetables
- sewage irrigation

For their own consumption, food safety is often associated with wilted produce, which is fed to the livestock or rotten food that is thrown away. Any food item cooked well and consumed in time is considered safe, and food was covered and kept in a safe place, away from insects and lizards.

In Varanasi, some women reported that the increasingly excessive use of *pesticides* contaminates produce. However, their effect on food safety is not believed to be significant 6-8 hours after spraying. Similarly, villagers from Chandawali in Faridabad District consider consumption of okra, cauliflower and spinach treated with insecticides to be safe the following day, provided these are washed thoroughly.

In the study villages, the vegetable producers take some precautions for handling of produce. These include allowing several days between use of pesticide and marketing of vegetables. All the vegetables are washed after being harvested and before being packed

[3] with the exception of a few female headed households

for transporting to markets, although this is generally done to improve their appearance rather than having any considerations about contamination reduction.

In hamlet Bangla Tola insecticides are sprayed 4 days before both okra and cauliflower are harvested. In the case of palak insecticides are applied so the insects perish and its leaves look green and fresh. After the cauliflower is harvested the insect-ridden leaves are removed from the cauliflower and they are arranged according to their size. Some of the farmers also apply 'hypolin' on okra *post-harvest* to retain its green colour. When asked about this the farmers argued that as buyers prefer green, fresh vegetables, vegetables treated with this chemical fulfil consumer demand and supports producers with a better price.

Other production practices may also affect food safety. In two villages farmers revealed that they inject a 'medicine' into the pumpkin and brinjal plants to double or triple its size and weight, therewith increasing their earnings. These farmers were not sure if such 'medicine' had a bad impact on human health, but they admitted that the taste of such vegetables was not good and that they took longer to cook. Indeed, for their home consumption they always grew separate plants without applying the 'medicine'.

The application of sewage irrigation water was reported for several villages. Whilst farmers do not consider this practice to have any impacts on human health, some expressed their apprehensions towards its impact on the taste of sewage fed crops. For instance, in village Badoli Sheela Sharma informed that a bad odour emanates from the pressure cooker while cooking vegetables grown with sewage water. And Shri Santraj informed that chapattis made out of wheat grown with sewer water also have an odd taste.

In general, little information about food safety exists for farmers in the peri-urban area except through television, radio programmes and discussion with friends, which accordingly are mostly relied upon. Shopkeepers do not provide information associated with food safety issues to farmers, but of do continue to provide the most accessible form of advice regarding inputs. (our previous DFID funded participatory research with 1200 farmers investigated information and advice systems regarding inputs)

In village Ramna in Varanasi, farmers informed that prior to marketing, vegetable produce is washed at the tubewell or in the pond, although the water is often very dirty. Farmers are aware that by being washed in such water the vegetable may become contaminated with substances that could be damaging to health. However, they informed that although consumers would avoid purchase if made aware about this, rarely consumers are concerned of the source site and quality of water used.

e. Vegetable consumption and the poor

i. Nutritional awareness

In the peri-urban areas of Faridabad and Varanasi, people think that selected vegetables are needed for 'strength' and these protect them from various diseases. Palak is consistently identified by farming communities –equally women and men- as a highly nutritious vegetable. It was considered good for vitamin intake, energy, blood formation and eyesight and for prevention or treatment of gastric diseases. Women from poor as well as better off households are clearly aware that spinach is good for health and also good for pregnant women. Other properties ascribed regards heating up the body and therefore consumption in winter is preferable. Okra and cauliflower on the other hand are not considered to be particularly nutritious.

ii. Consumption of vegetables and food preparation habits

According to Dr. Gill, a former head of Division of Vegetable Crops, IARI and Directorate of Vegetable Research, ICAR, consumption of vegetables is still very much limited to urban consumers that are aware of the nutritional benefits of vegetables. Rural producers are often much more sticking to traditional cereal based diets, without much vegetables, even when these are cultivated for the markets (pers. comm, 2000).

Indeed, field work indicate that most villagers in and around Delhi and Varanasi aim to eat those seasonal vegetables grown in their fields or kitchen garden rather than purchasing them from the market. Village households, in need of vegetables, directly approach producers and get to buy fresh vegetables from the field at a cheaper price. Those vegetables not available in the village are purchased from the urban/other markets, if there is a special need like entertaining important guests or on festive occasions. Faridabad villagers also informed that poor households have lost their traditional access to wild varieties of vegetables grown on common land due to encroachment for construction and cultivation.

Poor households often eat only two meals a day- first time around 9-11 AM in the morning and second time around 7-9 PM in the evening. Hence they focus on energy intake through self-cultivated wheat and rice and eat fewer vegetables. However, many households supplement vegetable consumption through spinach grown in home gardens. Okra and cauliflower are often not grown on marginal landholdings and henceforth less accessible for the poor –who prefer not to buy-. Vegetables such as cucumber, tomato, carrot and radish are also eaten raw, often while working in the fields or transporting produce to markets. Children consume relatively more than adults. Daily wage labourers often depend on the generosity of their landlord granting some vegetables.

Seasonal differences in consumption are pronounced. During off-season - summer and early rainy season, vegetables are expensive hence the villagers purchase only about 250 gm potato for six persons. The rainy season also decreases the options of purchase of potato in markets in the absence of vegetables grown domestically, as incomes drop due to lack of work. Sometimes inferior quality vegetables are purchased at reduced prices. In absence of vegetables they take food with chili chutney.

Table D.1.16. Consumption of Vegetables in village Chandawali Jatwara, Faridabad

Vegetables	Men	Women	Children
Spinach	Consumes 200gms cooked vegetable	150-200gms	Not more than 100gms
Cauliflower	100gms	100gms	50 gms
Okra	200gms	150gms	100gms
Potato	250gms	200gms	200gms

Source: From Field notes of Sarawati, Date: 12.04.2001

The relatively better off have usually three daily meals – breakfast, lunch and dinner though vegetables are not included in all the three meals. Mostly vegetables are prepared mixed with other vegetables and spices as a curry (except for okra), of which about one/two tablespoons is consumed, accompanied by a chutney prepared from green/dry chilies, garlic and salt. In season, a rich family of 6 members consumes about 500 gram to 1 kg of okra per day. During the harvesting season the frequency of okra consumption is four to five times in a week, cauliflower 3 to 4 times a week and spinach 3 times a week to daily. Hence cauliflower is consumed predominantly in winter, okra in summer and rainy season and spinach beet is consumed mostly in winter.

Whilst in well-off families pregnant women and the elderly are given additional doses of fruits and vegetables for enhanced vitamin intake; in poorer households the pregnant/lactating/old are not given or demand any special diet.

Village women wash all vegetables with (tube) well water to clean them of sand and insects. Palak and okra are washed and then cut for cooking, whilst cauliflower is cut before washing in order to get rid of insects. Many households who retain a small portion of vegetables for household consumption use the water of the ‘kundi’ to wash vegetables. This is undertaken before household cooking and if no kundi is available then the vegetables are washed in large vessels. For cooking purposes the women wash the vegetables more than once in order to clean them. Cauliflower, when cut into pieces is washed for removal of insects and dirt. Okra is washed before cutting. Spinach is washed several times before cutting so as to clean it of sand and dust. Spinach is not washed after cutting because it is perceived that this process will remove the vitamins from the leaves.

D.1.3. WHAT IS THE POTENTIAL CONTRIBUTION OF MARKETING, DISTRIBUTION AND RETAIL SYSTEMS TO ENHANCE THE SAFETY OF VEGETABLES PRODUCED AND/OR MARKETED IN DELHI AND VARANASI?

The food chain does not just concern the supply of products but is a series of interactive and interconnected flows of goods, services, incentives and information between the different participants in the market chain. As feedback between firms and individuals occur, individual decisions to produce, sell and buy become better coordinated and feedback effects accordingly tend to make the chain more responsive and efficient. In more coordinated food markets, it is this responsiveness that results in the food system delivering to consumers the products that satisfy their preferences.

The number, size and functions of firms within the food chain, access to market and the competitiveness of the system are structural features. The way firms interrelate and their individual strategies make up the conduct of the system. The outcomes in terms of efficiency and effectiveness are performance characteristics. Efficiency in terms of interstage margins and value addition are one element of performance relevant to this study; of primary importance, however, is the safety of the vegetables themselves.

In our case study vegetable wholesale markets are investigated for the existence of such characteristics of structure, conduct and performance.

I. ACTIVITIES

A well-functioning food market system is one that delivers quality food products to consumers and reasonable economic returns to producers and market intermediaries. Its performance depends on three characteristics. The structure of the market system and the strategies of producers and traders are two important factors in determining how the system performs. The third factor concerns the level of coordination throughout the system. This is influenced by the extent to which producer, trader and consumer incentives and rewards are aligned and communicated within the market, and, in turn, is largely a function of the level and flows of information through the system. Improved market coordination is most likely to be one of the tools to improve market performance in respect of food safety and traceability.

The objective of the marketing research was to investigate the performance of the vegetable market system in respect of the efficient delivery to consumers of safe food supplies, and to make recommendations about appropriate QA mechanisms for vegetable supplies. Accordingly, the aims of marketing studies were to understand the organisation of the vegetable marketing system from production to consumption, to assess the level of coordination, and to identify policy entry points for improving performance.

The analysis thus focuses on two key research questions:

i. How does the horticultural marketing system function and how can common trading practices affect conditions for successful introduction of quality assurance interventions for improved safety in vegetable trading?

   This includes questions such as:
   - Who is involved in marketing urban vegetables?
   - What are the physical produce flows from producer to consumers?
   - What are the possible sources of contamination?

- What are current awareness levels and perceptions towards food safety in the vegetable trading, retailing and distribution business?

ii. What is the potential for and propensity of private sector vegetable marketing systems to introduce quality assurance interventions to enhance safety of vegetables in India? What lessons can be learned from examples/case studies of advanced vegetable or other food systems in India?

For the purposes of this summary we have confined the detailed description of some of the research activities to the Delhi case study. More detailed reports of similar activities on market structure and function carried out in Varanasi are available separately.

a. Exploratory study of marketing of three vegetables in Delhi

Three important vegetables were selected on the basis of their perishability, seasonality and physical characteristics: spinach beet (*palak*), okra (*bhindi*) and cauliflower (*gobi*). The first exploratory study was initiated by deploying three interviewers in the *mandi* for a week from 6-11 November 2000 to conduct interviews using a structured questionnaire. Interviews were conducted from morning to evening depending upon the availability of the respondents. Interviewees were the three main categories of wholesale market actors prior to distribution through the myriad small retailers and hawkers:

- 15 assembly wholesalers
- 15 commission agents
- 24 mashakhores

Having analysed the data for the three vegetables, further research was conducted to test the results and generate more in-depth knowledge of the marketing system. Of the three products, cauliflower was chosen for reasons of timeliness: January is the peak season for cauliflower in Delhi and Varanasi.

A total of 55 or so different kinds of vegetable arrive at Azadpur Market, Delhi, with range, quantities and origins varying with seasonal factors. Cauliflower is one vegetable that arrives at Azadpur market from within the city limits (UPU production sites) in the local peak-season. In Delhi, cauliflower is grown largely in the west-Najafgarh block and also in the north Alipur block. It also arrives from nearby areas like Sonepat and Faridabad, Haryana; Merut and Ghaziabad, Uttar Pradesh and Alwar and Jaipur, Rajasthan. The local season of the produce is during the winter months of November till February-March. In the local off-season supplies to Delhi come from Himachal Pradesh in the north to Maharashtra in the central part, to Calcutta and North-east states in the East, and Jaipur and Ajmer in the West.

During January-February 2001 further interviews were conducted among 150 producer-sellers arriving at Azadpur to elicit baseline information on quality attributes and transaction characteristics. The questionnaires are reproduced in Appendix 1. These results are reported in this section 2.3.2.2, which is followed by the results of interviews with 25 wholesalers (section 2.3.2.3), 25 commission agents (section 2.3.2.4), and 67 mashakhores (section 2.3.2.5). Comparisons are made between classes of respondents and conclusions drawn in the summary section 2.3.2.6.

In collaboration with researchers at the Delhi School of Economics, contacts were made with commission agents in Azadpur market who provided information on a selection of villages supplying Azadpur, and key informants in those villages. Key informants were visited and interviewed during the day about production and marketing practices. Researchers returned in the evening to interview farmers in their homes. Farmers were selected purposively, being those in each village who were willing to cooperate. A total of 250 interviews were conducted

over a ten-day period in May 2002 in 19 villages in the Alipur (north of Old Delhi) and Najafgarh (south-west) areas of the city. All respondents were male. Farms were located between 11 km and 34 km from the market at Azadpur.

A total of 25 wholesalers were interviewed during the same period in January-February 2001 to elicit their responses about cauliflower trading in Azadpur market and to triangulate the data from producer-sellers and other traders.

The mashakhore is a local term used for a functionary in Azadpur, and usually is a small wholesaler or a big retailer. He buys vegetables from the market in larger quantities and then re-sells in smaller units to the retailers, vendors and consumers. A total of 67 mashakhores were interviewed in Azadpur market during the period 2-8 February 2001 to elicit their responses about cauliflower trading in Azadpur market and to triangulate the data from producer-sellers and other traders.

A detailed analysis of vegetable consumption patterns was made by conducting a formal questionnaire survey in Ali Vihar colony of southeast Delhi. The colony was selected with the following considerations: a substantial part of fresh vegetables consumed in the area originates from the colony and nearby areas; secondly, a substantial number of residents are either poor or people with low income and lower middle class, and thirdly, other researchers associated with the project were also working in the same colony.

b. Retail practices

Before the start of the project, there was little knowledge of vegetable retailing practices in Delhi, particularly with regard to questions such as from where (wholesale market) the vegetables are brought, how many retailers and vendors are engaged in the trade, the level of daily or weekly turnover, transport mechanisms, relations with suppliers and buyers, etc. a retailer survey was designed to understand the organization of the vegetable retail trade focusing on cauliflower. The objectives were to:

- Identify the sourcing patterns and preferences of retailers;
- Analyse the value-adding functions undertaken by distributors;
- Assess the level of awareness of the sellers of quality management of vegetables;
- Understand the quality incentive structure of retail trade.

The conduct of the consumer survey conferred considerable prior knowledge of retailing practices. Informal interviews were conducted with traders and key informants in Ali Vihar and in the nearby general and wholesale street market in Badarpur in August 2002. The total number of retailers was estimated at somewhat less than 100 in Ali Vihar, some of whom were known personally by the research staff from conducting the consumer survey. It was decided that a census of the retail sellers in the area would be feasible and as a result, all the 71 retail sellers active at that time in the colony were interviewed. The interviews in the colony were conducted in October and November 2002 (see Appendix for questionnaire).

c. Price analyses from production to consumption in Delhi – a case study of cauliflower

The price-spread analyses were planned in the month of January when the season was at its peak. The objective was to understand the contribution of different market intermediaries to the marketing functions of storage, transportation and processing within the principal marketing channels, the scale of value addition and margins. Most of the farmer respondents who were contacted while selling in Azadpur market were from Delhi itself and a substantial number from a particular village called Dichau in Najafgarh block. Later, other project

partners who visited this village confirmed that almost the entire village grows cauliflower, which can be seen to spread in the fields from one corner to the other of the village.

The spread in prices involves remuneration of the market functionaries for services provided in the marketing process and also their profits after adjustment of costs incurred. The lesser the price spread the more efficient (or competitive) the market is considered to be.

To understand the entire marketing process of cauliflower - three interviewers were deployed in Azadpur market for a week to follow the individual lots of produce from Azadpur market to the final consumers in different areas of Delhi. Variables noted included:

- time taken in transportation
- distance travelled
- type of transport and packaging used
- the number of sales made in the disposal of the entire lot
- the expenses incurred on transportation, packing material, labour charges or any other charges
- wastage or unsold part of produce was noted at the end of the day
- any direct value addition in addition to time and place

Terms of payment and ownership of the material were noted. Direct value addition was considered as any type of service such as removing of leaves, trimming, sprinkling of water, merchandising or sales promotion.

The data were collected for 6 days between January 27 and February 2 2001. The area of study covered includes from supply points like Bakhtawarpur in Alipur block, Delhi to Pitampura and Shakarpur; Kherakalan, Alipur block to Partapbagh and Nirankari Colony, Budh Vihar, Model Town, Sarswati Vihar and Rameshwar Nagar; Dichau, Najafgarh block to Tri Nagar, Naraina, Ashok Vihar, Roop Nagar and Sant Nagar; Kushak, Alipur block to Gujranwala town, Rohini- Sector-8 and Kishan Ganj; Holambi Kalan, Alipur block to Jahangirpuri and Badli and Sonepat (Haryana) to Mukherji Nagar, Rohini, Sector 18 and Jahangirpur

The study was based on data collected from the local producers while selling in the Azadpur Market. Most producers brought only cauliflower. All initial respondents were male, although female vegetable sellers are found in the marketing chain from mashakhore to retail sellers. Almost all the wholesalers/commission agents and even the mashakhores had permanent or fixed sale points, where the initial transactions occurred.

The sale points were defined as fixed or permanent where a seller had some possession rights (ownership, leased or hired) to sit and market his/her produce. A semi-fixed point was where such type of ownership did not exist but the seller generally used a particular place for business. The sample data reveal that only 4.5% mashakhores have semi-fixed sale points. However, that is not the case with the retailers and vendors particularly: about 60% of retailers have fixed sale points and the remainder have semi-fixed sale points. All the vendors were without any fixed or semi-fixed sale points and can be termed as mobile sellers, or ambulant retailers, whose practice is to keep moving from one road and house to another. Mobile sellers used a cart (a wooden raft with 4 bicycle wheels, or a three-wheeled peddle cart) or bicycle with a flat basket fixed on the carrier and two bags made of jute or polythene sack on each side of the carrier.

d. Sophisticated marketing practices: Case studies in Delhi
A number of visits were made to INA market in New Delhi to identify the particular characteristics of the vegetable market. This market is known for selling superior quality fresh vegetables to elite customers of Delhi, particularly the diplomatic community in the city. Key informant interviews were made by two members of the research team on 28.3.03. There are a total of 6 vegetable stalls, and all stallholders were interviewed.

The differences between the INA and other vegetable markets in Delhi are obvious at first sight. In the INA market, one can find almost all varieties of domestic as well as foreign vegetables exhibited well-ordered, well-sorted (by colour, shape and size) with price labels and even branding, in a manner that is unlike any other market in Delhi.

e. A Case Study on Mother Dairy Fruit and Vegetable Product Pvt. Ltd
Mother Dairy Fruit and Vegetable Product Pvt. Ltd was initially a pilot project of NDDB under the name Fruit and Vegetable project. It became a private Limited company only in 2000. The main purpose is to provide a direct link between fruit and vegetable growers and consumers. From procurement to marketing, the company handles the entire range of operations.

Based on crop plans worked out in discussion with farmers, produce from villages around Delhi and many states is received at the cold store complex at Delhi. It receives, sorts, grades and dispatches to retail outlets over 30 items daily. Specially designed crates are used through the entire system from procurement of produce from farmers to all operations at the complex and delivery and storage of produce at the shop. Produce daily sent from the procurement centre is received and weighed on electronic weighbridges and the details are put into a computerised management information system. The produce is then graded on the various sorting and grading lines for different types of produce. Standards are defined for each fruit and vegetable so as to link the price with the quality (grading, not food safety). Procurement specialists and trained field staff help the farmers in crop management and protection, including use of fertilizer, insecticide application etc. Seed multiplication and demonstration farms are also planned. According to Mr. M.G Sharma (legal consultant to Mother Dairy) no case has yet been filed against Mother Dairy Fruit and Vegetable Product complaining about the quality of fruits and vegetables supplied (pers comm, 2000).

II. OUTPUTS

a. Structure and strategy
Peri-urban production of the three study crops is an important source of seasonal vegetable supply to all consumers in Delhi and in Varanasi. Produce flows from farmers through complex market channels of intermediaries, who assume individual responsibility for the value-adding functions of transport, assembling, (limited) storage, (limited) processing, exchange, and distribution to final consumers.

Case study: Azadpur wholesale market, Delhi
Some, but not all agricultural wholesale markets in India, are governed by the Regulated Market Acts. The focus of the regulated markets policy is primarily to reduce inequities at the first point of sale and ensure remunerative prices to otherwise exploited producers (Agriknowledge, 2001b; Agriknowledge, 2001a). In Varanasi, in Uttar Pradesh, three of the four major wholesale markets are unregulated, while the fourth (Sarnath) is only 'regulated' in a nominal sense. For the wholesale trade of vegetables in Delhi, there are three main markets (Azadpur, Shahadra and Okhla). In addition to these Nangloi, Tilak Nagar and Daryaganj markets also receive vegetables.

Azadpur fruit and vegetable *mandi* (market) is the largest fresh produce wholesale market in India, and in terms of volumes handled is said to be the largest in Asia. In Azadpur, about 55 vegetables are traded daily. However, the actual number depends upon the season and arrivals of the day. Total annual arrivals in the market exceed 1.5 million metric tonnes. Some, but not all agricultural wholesale markets in India, are governed by the regulated market acts. The focus of the regulated markets policy is primarily to reduce inequities at the first point of sale and ensure remunerative prices to otherwise exploited producers (Agriknowledge, 2001b; Agriknowledge, 2001a). In Varanasi, in Uttar Pradesh, three of the four major wholesale markets are unregulated, while the fourth (Sarnath) is only 'regulated' in a nominal sense. For the wholesale trade of vegetables in Delhi, there are three main markets (Azadpur, Shahadra and Okhla). In addition to these Nangloi, Tilak Nagar and Daryaganj markets also receive vegetables.

Azadpur fruit and vegetable *mandi* (market) is the largest fresh produce wholesale market in India, and in terms of volumes handled is said to be the largest in Asia. In Azadpur, about 55 vegetables are traded daily. However, the actual number depends upon the season and arrivals of the day. Total annual arrivals in the market exceed 1.5 million metric tonnes.

a.i. Actors involved in vegetable trading and distribution

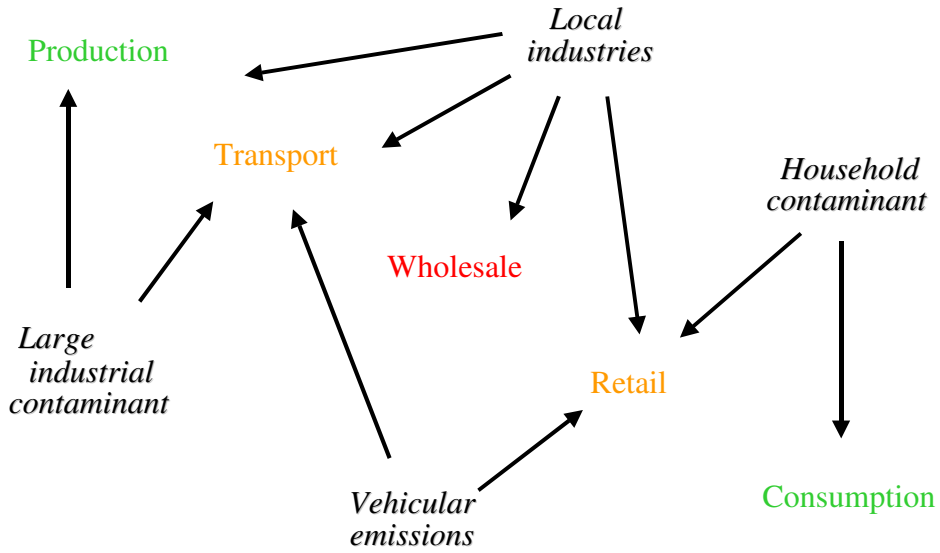
Vegetable arrivals at Azadpur are brought by both producer-sellers, who bring their own produce to market, and by assembly wholesalers who visit production sites, buy and transport produce to the market. There are three principal classes of market participant within wholesale markets such as Azadpur, one of who, the mashakhore, is unique to Delhi. Their functions are briefly described below:

- Assembly wholesaler: is the main actor who performs a dual task as a seller and as a buyer. He assembles vegetables after buying from other markets and/or directly from the producer-sellers. The incentive is to take advantage of price differentials and he is thereby responsible for the addition of time and space utilities.
- Commission agent: the APMC issues two types of licenses to the traders operating in the Azadpur mandi: the 'A' class commission agent is a buyer for his own purposes and does not act on behalf of any other buyer. The second type of licensee is categorised as 'B' class. The B class license holder does not buy for himself, but rather acts on behalf of some other wholesaler and in lieu of his service he charges commission as stipulated by the APMC. At present no pure wholesaler or 'A' class commission is working in the mandi though the APMC has issued such licenses. The function of the commission agent is to add exchange utility: bringing together buyers (retailers and mashakhores, vendors and consumers) and sellers (assembly wholesalers and producer-sellers), overseeing volumes, and negotiating the exchange. Therefore, his source of income is a fixed percentage of the total trade conducted, which is independent of profit or loss of the buyers/sellers[4].
- Mashakhore: the mashakhore is a local term used for a functionary between the wholesaler and the retailer. This functionary acts only in Azadpur, and usually is a small wholesaler or a big retailer. He buys vegetables from the market in sufficient quantity and then sells in small units to the retailers, vendors and consumers who frequent the market.
- Retailer/vendors sell the vegetables to the consumers. About 82% of all 72 retailers were vendors, about 10 % with temporary stalls, and the remaining 8 % were having permanent or fixed places in the form of shops/ stalls. 15.5% of the respondents were women (from all major religious communities in India), who mostly used temporary places in the surveyed colony to sell their goods.

4

The market system and critical points for quality assurance with reference to airborne contaminants are depicted in Figure :

Figure D.1.5. Critical points in the vegetable supply to UPU areas, India



Producer-sellers are numerous and represent a highly atomistic source of supply into a concentrated structure of exchange in the wholesale markets. The principal channel to market is for producers to arrange transport of their own produce. Within the wholesale market, the main players are the wholesaler, the commission agent, and (in Delhi) the mashakhore. In the regulated wholesale market system such as in Azadpur, and also in the unregulated wholesale markets such as in Varanasi, the commission agents are a nexus of facilitation and control in arranging buyers and negotiating prices between producers and wholesalers. Produce is distributed from central wholesale markets directly to retailer-vendors and via secondary wholesale-retail markets.

Regarding the efficiency of transactions, data suggest that there are channels where commission agents were paid up to 8-9% of sales values, somewhat different from the norm of 4-6%. Reducing punitive commission rates and eliminating the illegal negotiation practices reported elsewhere would appear to be of benefit to producers. However, there is evidence that producers' net margins were greater where commission agents had negotiated prices (mean 25.1%; SD 4.46) than where negotiations were conducted in the producer sheds without involvement of commission agents (mean 19.5%; SD 4.36). This result would be consistent with the hypothesis that producers gain from employing the negotiating expertise of commission agents, and that otherwise they are ill-equipped to negotiate effectively with traders.

Distribution to the final consumer is characterised by retail exchange that is highly atomistic in nature. Early morning sales volumes are small. Peak sales time is late afternoon or evening. Consumers tend to buy frequently during the week from a range of outlets. The principal distribution channel to consumers is through temporary stalls and ambulant vendors, and secondarily through retailers in local periodic markets, and thirdly, for a small market segment, through permanent stalls and shops.

An unexpected finding in the cauliflower study was that almost all retailers have some cauliflower left to sell on the second day. Moreover, more than 7% of retailers were left with unsold cauliflower, amounting mostly to about 5% of the total. The implication for retailers is that produce left till the second day or produce left unsold is likely to lead to economic

losses. Revenues will be reduced because retained produce will earn reduced prices because of lower quality, and because some produce is unsold. It is evident that retailers' margins need to cover this risk element in trading.

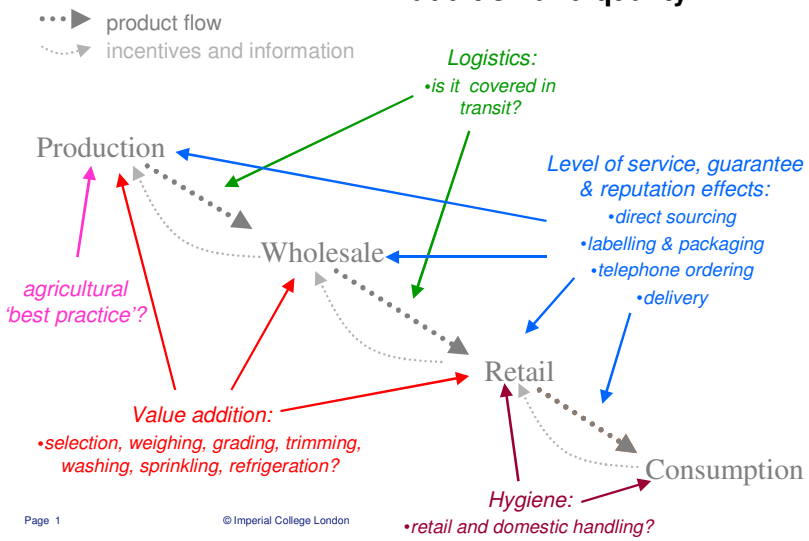
a.ii. Value-adding in the fresh produce chain

There is little processing of fresh vegetables: farmers and some intermediaries add value by selecting and cleaning produce and improving its presentation, and wholesalers also select on quality. Retailers maintain and enhance appearance by cleaning, trimming and freshening with sprinkled water. Packaging is not a significant marketing strategy. Maintaining freshness is the primary quality strategy and the primary determinant of pricing of the most perishable vegetables (eg palak).

Transport is a critical function for two reasons: it is costly, and, together with the retail function, encompasses the time when post-harvest, produce is most exposed to the air-borne contaminants that are the subject of this study. The speed and means of transport may have quality impacts; and exposure to the fumes of traffic may also adversely affect quality. Mechanised delivery (auto-rickshaw) was only used by only 11 of the 71 retailers in the retailer research area in Delhi, and the remainder used hand-drawn and cycle rickshaws, bicycles and hand-drawn carts.

There is little storage of the perishable products such as palak, which are marketed and sold within the same day, except where enterprising retailers use fridges to extend the shelf life of products that are mainly destined to higher income consumers. Storage of the less perishable vegetables is the responsibility of wholesalers.

Figure D.1.6. Market chain: critical points for marketing functions, addition and quality



Distribution to the final consumers by vendors and retailers earned the highest gross and net margins. Mean total costs of marketing activities were found to be just under 20% of the retail price. Labour, transport, packaging materials and market fees were the main cost items, of which transport was the most significant, borne by the producer (from farm to market) and the final distributor (retailer or vendor from market to location of final sale). Marketing costs were not found to be related meaningfully to the number of intermediaries in the chain.

a.iii. Vertical relationships in the wholesale market system

As noted, buying and selling within the market system is dominated by the important relationship between price and quality. Price premia for high product quality was a common feature of transactions, although not always practised. Otherwise, prices of comparable quality products in the mass market are homogeneous, and by inference can be regarded as set competitively. Market intermediaries engage to only a very limited extent in client relationships involving credit and information flows about production practices and consumer preferences. Intermediaries sometimes traded on credit and sometimes communicated information about consumer preferences. Ties between buyers and sellers were less strong regarding information sharing about production practices and still less were mashakhores inclined to grant premia to known suppliers.

Non-committal answers ('I neither agree nor disagree') formed the majority of responses to questions about 'trust', 'satisfaction' and traceability. Mistrust exceeded trust, dissatisfaction with quality exceeded satisfaction, and lack of knowledge about the origin of produce exceeded knowledge. Thus the occurrence of repeat dealing is not evidence of strong 'client relationships' between the different buyers and sellers in the chain, except in the niche 'quality' market where specific and coordinated sourcing policies are sustained by reputation effects in distribution to final consumers (2.5). There is little exchange of information, such as knowledge about production practices and consumer preferences. At current levels of information on product quality, it seems that the price mechanism in the mass, wholesale market system has limited potential to align quality incentives between production and consumption.

a.iv. Retailing practices and consumer behaviour

The principal distribution channel for fresh produce is through street vendors and operators of temporary stalls. The principal purchaser in Delhi is the 'housewife', whereas in Varanasi the male head of household was found to be a more frequent purchaser.

Purchasers buy frequently during the week from permanent stalls, from retailers in local periodic markets, and from vendors. There are many retail outlets available to consumers, ranging from relatively sophisticated permanent shops and stalls, where the most enterprising retailers use fridges to extend the product shelf life, to rudimentary small-scale, roadside retailing. Purchasing decisions are based on the same quality-price relationship as that observed within the wholesale markets.

Efforts to improve presentation of the product are not widely employed by retailer-vendors, except that maintaining freshness by sprinkling with water is practised by the majority of sellers. The majority of retailers were conscious of the importance of protecting vegetables from ill effects of sun and air (probably flies). There was almost no evidence of entrepreneurial practices to add value such as dicing or packaging. It can be inferred that the level of service offered to consumers in the mass market is rudimentary, but that opportunities exist to differentiate retailing practices and produce on the basis of quality.

There is a tendency for customers to return to the same buyers, although they are by no means averse to switching from one retailer to another. Among retailers there is considerable heterogeneity of type and income class of customers. In Delhi no significant relationships were found between type of retailer (fixed, temporary or vendor) and the customer type.

Retailers, and more so vendors, both provide a valuable distribution service to final consumers by transporting produce to convenient retail sites. The apparent competitive structure of final distribution of vegetables to consumers suggests that prices set by retailers and vendors are likely to be competitive, without the prospect of earning supernormal profits (2.4). Almost 70% of retailers said that they sometimes engaged in price strategies to win or

retain customers. About 60% of retailers sometimes received complaints about prices, and slightly more received complaints about the appearance of the produce. *Post-hoc* complaints about the flavour of the produce were almost unheard of.

Notwithstanding the diversification of some retailers into fruit marketing, in Ali Vihar vegetable retailing is a small-scale enterprise, with mean daily revenues of just over Rs 700, or about £9.80 (£1=Rs 73), compared with a mean daily purchase cost of Rs 461, or £6.30. Although it is the retailers and vendors who earn the greatest margin, they deal in the smallest quantities, and bear the risk of losses due to quality reduction and unsold produce. Notwithstanding the high margin earned, total returns to retailers and vendors are meagre.

There was evidence of sophisticated sourcing and distribution policies. During informal interviews, retailers in Ali Vihar and traders in Badarpur acknowledged that orders were often placed by telephone, and delivered to Ali Vihar. In the niche 'quality' market, (eg INA market, Khan market, and in the Safal enterprise) specifications, direct sourcing, improved handling, packaging and delivery were linked to labelling and branding and creation of reputation effects (2.5).

a.v. Product price and quality characteristics

- *Prices and quality attributes:*

  Prices in the market are mostly set by auction, sometimes negotiated and in a few cases agreed through the illegal handkerchief practice. More than 57% of farmers never negotiate prices on the basis of quality. The nature of the market does not perhaps permit that. Azadpur is a very big market and prices are determined by the overall supply of any commodity on the day and not merely by its quality. Moreover, the market actors in the *mandi* dominate the negotiations or price settlement mechanism. The farmers have a very limited role. That is why only 43% sold sometimes after negotiating on the basis of quality. And that is why, that not a single case is there who might have always negotiated prices on the basis of quality.

  Price levels within the market were homogeneous within the day, but there was evidence of strong premia for product quality and seasonality effects. According to farmers, the importance of other attributes varied with the type of vegetable:

  - Palak: freshness> physical damage>colour>size>variety>shape
  - Cauliflower: size>freshness/colour>shape>physical damage>variety
  - Okra: size>freshness>colour>variety>shape>physical damage

  Commission Agent/Wholesalers' perceptions of quality/pricing characteristics are similar, indicating that incentives are communicated between buyers and sellers. Mashakhores also consider freshness, freedom from physical blemishes, colour and size as important characteristics.

  That perceived quality attributes should vary between vegetables is not surprising. Spinach is sold in bunches, such that the leaf shape and presence of blemishes on individual leaves is not easily observable. Physical damage certainly does matter for spinach: leafy vegetables are known to show imperfections when exposed to gaseous contaminants (and agrochemical abuse). 'Search' methods cannot serve as a QA mechanism for such attributes that are hidden, at the wholesale marketing stage. The variety of each of the three vegetables was cited less frequently as a quality characteristic, and was perceived by traders to be less important for cauliflower than other characteristics. There is evidence that important varietal differences do indeed exist for some vegetables concerning ease of contamination by heavy metals, and susceptibility to gaseous damage.

- *Handling and transport practices that may affect heavy metal contamination of vegetables:*
  The handling of vegetables by the different market actors both during transport and at point of sale can have an effect on the levels of contamination. Washing or cleaning may reduce whilst exposure to dirty dusty roadsides etc may increase surface born heavy metals on the vegetables.

  Very few of the retailers, wholesalers and mashakhores cover vegetable produce whilst transporting it. However, several protective measures are already in place in both Delhi and Varanasi. In case of cauliflowers farmers stack produce during produce when still folded in its leaves, which provide a natural protection against damages. Palak is bundled in the field at point of harvest and remains like this until sold by retailers to consumers. Okra is often put in jute bags for transport and trading.

  Whilst trading at Azadpur and other observed wholesale markets in Varanasi and Delhi generally takes place in semi-covered areas, retailers generally do not cover produce at point of sale. Little was done in Azadpur markets to add value to any of the produce beyond limited grading, trimming of cauliflower leaves and washing of vegetables. It is uncertain whether washing produce at this stage in the marketing chain is beneficial in reducing heavy metals on the surface.

  Whilst no farmers conducted washing of cauliflower or sprinkling with water to maintain freshness and improve appearance, within the market and at retail level, however, many traders were found doing so. Wholesalers and mashakhores, whose primary function in the market is debulking large quantities and selling small quantities to retailers and other vendors undertook no functions (eg sprinkling with water) to maintain product freshness, but sometimes clean or remove leaves. Value addition through preparation or packaging of the produce was negligible. Differences in handling practices may be observed between vegetables and seasons. For instance, cauliflower is only semi-perishable when compared with other products (eg palak) and its handling and presentation are less critical. Moreover, it is sold in winter season when the impact of weather is reduced.

  Perhaps the most important point where produce is handled prior to its shifting of ownership to consumers is at the retailer. A good 39 percent of retailers always wash vegetables prior to sales and half of all to so at times. Those who never did any washing or cleaning were less than 10% in both the cases. Cleaning of vegetables was mostly done regularly/ always in the area by about 22.5% retailers and at times by 72%. Repacking or dicing produce was not practiced.

  There was almost no evidence of entrepreneurial practices to add value such as dicing or packaging. It can be inferred that the level of service offered to consumers is rudimentary, but that opportunities exist to differentiate retailing practices and produce on the basis of quality.

  Most of the retailers, throughout Delhi, sell vegetables in the late after noon or in the evening. Hardly 9% vegetables are sold in the early morning, and about 18% are sold during the middle of the day. However, the bulk of the vegetables (about 60%) are sold in the late afternoon, and about 12% are left unsold for the second day and the remaining around 2 % are not at all sold.

  With the majority of sales taking place later in the day and purchases in the early morning hours, there is enhanced risk of exposure to heat and dust during the course of the day. In this respect, 24% of retailers always take measures to protect

vegetables from the burning sun and the rest do so regularly. However, routine protection from air borne dust particles was reported by only 3% and occasionally by 86%, whilst 11% never take protective measures in this respect.

Table D.1.17. Handling of vegetable produce by retailers/vendors

Marketing functions	Always		Sometimes		Never	
	No.	%	No.	%	No.	%
Cleaning/removing leaves	16	22.54	51	71.83	4	5.63
Washing/ sprinkling water	28	39.45	37	52.11	6	8.45
Dicing/ packaging	0	0	1	1.41	70	98.59
Protecting from Sun	17	23.94	49	69.01	5	7.04
Protecting from air	2	2.82	61	85.92	8	11.27

Price levels within the markets were homogeneous within the day, but there was evidence of strong premia for product quality and seasonality effects. Freshness was regarded as the paramount quality attribute and the principal determinant of price, and the importance of other attributes varied with the type of vegetable.

There is evidence that producer margins can rise due to high product quality, although the effect is not easily disentangled from negotiation effects. Nevertheless, survey data from Azadpur market reported elsewhere have confirmed that product quality is a major determinant of price. Thus if high producer prices are assumed to be an indicator of high product quality, the high correlation between the prices paid to producers and the net margin received by producers (R = 0.88) suggests that producers' best opportunity to improve net marketing returns is to produce high quality produce.

As noted, that perceived quality attributes should vary between vegetables is not surprising. For cauliflower, the presence of physical blemishes and product colour were followed by size. Variety was of little importance except for a few respondents for whom it was regarded as very important, although the reason for this was not discovered. Stage of maturity and cauliflower shape were regarded as of no importance. Spinach is sold in bunches, such that the leaf shape and presence of blemishes on individual leaves is not easily observable, nor are they important in food and presentation. Physical damage certainly does matter for spinach: leafy vegetables are known to show imperfections when exposed to gaseous contaminants (and agrochemical abuse).

The variety of each of the three vegetables was cited less frequently as a quality characteristic, and was perceived by traders to be less important for cauliflower than other characteristics, whereas there is evidence that important varietal differences do indeed exist for some vegetables concerning ease of contamination by heavy metals, and susceptibility to gaseous damage.

It is noteworthy that the importance of 'health', which is probably a *credence good*, exceeds that of 'flavour and eating quality' which is an *experience good*, and of 'colour and appearance' and 'price', both of which are *search goods*. Thus there is an inverse relationship between the level of importance that consumers attach to these quality attributes, and the ease with which assurance of these quality attributes can be gained. Therefore, a proper level of accurate quality information assumes great importance in order for consumers' private preferences and public food safety objectives to be satisfied.

Higher income consumers have options not available to poorer sections of the population. Better-off consumers are able to exercise their preferences for high quality appearance, and for location by purchasing from enhanced retail outlets and vendors who visit at home. In addition, quality assurance is implicit through retail outlets such as Safal, and the INA market where value is added through reputation effects and added services such as packaging and delivery. The high quality retail outlets are supplied through short market channels and fewer middlemen. The ability to trace produce from such retail outlets to production is a characteristic of the sophisticated market segment that is not feasible in the mass segment flowing through the wholesale markets (2.5). Better-off consumers are also able to exercise their preferences for out-of-season produce by paying premium prices that the mass of consumers cannot afford.

D.1.4. CONSUMER STUDY

I. ACTIVITIES

I.a. Consumption patterns and awareness of food safety – Delhi

A study of consumption pattern and consumers' awareness of food safety with reference to vegetables was conducted in the city of Delhi. The survey involved 500 at-home face-to-face interviews during November 2001. Respondents were the female household decision maker. Ali Vihar (453 respondents) and Jagdamba Colony (47 respondents) of the Badarpur assembly constituency (number 36 of the Delhi state assembly in the south-east of Delhi NCT) were chosen purposively as the other teams associated with the project were also working in this area.

The sample frame was a CD of the list of voters from the last electoral roll published by the election office purchased from the office of the Chief Election Officer, Delhi and cases were selected for interview on a randomised serial basis. Wherever the respondent was not available due to any reason[5], the next number in the serial was taken to replace the random number. A quota was also applied. The official poverty line in urban areas is household income of less than Rs 2400 per month.

Two female assistants accompanied the male interviewers in order to secure adequate response from the female household heads.

I.b. Consumption patterns and awareness of food safety – Varanasi

A study of consumption pattern and consumers' awareness of food safety with reference to vegetables was conducted in the city of Varanasi. A multi-stage sampling procedure was adopted in the selection of wards, mohallas and finally the households.

The Varanasi Municipal Corporation is divided into 90 Wards. At the second stage of sampling, 5 wards were selected purposively considering with the highest air pollution levels (Agrawal, 2001). Out of the remaining 85 wards, 30 wards were also selected randomly making a total sample of 35 wards. Further, a list of all the mohallas in each sample ward was prepared. The number of mohallas in different wards was not equal. There was a minimum of 2 and maximum of 8 mohallas per ward in the sample wards. One mohalla in each sample ward was selected randomly at the third stage of sampling.

[5] In 9 such cases in spite of our repeated visits the respondents could not be contacted., mainly because they were single members and were not easily available at their residence.

For the last stage of sampling, a list of the total of households in each sample mohalla was prepared. The numbers of households varied from 62 to 470 in the different sample mohallas. The systematic random sampling procedure was used in the selection of ten households per sample mohalla making a sample of total 350 households. Data were collected between the end of September and November 2001 by trained enumerators at Banaras Hindu University.

II. OUTPUTS

a. Delhi:

Potato was the vegetable most purchased (by volume, taken to be equivalent to preference), constituting the first choice of almost three-quarters of the sample (73.2%), followed by palak (11.4%) and pumpkin (6.0%). First preferences for other vegetables were cited by less than 2% for each and included a wide range of other vegetables. The vegetables which ranked 2-5 in terms of purchase volumes included a wider range: sitafal (squash/pumpkin); sponge gourd; radish; arbi; bitter gourd; and methi (fenugreek).

Table D.1.18. Vegetable most bought during year (by volume)

	Frequency	Percent
Potato	366	73.2
Palak	57	11.4
Pumpkin	30	6.0
Brinjal	9	1.8
Cauliflower	8	1.6
Onion	8	1.6
Tomato	8	1.6
Cabbage	6	1.2
Peas	4	.8
Carrot	3	.6
Okra	1	.2

During peak season, 83-86% of consumers buy cauliflower and palak two to three times a week, and okra is purchased by 55% this frequently. However, even during off-season, when prices rally, over 90% of respondents still buy cauliflower, okra and palak once a week. In about 80% or more of cases, the 'housewife' is responsible for purchasing the vegetables, approximately 1-3 kg per week.

Table D.1.19 shows how respondents reported that vegetables were cooked:

Table D.1.19. Cooking (% responses)

	Okra	Cauliflower	Palak
Boiled	0.4	0.4	32.6
Fried	99.6	96.4	66.6
Boiled and fried		3.2	0.8

A ranking of factors affecting purchasing decisions is shown in Table 57. Overall, ranked of most importance was 'health reasons', followed by 'flavour and eating quality'. It is noteworthy that the importance of 'health', which is probably a *credence good*, exceeds that of 'flavour and eating quality' which is an *experience good*, and of 'colour and appearance' and 'price', both of which are *search goods*. Thus there is an inverse relationship between the level of importance that consumers attach to these quality attributes, and the ease with which assurance of these quality attributes can be obtained. Therefore, a proper level of accurate quality information assumes great importance in order for consumers' private preferences and public food safety objectives to be satisfied.

Consumers were asked from what type of retail outlet they usually purchased okra, cauliflower and palak. The pattern of responses was almost identical for purchases of okra and cauliflower. Retail outlets for purchases of palak were approximately the same. Street vendors were cited by more than 450 of the 500 consumers interviewed, and constituted the most important category of retailers. Temporary stalls were cited by about 340 consumers. Permanent stalls were cited by 70 or so consumers, and purchases made at wholesale markets accounted for less than 2% of responses.

Washing of the three vegetables prior to cooking was always conducted by 100% of respondents, and the sample was equally split on whether vegetables were washed once (49.6%) or more than once (50.4%). In almost all cases (98% - the remainder were missing values) washing was conducted prior to preparation activities such as dicing and slicing. For 91%, the source of water was a bore well or hand pump, with 9% of respondents dependent on a tanker, and only 0.4% (2 respondents) using a community tap.

b. Varanasi

About 37% of consumer households surveyed in Varanasi had incomes less than 3000 monthly, and therewith were classified as poor consumers.

Table D.1.20 Total monthly household income-sample

Rs	Frequency	Percent
< 3000	132	37.7
3001-10000	197	56.3
10001-20000	20	5.7
> 20000	1	0.3

Potato was the most frequently cited the vegetable most purchased, followed by okra and brinjal, although the range of gourds together were more consumed than okra. The vegetables which ranked 2-5 in terms of purchase volumes included a wider range (Table D.1.21). After potato, the consumption index, which accounts for volumes consumed other than first choice, points to okra as the next most consumed vegetable

Table D.1.21. Vegetable most bought during year (by volume)

	Frequency	Percent
Potato	154	44.0
Okra	58	16.6
Brinjal	27	7.7
Sponge gourd	23	6.6
Pointed gourd	22	6.3
Palak	17	4.9
Other gourds	15	4.2
Cauliflower	13	3.7
Cabbage	5	1.4
Pumpkin	5	1.4
Others	< 5 each	3.2
Total	350	100.0

The contribution to diet and health were the principal reasons cited for consuming vegetables. Compared to Delhi, frequency levels of consumption are relatively high. However, in contrast, it is the husband (or male head of household) that was recorded as the main purchaser of vegetables, followed by children and servants.

Table D.1.22. Vegetable purchase frequency in Varanasi (in per cent)

	Okra		Cauliflower		Palak	
	Peak-season	Off-season	Peak-season	Off-season	Peak-season	Off-season
Never		80.9		54.0		66.9
Daily	58.6		60.0	0.6	59.1	
2-3 times per week	36.9	2.9	36.0	3.4	36.3	2.6
Once per week or less	4.3	14.9	4.0	41.1	4.3	29.7
Missing	0.3	1.4		0.9	0.3	0.9

Mean weekly quantities purchased for cauliflower, okra and palak range from 1.1-1.7 kg.

A highly significant relationship ($p>0.001$) was found between income levels and the price paid for okra: the low-income group paid significantly lower prices than did the middle and high-income groups. Knowing that quality is the major factor influencing prices, and that quality is mostly associated with freshness (see below), this result confirms that purchasing power affects the quality of produce purchased

Washing of the three vegetables prior to cooking was always conducted by 99% of respondents. 80% used water from household taps, while the remainder used other sources including community taps, a bore-well and hand pumps. Detergent was never used, but 30% said that they washed the vegetables twice rather than once.

c. Food safety awareness

Food safety scares in India have increased general awareness about food safety problems in the last 5 years. Major scandals have been elaborated upon in the media, such as mustard adulteration leading to 'dropsy' deaths and adulteration of milk with urea and chalk. Persistent rumours about vegetables dipped in pesticides/other toxic substances against insects and injections of mellons with dyes and sugary syrups have recently been confirmed by a revealing TV report at Okhla wholesale market.

Recent high profile campaigns of Centre of Science and Environment regarding pesticide residues in mineral water and soft drinks, as well as the findings of the current study have received a lot of press coverage and political interest, with questions raised in state and national legislative assemblies.

However, these issues are highly topical and without media exposure, awareness levels are much lower. This is for instance the case in Kolkata, where an elaborate study found customer awareness about food safety issues concerning street foods to be low. More so, awareness levels amongst food handlers was poor reflected in unhygienic handling practices of street food vendors (Chakravarthy, pers. comm, 2003).

Our consumer surveys also indicate that it is evident from the consumer research that there is a positive relationship between income and education levels on the one hand, and awareness of food safety hazards on the other. That is to say, poor consumers who are more likely to be subject to environmental health hazards, are not only less able to pay a price premium, but are also less aware of the potential health hazards of food contamination.

The questions on food safety were exploratory in nature, and perhaps were leading in their simplicity. However, the request for specific answers in response to awareness questions introduced a check on responses. Table D23 summarises the responses.

Table D23. Awareness of food safety hazards Delhi-Varanasi

Food safety issue	Delhi	Varanasi
	%	%
I have heard of (specific) food adulteration scares	34.4	24.6
I am aware of (specific) health problems from consuming contaminated food	56.0	19.4
I know the causes of these health problems	41.0	15.4
There are (specific) types of food for which health risks are greater	67.8	41.7
My household have suffered (specific) food-related health problems	25.6	14.3
My household consume street food (1-2 x per week)	63.0	42.6
I use specific practices to ensure that vegetables are safe to eat	14.2	32.3
I believe that air pollution can contaminate food and cause health hazards	91.4	63.1
I believe that agrochemicals can contaminate food and cause health hazards	77.8	62.6
I have (specific) ideas of how vegetables could be made safer and healthier	29.6	38.3

The outcome of the study is that poorer consumers are unlikely to demand vegetables that are quality-assured in respect of food safety such as freedom from contaminants (be they heavy metals from air pollution, or from agrochemical or microbial sources). Moreover, the current mass assembly and distribution system through the wholesale markets is not able to convey signals about food quality other than freshness, nor mechanisms of quality assurance other than visual inspection of produce.

Higher income consumers have options not available to poorer sections of the population. Better-off consumers are able to exercise their preferences for high quality appearance, and for location by purchasing from enhanced retail outlets and vendors who visit at home. In addition, quality assurance is implicit through retail outlets such as Safal, and the INA market where value is added through reputation effects and added services such as packaging and delivery. The high quality retail outlets are supplied through short market channels and fewer middlemen. The ability to trace produce from such retail outlets to production is a characteristic of the sophisticated market segment that is not feasible in the mass segment flowing through the wholesale markets. Better-off consumers are also able to exercise their preferences for out-of-season produce by paying premium prices that the mass of consumers cannot afford.

Food safety awareness levels are also reported to be not always sufficiently developed in the certified food industry. For instance, Bhat (2000) showed that awareness levels about food safety amongst food handlers in a HACCP certified mushroom industrial units are unsatisfactory and as a result, many Indian export consignments get rejected simply because of the presence of human hair in the food products.

d. Poverty-health relationships

The analysis of the stages of the cauliflower market system has certain implications for poor traders and consumers. Any marketing interventions such as requiring improvements to retail practices will raise costs of retailing and/or prices paid by consumers. However, average retailing costs were 7-30% of gross margins (mean 19.6%, SD 6.44), mainly accounted for by transport. Some retailers and vendors incurred zero transport costs and for others transport costs accounted for 100% (mean 50.5%; SD 35.18). For producers, transport costs ranged from 43.1% to 76.7% (mean 58.0%, SD 12.68). More elaborate mobile and fixed retail structures would increase marketing costs of final distributors.

For producers, any marketing-type interventions to maintain product quality will be simple – like improved packaging or covering of produce – and will have only a small impact on the margins. On the other hand, the opportunity to reduce transport costs, for example by collective bulk marketing could reduce what is the major element of their marketing costs.

However, any interventions that reduced transport costs might adversely affect the incomes of the rickshaw-wallahs.

Various income effects were identified in the consumer research. For example, for okra, a highly significant relationship was found between income levels and the price paid: the low-income group paid significantly lower prices than did the middle and high-income groups. Knowing that quality is the major factor influencing prices, and that quality is mostly associated with freshness, this result confirms that purchasing power affects the quality of produce purchased, and that low income households are likely to consume smaller quantities.

Freshness is of paramount importance, but otherwise quality is perceived differently for different vegetables, and ranking of the importance of quality characteristics, concern about price, features of purchasing habits, both vegetable types and street food, are income-dependent.

The study has found that flows of information and incentives through the mass market are limited by the focus on the price-appearance relationship. It is evident from the consumer research that there is a positive relationship between income and education levels on the one hand, and awareness of food safety hazards on the other. That is to say, poor consumers who are more likely to be subject to environmental health hazards, are not only less able to pay a price premium, but are also less aware of the potential health hazards of food contamination.

The outcome of the study is that poorer consumers who are unaware of food safety hazards are unlikely to demand vegetables that are quality-assured in respect of food safety such as freedom from contaminants (be they heavy metals from air pollution, or from agrochemical or microbial sources). Moreover, the current mass assembly and distribution system through the wholesale markets is not able to convey signals about food quality other than freshness, nor mechanisms of quality assurance other than visual inspection of produce.

However, responses to the provision of information to consumers in Varanasi about food safety hazards through a choice experiment showed that there was willingness even amongst the poor to pay enhanced prices for quality assured cauliflower. Willingness to pay, and the level of premium, were both positively associated with income level. This is a major finding nonetheless, and needs further testing.

RECOMMENDATIONS

1. Producers

- In the short term, a limited choice in market access disadvantages producers. Where produce has to pass through the control of commission agents in the wholesale markets, producers are price takers. Regulated markets such as Azadpur will continue to have a part to play in the national food system. However, Delhi may wish to embrace other types of market system that operate elsewhere in the country, particularly where farmers have the opportunity to avoid the control of middlemen:
    - farmers' markets such as the 'apani mandies' in Haryana and Punjab
    - 'hardupsar mandies' near Pune;
    - 'ritubajar mandies' in Andhra Pradesh (Vishakapatnam)
- The intention of the Azadpur to set up two markets for organic products is an example how 'plural' market systems are likely to evolve, giving greater choice of outlet to producers.

2. Market systems

- Exposing farmers to the marketing concept will hasten the professionalisation of post-harvest business practices and the shift to more integrated supply chain management of peri-urban supplies. Wholesale market authorities such as Azadpur Produce Marketing Committee are an entry point for enhancing quality-awareness and production and post-harvest practices among producers.
- The wholesale market system is probably a permanent feature of Indian food marketing. In the long term, the market system is likely to evolve towards more direct sourcing and more sophisticated distribution systems with reduced linkages that may be more efficient and exhibit lower producer-consumer margins. Thus, 'best practice' can be expected to trickle down to the mass market, and NGOs, small business support organisations and legislative instruments that address issues of social responsibility (eg use of PILs within the framework of a new food safety law) can expedite the innovation process.
- The innovative practices that emerge will be a likely source of competitive pressure for improvements to the traditional systems.
- The evolution of markets is also likely to lead to a proliferation of premium quality systems such as Safal and the well-coordinated INA model.

3 The link between market infrastructure and market coordination

- The government authorities at Central and State (Delhi city) level have the means to expedite the evolution of better-coordinated markets. In particular, there is a need for better provision of retail market physical infrastructure such as roofs, permanent stalls, facilities and clean access to provide shade, shelter and hygiene in each colony. Ideally these retail markets would be physically removed from the roadsides that are likely to be a major source of contamination, not only concerning heavy metals, but also other health hazards (eg microbial contaminants). However, this is not entirely practical and does not begin t address the problem with regard to mobile vendors.
- Local Area Development funds could be made available and market fees managed through a range of public sector authorities to improve infrastructure:
- Provision of facilities and implementation of economic fees structures payable by traders is likely to expedite the concentration and professionalisation of the food retailing function among dedicated firms. This is likely to lead to more efficient and better-coordinated markets. The 'casualisation' of food retailing is likely to reduce, not

without consequences for the smallest retailers, but thereby, food safety standards are likely to rise.

4 Public awareness of food safety hazards

- There is a need for dissemination of information and creation of awareness of safety hazards, targeted not only to consumers but also to market intermediaries. The targeting of and dissemination media for such information must take into account that the major beneficiaries will be the poorest and least educated.
- Information strategies for consumers can follow the pattern used for polio, HIV/AIDS, etc.
- The market intermediaries can be reached through
    - the secretaries of the Agricultural Produce Marketing Committees of the regulated markets such as Azadpur, which can develop forward and backward linkages in the chain to convey information flows to retailers and to producers;
    - the National Institute of Agricultural Marketing (Jaipur) and organisations in Lucknow and Surat.

5 The transport of food produce

A final recommendation is that produce should not be uncovered in transit to and from markets. Use of tarpaulins is advisable for cycle- and auto-rickshaws that are the principal form of intra-urban transportation, and tend to leave produce exposed to environmental contamination and other quality degradation. This is likely to involve only small-scale start-up costs in the purchase and eventual repurchase) of covering material that will be borne by producers and retailers.

D.2. ASSESSING THE EXTENT, NATURE AND SOURCES OF HEAVY METAL CONTAMINATION OF VEGETABLES IN DELHI AND VARANASI

Introduction

The chapter summarises the rationale, methodology and outputs of experimental field studies which were carried out to assess the nature and extent of heavy metal contamination in vegetables crops taken from markets and field locations in Delhi and Varanasi. There is strong emphasis on the data that were utilised by other members of the multidisciplinary research team in raising awareness of the threat of environmental pollution to food safety, and in discussing practical policy measures and associated programmes to reduce the contamination of vegetables with heavy metals. Thus, whilst the credibility of the data is established through evidence of sound field methodologies, equipment and analytical techniques; complex analysis is avoided and the results are presented in a way that can be understood by a non-expert audience. For example, results obtained in this study are compared with national and International established permissible limits from the perspective of food safety. Other aspects of the results which are discussed here include seasonal trends in contamination, and the proportion of the measured contamination that may be attributable to air borne heavy metal depositions versus other sources. These are all aspects of the results that point to potential measures to reduce either the contamination of vegetables, or the consumption of contaminated vegetables.

The experimental results will be presented at a later date in the form of peer reviewed scientific journal articles, but this was not the main objective in the context of this study. Here we were aiming at integrating evidence from good scientific field studies into a much wider assessment of environmental threats to food safety and associated livelihoods, and in engaging stakeholders both within and beyond our project team (community groups, markets actors, policy advocacy groups, government departments etc.) in the process. The original data sets are large, and are not presented here, but MS excel files including all the data and appropriate summaries are available.

Another aspect of experimental work carried out during this project was an investigation into the impacts of gaseous air pollution on the nutritional quality of vegetable crops in Varanasi.

An example of relevant scientific experimental work is given, but this aspect of the work not discussed in detail in other areas of this report. This is partly because the results became available rather late in the project (due to logistical difficulties with the equipment). In addition, the project team made a decision to focus stakeholder consultations and policy related activities on the rather more tangible issue of heavy metal contamination. However the open top chamber equipment used to assess air pollution impacts on nutritional quality remains operational and Dr Madhoolika Agrawal has trained a number of postgraduate students and has established a research team to take this forward. One significant aspect of this is that the young scientists involved in this work have experience beyond the usual plant science training, of investigating issues that affect the livelihoods of the poor, and seeing how these efforts can become part of an integrated effort with people from other disciplines and sectors who are working towards policies and programmes to address current development issues.

D.2.1. EXPERIMENTAL STUDIES TO ASSESS THE NATURE AND EXTENT OF HEAVY METAL CONTAMINATION IN VEGETABLE CROPS IMPORTANT TO THE POOR.

Key research questions that guided this process included the following:

i. Contamination at market retail sites
   - Do measured levels of HM contamination in vegetables sold in retail markets in Delhi and Varanasi (city/municipal corporation) exceed (Indian/European etc.) legal permissible limits?
   - What is the seasonal variation in HM contamination?
   - To what extent can these potential increases be attributed to air borne heavy metal depositions at the point of sale?

ii. Contamination at source in farmers' fields
   - What are contamination levels at field sites (does these results indicate the proportion of overall contamination monitored at market outlets that is attributable to pre-harvest exposure and handling)
   - Do measured levels of HM contamination in vegetables grown in urban and peri-urban fields in Delhi and Varanasi (city/municipal corporation) exceed (Indian/European etc.) legal permissible limits?
   - What is the seasonal variation in HM contamination?

iii. Potential for reducing contamination:
   - How much of the contamination can be removed by washing of samples from market and field sites?
   - Can different washing regimes be applied to achieve better results?

iv. Impacts of air pollution on the nutritional quality of selected horticultural produce important to the poor
   - What are the nutritional values of crops grown at both polluted and relatively clean sites across the city and how do these compare with recognized 'published' nutritional contents of these vegetables?
   - Is there evidence from controlled studies that ambient air pollution levels in important vegetable production areas affect the nutritional quality of vegetables?

I. CONTAMINATION OF VEGETABLES AT MARKET SITES (VARANASI)

Methodology

Market sampling locations were selected with the aim of reconciling the practical limitations of the number of sites that could be visited, with the need to include a wide range of areas across the city housing different socio-economic groups. In addition, there was the requirement of being able to illustrate to lay target audiences, that sampling was 'representative' of vegetables available in markets across the city.

The city sprawl covers approximately 40 square kilometers. This area was divided into 40 grids of 1x1 square km covering most of the city area on the basis of Survey of India City Guide Map for Varanasi (scale 1:20,000). Accordingly, the team of geographers and natural scientist identified vegetable sellers within each grid, thus totalling 40 sampling locations.

Out of 40 market outlets, 7 were whole sale, 18 retailers, 12 were vendors, and 3 evening markets. Thus the sample sites represented the wide range and types of markets from which Varanasi's consumers buy fresh vegetables. As the population size of each category is unknown, the selection is not necessarily a precise representation. However, care was taken to include the larger markets were poor consumers can generally obtain the cheapest produce, as well as the outlets preferred by more middle- and upper class consumers, such as the vendors that conveniently deliver vegetables at consumers' doorsteps at a price premium. Clearcut definitions for the outlet types are hard to make due to the high fluidity and hybrid character of markets, which combine wholesale and small-scale trading with retailing business functions. Farmers as well as merchants come to sell produce in the wholesale markets.

Evening markets only operate in the late afternoon/early evening from about 5-9 pm and are a popular facility for consumers to buy produce often coming freshly from the farm. Although these markets have a more retail like character, farmers also directly market fresh vegetables here.

At each of the 40 sampling locations (Table D2.1), vegetable samples were collected from three different shops. Thus the minimum number of samples was 120 for each crop sampled on each sampling occasion. For palak and bhindi, 1 kg samples each were collected from three different shops i.e. from 1 market site 3 samples were collected from different shops/carts. For gobhi, 1 similar sized head each was collected from 3 different shops. Care was taken to ensure the similarity of bought produce: for palak fully expanded leaves were taken, whereas for bhindi the fruits were tight and more or less of similar size. Cauliflowers were always selected on the basis of size, and 'tightness' of head, as is common consumer practice in Varanasi. Samples from market site were collected between 7 to 10 am from whole sale market, from 10 am to 2 p.m. from retailers and vendors and 5.00 to 6.00 p.m. from evening markets. The individual samples were placed in closed polythene bags and immediately transported to the laboratory. Regular monthly sampling was maintained (with occasional losses due to weather and transport difficulties) throughout the collection period, which covered the peak supply seasons for each of the three crops from June 2000 to April 2002.

Table D.2.1. Market locations in Varanasi for vegetable sampling

S.No	Grid	Name of Location site	Type of market	Source/s of Vegetables
1	D4	Shivpur Police Station	Retailer	Bhojubir Satti
2	E4	Bhojubir Satti	Whole sale	Sarsauli village
3	F4	Mahabir Mandir, east of Bhojubir	Retailer/vender	Lalpur & Chandua satti
4	G4	Lalpur Mandi	Whole sale	Cholapur, Lalpur, Mohai
5	D5	Near Central Jail	Vendor	Bhojubir Satti
6	E5	Near Commissioner Compound	Vendor	Bhojubir Satti
7	F5	Varuna bridge, near SBI	Vendor/ Retailer	Bhojubir Satti
8	G5	Dube Purwa, Premchand Rd	Vendor	Lalpur & Bhojubir Satti
9	F6	Nadesar, near Mint House	Retailer	Chandua Satti
10	G6	Hukulganj, Chauka Ghat	Vendor	Lalpur Satti
11	F7	Behind RlyStn, Cantt. Church	Vendor	Chandua Satti
12	G7	Anand Mandir, near Andhrapul	Vendor	Chandua Satti
13	H7	Lahurabir, near Queens College	Retailer	Chandua Satti
14	I7	Vishveshvarganj Satti	Whole sale	Pancakroshi Mandi
15	J7	Adampur PS (East)	Retailer	Chandua S, Pancakroshi
16	K7	Colony near Kashi Rly Colony	Retailer	Chandua S, Pancakroshi
17	E8	Lahartara, near Rly Stn	Vendor	Chandua Satti
18	F8	Chandua Satti, Stn Rd	Whole sale	Chittanpur village
19	G8	Lallapura, Fatman Rd	Retailer	Chandua Satti
20	H8	Kabirchaura, near SPG Hospital	Vendor/ Retailer	Chandua Satti
21	I8	Kotwali, near Town Hall	Retailer	Chandua Satti
22	C9	Near Industrial Estate, Chandpur	Retailer	Rajatalab Mandi
23	F9	Mahmoorganj	Vendor/ Retailer	Rajatalab, Chandua Satti
24	G9	Rathyatra, near Shish Mahal Col	Retailer	Chandua Satti
25	I9	Dashashvamedha Satti	Whole sale	Chandua Satti
26	D10	Bhulanpur Rd, Maruadih PS	Retailer	Rajatalab Mandi
27	E10	Maruadih crossing (evening)	Retailer/Eve.Bz.	Rajatalab Mandi
28	F10	Kolhua (Gaibi Purwa)	Retailer	Chandua S, Sunderpur
29	G10	Kamachha Satti	Whole sale	Bhagwanpur village
30	H10	Harishchandra Ghat lane	Retailer	Chandua Satti
31	D11	Kakarmatta, D.L.W. Satti	Evening market	Nearby villages
32	E11	Lakhrampur	Retailer	Kamachha, Sundarpur
33	F11	Bajardiha	Retailer	Kamachha, Sundarpur
34	G11	Khojwa Satti	Retailer	Kamachha, Sundarpur
35	H11	Asi-Bhadaini Rd	Retailer	Sundarpur satti
36	C12	D.L.W. Colony	Retailer/Eve. Bz	Jalalipatti, close villages
37	F12	Sundarpur Satti	Whole sale	Rajatalab, close villages
38	G12	Kabir Nagar, near Durga Tem.	Retailer	Sundarpur, Kamachha
39	H12	BHU Gate, Lanka	Retailer	Near villages
40	F13	Karaundi	Retailer/Vendor	Sundarpur Satti

Table D2.2. Total samples collected in Varanasi:

	Palak	Period	Cauliflower	Period	Okra	Period
Markets	1640	May 2000-April 2002	835	October 2000-March 2002	1450	May 2000-October 2001
Fields	36	November 2001-march 2002	162	November 2001-March 2002	120	June 2001-October 2001

Additional sampling
This regular sampling was augmented with a more intensive sampling of individual crops at selected outlets to assess the variation of contamination levels. For example, in each of the months of June to October 2001, 10 okra samples were taken at each of 5 pre-selected points of sale (12: near Anand Mandir/Andhrapul; 20: Kabirchaura; 22: near Chandpur Industrial Estate; 24: Rathyatra/Gurubagh and 39: Lanka). These retail locations were selected as they represent locations where monthly contamination levels during 2000 were found to represent categories of relatively high contamination (site 22, 24), moderate contamination (12, 20) as well as relatively low contamination (site 39, Lanka).

Similarly, the number of replicates of cauliflower were increased to 15 at Channua Satti in March 2002 and 5 replicates were taken at 4 other market sites. The same additional replicates were selected from the same markets for Palak in May 2002.

In the month of April 2002, when contamination levels are expected to be relatively high (on the basis of our previous summer season data), in the Chandua Satti wholesale market, a larger number of replicate samples was collected for the dual purpose of

- assessing the variation of contamination between vegetable samples
- Determining the impact of washing on the measured levels of contamination

15 replicate samples of 1 kg each were collected from 15 sellers and the replicate samples were split into 4 batches of ¼ kg. To each of the ¼ kg sub-samples a different washing regime was applied: washing once, washing twice, washing thrice or unwashed.

Accordingly, a clean bucket was filled with a measured amount (volume to be specified) of tap water, one sub-sample of the vegetable (1/4 kg.) added and rinsed/mixed with hands for 3 minutes, after which the water is drained using a sieve. This process is conducted either once, twice or thrice for each ¼ kg sub-sample, whilst another sub-sample was put aside for unwashed analysis. After each round of washing, the bucket was cleaned. Subsequently the same process was applied to the all 15 replicates. Finally, the 15 replicate samples were analysed for each of the 4 treatments.

II. POTENTIAL FOR REDUCING CONTAMINATION BY WASHING

Here the following research questions were addressed:

- What is the potential for reducing contamination by washing?
- Can different washing regimes be applied to achieve better results?

Methodology
For a number of pre-selected sites, washing was applied as follows:

i. Palak and okra:
Three replicate samples for each (market and field) site of 1kg each were used, which were split in two equal portions of ½ kg in the laboratory, subsequently using one for analysis with and one portion for analysis without washing. A clean bucket/tub was filled with a measured amount (7.5 liter) of tap water, one replicate sample of the vegetable (1/2 kg) added and rinse/mix with hands for approximately 1 minute (again this was not standardised or timed), after which the water is drained using a sieve. This process is repeated twice for each replicate sample, thus thoroughly washing it thrice, after which the bucket was washed and the sample laid to drip dry on blotting paper. Subsequently the same process was applied to the other 2 replicates representing the field and market sites. Finally, the 3 replicate samples were analysed and washed and unwashed samples compared for their heavy metal contents (digestion and atomic absorption spectrophotometry).

ii. Cauliflower:
In accordance with local household practices, similarly sized pieces were manually torn from the head of the cauliflower and approximately half of these put into the tub for washing. Otherwise the washing process was identical to that carried out for palak and okra.

Field sampling and sample washing

Field sample locations were selected on the basis of the market surveys carried out the geographers and agricultural economists at Banaras Hindu University which has identified major supply villages for our selected crops. Amongst these, a random sub sample of villages was selected. The details of the sampling regime were also determined by the availability of a given crop at the allotted sampling time (table D2.3)

The same members of the project team visited each field site on each occasion and interacted with the local farmers where possible. Farmers were provided with financial compensation for the crop samples taken for analysis.

Individual vegetable plots within a given site were selected on the availability of the farmers and his willingness to participate.

For okra three X 1 kg samples (equal to 30-40 units of okra) were taken. Each 1kg sample was selected randomly within an individual field from 30-40 plants.

For cauliflower/Gobhi 3 units were taken from an individual field, and this was repeated across three fields as available. On a number of occasions more intensive sampling (10 replicate samples per field) was carried out in the key production areas namely, Parmanandpur, located closely to the north of Bhojubir market and Karnadandi, located to the west of Chandpur industrial area.

For palak, which was sampled during the hot dry season, farmers were often not able to access sufficient irrigation water to grow large plots, and it was not appropriate to ask for 1kg samples. As a result the sample size had to be reduced to 0.5kg. Five individual samples of 0.5kg each sampled across an individual field were collected.

For two sites there was a more intensive sampling of ten x 0.5kg samples.
- Where 10 replicates of 0.5 kg were taken these were split into two sets of ¼ kg to be washed thrice and unwashed

- Where 5 replicates of 0.5 kg were taken these were split into two sets of ¼ kg to be washed thrice and unwashed

Table D.2.3. Overview field samples Varanasi

Crop	Sampling location	Period covering	Sample replication
Palak	5 sites Lohta, Sarsoan, Tikari, Rohania, Susuvahi	March, April, May 2001	3 reps x 1 kg bundle collected across field
Palak	4 sites Lohta, Daniyalpur , Tikari and Rohania	November 01, January and March 02 4 sites	3 reps x 1 kg
Palak	6 sites, Bachhav, Gangapur, Ramanna, Tikari, Lohta, Shivpur	April-June 02	For April: 2 sites x 10 reps. In addition 4 x 5 reps (to compare washed-unwashed).
Okra	8 sites: The sites 1, 2, 3, 4, 5, 6, 7, 8 are Banpurwa, Akhari, Lathwan, Parampur, Nakain,Ramraipur, Batpurwa and Murdi, respectively.	June, July, August, September, October 2001 (September and October samples were washed for site nr: 1,5,6,8)	3 reps X 1kg sample. Each sample = 30-40 units
Cauliflower	11 sites; Nakain, Madhon, Derekhu, Karnadandi, Lakhanpur,, Burthara, Chuppeypur,Paramanandpur, Bhushaula, Kotwa, Rustumpur	November, December, January, February 2002	3 reps x 1 unit
Cauliflower	2 sites (Parmanandpur, Karnadandi because here large amounts of production	March 2002	15 samples of one head each (similar size and compactness) were collected per site and subsequently split in halves, such that 15 x ½ heads were washed thrice and 15 x ½ units unwashed

III. ANALYTICAL METHODOLOGY FOR HEAVY METAL ANALYSIS

Each crop sample (i.e. monthly 120 samples per crop (3 samples from 40 market sites) was dried, digested and analysed for HM separately. All sample material was put in the oven at 80^{o}C until completely dried. Subsequently, samples were ground by electrical grinder and passed through a 0.5 mm. mesh sieve. The ground samples were digested in ternary acid (5:1:1, HNO_3: $HClO_4$: H_2SO_4) solution until the solution became fully transparent. The resulting solution was filtered and the filtrate was used for measurement of heavy metals Cadmium (Cd), Zinc (Zn), Copper (Cu) and Lead (Pb) using Atomic Absorbtion Spectrophotometer (Model 2380, Perkin Elmer,USA). For logistical reasons it was necessary to select a limited number of heavy metals to sample. These four heavy metals were selected from those that were (according to the literature and local knowledge) likely to be widely associated with aerial emissions from local industries.This choice was supported by analysis of a small number of vegetable samples for a wider range to heavy metals, in which other metals of concern in some samples were chromium, nickel, aluminium and iron.

The atomic absorption spectrophotometer was calibrated with known concentrations of respective heavy metals prepared from known compounds of individual HM/reference material. Blanks (i.e. triacid solution heated as the samples in triacid) were also measured to check for any contamination of HM in the reagents or glassware.

A number of other analytical quality assurance measures were adopted. Standard reference material, in this case, spinach, with known concentrations of the heavy metals was purchased and 'blindly' analysed to check for any major errors in the analytical procedure. In addition, a subsample of our field and market samples were sent to other laboratoratories including the NRM international laboratory in Bracknell for commercial analysis.

IV. METHODOLOGY SPECIFIC TO DELHI: MARKET AND FIELD SAMPLE COLLECTION

Considering the much greater population and physical area of Delhi, when compared to Varanasi, a different approach towards sample collection was needed. Accordingly, a major case study of Azadpur wholesale market was carried out – this being by far the largest market in Delhi. This case study was augmented by additional sampling in 5 key areas of urban and peri-urban production which supplied local markets.

IV.a. Azadpur wholesale market case study

The aim with this part of the study was to obtain regular sampling data from the largest market in Delhi to give an indication of the proportion of produce that is contaminated with heavy metals, and to what extent.The largest volume of trade in vegetable produce is conducted in Azadpur, and the trade is carried out by commission agents. A 10% sample of traders (amounting to 10 commission agents) were included at each monthly sampling, which was repeated during the peak arrival months for each vegetable. For each trader, three replicate samples were to be taken for each crop, (according to our standard protocol described for Varanasi above)

Unfortunately there was a considerable unforeseen delay in receiving permission to start the research from the Ministry of Agriculture/ICAR, and as a result the Delhi scientific team at the Indian Agricultural Research Institute began (with a limited amount of data collection) in the month of May 2001 (as compared with . However, the team were hampered by a number of difficulties, including regulations that did not permit the junior staff to use appropriate transport to enable them to collect the full sample allocation. As a result the total sample size was rather smaller than hoped. 600 samples were collected in total. However, then limited sampling was managed such that all three crops were represented in our overall sample, and replication was achieved as planned, but not all planned sampling dates were achieved, and when more than one of the three crops was available in the Azadpur it was not always to sample more than one.

IV.b. Sampling locations in addition to Azadpur

Five areas were selected, which covered the north, west, south and centre of the urban core of Delhi. (Faridabad/Ballabgarh, Okhla; Alipur, Yamuna Pushta and Najafgarh). In these five areas, samples were collected monthly, and from the fields and market location on one day. Within each sample area, five market outlets were selected (amounting to 25 market outlets), and at each of these outlets three replicate samples were taken (accordingly to the methodology described for Varanasi above) for each of the three crops palak, okra and cauliflower. Five production locations (known to supply the market outlets included in the sample) were selected within each of the five broad sampling areas. At each of these production locations three replicate samples were taken for each of the three crops, as described in the methodology for Varanasi.

The sampling periods were: April and May (palak); July and August (okra) and December and January (cauliflower). If the sampling had gone according to plan there would have been up to 225 samples on each field and market sampling occasion. However, in practice the number of samples is was possible to collect was considerably less than this, and less than half of the sample number collected for Varanasi (Table D2.4).

Table D.2.4. Total samples collected and analysed in Delhi.

	Palak	**Period**	**Cauliflower**	**Period**	**Okra**	**Period**
Markets (inc. Azadpur)	663	May 2000-September 2002	190	December 2001-January 2002	150	May 2000-September 2002
Fields	379	May 2000-September 2002	147	December 2001-January 2002	76	May 2000-September

As a result of these difficulties, the Delhi data was much less comprehensive than that obtained in Varanasi, but despite this, we were able to provide a valuable indication of what the nature and extent of heavy metal contamination of vegetables available to the cities consumers might be. In practice we had more data available for palak (which is available from local producers in the markets almost year round), and therefore we have focused on this data in the representation of results and further discussion. However, data from the other crops in referred to, and is available upon request.

D.2.2. SELECTED OUTPUTS

I. BACKGROUND

International safe limits for heavy metal traces in food

In India, the levels of heavy metals allowed to be present in food stuffs is regulated by the Prevention of Food Adulteration Act 1970. Recently renewed European Union standards are set much tighter for cadmium and lead and are specified for a wide range of food products. For instance, different standards are set for cadmium concerning products from 14 distinct food groups.

With effect from 5 April 2002, EC Regulation No. 466/2001 applies in all EU member states, setting tighter limits or cadmium and lead in foods which contribute significantly to dietary exposures. Some of the limits for lead and cadmium applicable to vegetables from this regulation are: vegetables (excluding leafy vegetables) - 0.1 mg/kg lead, leafy vegetables - 0.3 mg/kg lead; leafy vegetables, fresh herbs, celeriac and cultivated fungi - 0.2 mg/kg cadmium, vegetables and fruits (excluding leafy, stem and root vegetables) - 0.05 mg/kg cadmium, stem vegetables, root vegetables and peeled potatoes - 0.1 mg/kg cadmium.

Table D.2.5. Legal standards for selected heavy metals in food/vegetables in India, UK and EU (ppm by wet weight)

	Legislation/ guidelines		**Cadmium**	**Lead**	**Copper**	**Zinc**	**Chromium**	**Nickel**
		Application						
India	Prevention of Food Adulteration Act (1970)	All food	1.5	2.5	30.0	50.0	-	-
European Union	EC regulation No. 466/2001	Vegetables (inc. peeled potatoes), excluding. brassica, leafy vegetables, fresh herbs and all cultivated fungi	-	0.1	-	-	-	-
		Brassica, leafy vegetables and all cultivated fungi	-	0.3	-	-	-	-
		Fruit, excluding berries and small fruits	-	0.1	-	-	-	-
		Berries and small fruits	-	0.2	-	-	-	-
	EC regulation No. 466/2001	Fruits and vegetables[6], excluding	0.05	-	-	-	-	-

[6] As defined in Article 1 of EC Directive 90/642/EEC.

		leafy -, stem- and root vegetables, all fungi, fresh herbs and potatoes						
		Leafy vegetables, fresh herbs, celeriac, all cultivated fungi	0.2	-	-	-	-	-
		Stem- and root vegetables and peeled potatoes, excluding celeriac.	0.1	-	-	-	-	-
UK		All food	-	-	20.0	50.0	-	-
FAO/ WHO	Codex Alimentarius (2001); CAC/GL-39; Codex Stan-230-source: website	Cereals, pulses and legumes	0.1	0.2	-	-	-	-
		Vegetables except brassica and leafy vegetables	-	0.1	-	-	-	-
		Brassica, leafy vegetables and all cultivated fungi	-	0.3	-	-	-	-
FAO	Guideline		0.01		-	2	0.1	0.2

Whilst EU law overrules existing UK legislation for all foods specifically mentioned, prior to EC Regulation No. 466/2001, in the UK all foods sold were subject to the general provisions of The Food Safety Act, 1990. According to The Food Safety Act it is an offence to sell foods for human consumption that fail to comply with food safety requirements or are rendered injurious to health. In addition, specific regulations declare statutory limits for certain metals in foods, which are enforcible, as well as guideline limits for others. For instance, the Lead in Food Regulations 1979 (S.I. 1979 No. 1254) as amended by The Lead in Food (Amendment) Regulations 1985 (S.I. 1985 No. 912) set down a general limit for lead in foods of 1 mg/kg. However, no UK statutory limits existed for cadmium.

The levels of lead and cadmium in foods not included in EC Regulation No. 466/2001 will remain controlled by the Food Safety Act 1990. The EC Regulation also does not include copper and zinc, hence the UK *guideline* limits (recommended in the 1950's by the then Food Standards Committee) of 50 mg/kg for zinc and 20 mg/kg for copper in general foods apply. Guideline limits for food have been recommended by expert committees such as, the Food Advisory Committee, and may be used by enforcement authorities and by the courts for the purpose of interpreting the general provisions of the Act. However, they are not

enforcible in themselves. No specific limits of traces of these heavy metals are specified for fresh fruits and vegetables (pers. comm, 2002, G. Obasogie, Food Standards Agency, UK).

Although the joint FAO/WHO Codex Alimentarius Committee of the United Nations has set standards for pesticide residues in food, so far it has not devised standards for the contamination of food products with heavy metals.

II. HIGHLIGHTS OF OUTPUTS FOR VARANASI

II.a. Do measured levels of HM contamination in vegetables sold in retail markets in Delhi and Varanasi (city/municipal corporation) exceed (Indian/European etc.) legal permissible limits?

Palak

The mean heavy metal contamination significantly exceeded the Indian PFA permissible limits for cadmium, copper and zinc for much of the year, with the exception of the rainy season (July to October). There was a marked seasonal variation in contamination, with the highest levels found during the hot dry summer season (April,May), when we would expect greatest aerial transport and re distribution of dust. For cadmium, copper and zinc the mean on each and every sample date exceeded the EU permissible limits (figures .. to ..)

To further explore the seasonal variation in heavy metals from aerial deposition, an addition experiment was conducted with dust deposition monitors at selected market sites. Dust was collected in custom made devices over a known time period and analysed for heavy metal content. The correlation drawn between dust deposition versus concentration of Cu, Zn and Cd in palak showed positive significant correlations. The correlation coefficient (r) was 0.49 for Cu & Zn and 0.93 for Cd. Atmospheric deposition of Cd showed the most direct correlation with Cd concentration in unwashed palak as for Cd only 20% variability is due to factors other than atmospheric deposition.

The data on heavy metal concentration of deposited dust clearly show that maximum aerial deposition was during May followed by June and then July. August has a more or less similar level of heavy metal deposition as that of July. However, the heavy metal concentration in vegetable samples collected from different sites did not always follow a pattern similar to deposition. The results clearly indicated that pre-harvest contamination is an important addition to the heavy metal concentrations in vegetables.

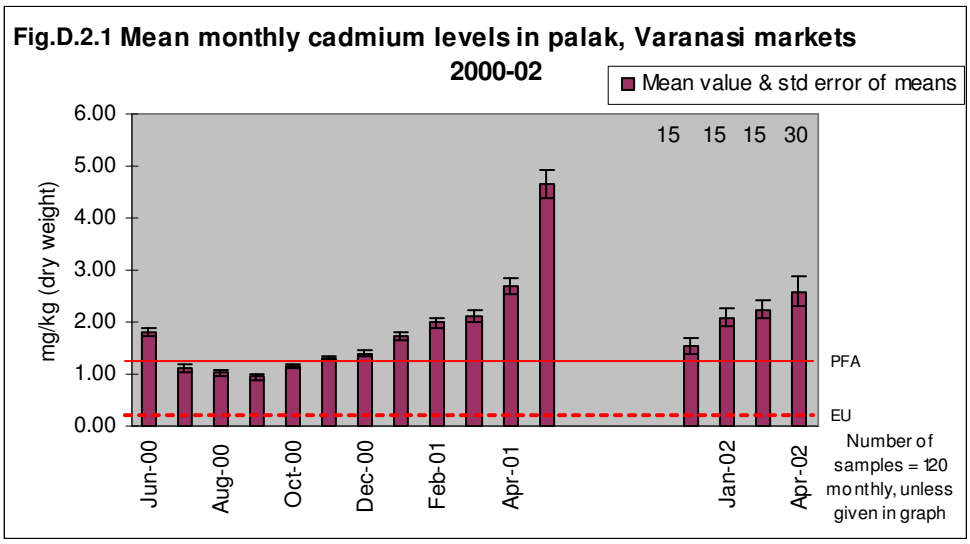


Fig. D.2.2.

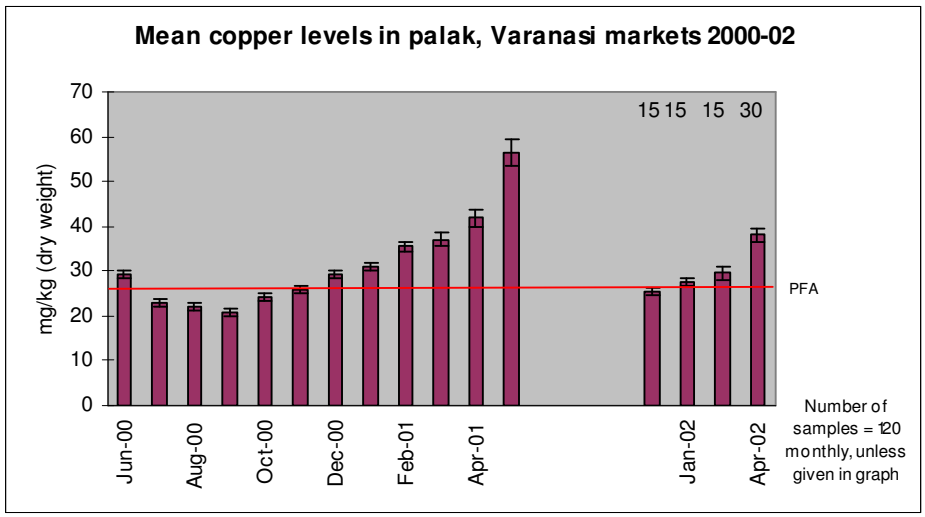
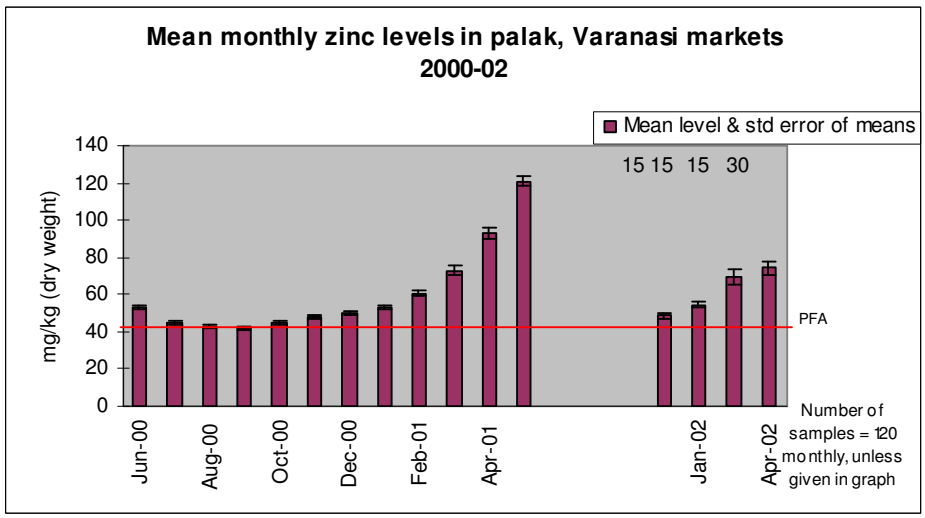
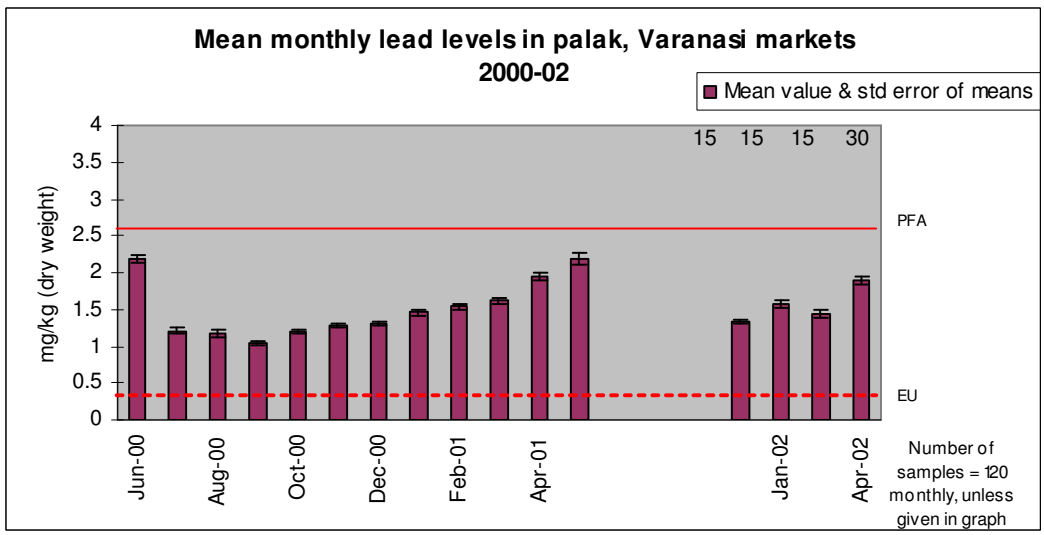


Fig. D.2.3.



For Lead (Pb), the mean of the samples consistently exceeded the EU permissible limits, but was well within the Indian standard. The same seasonal trends were apparent (figure D.2.4.)

Fig. D.2.4.



Lead and cadmium levels, which were found to exceed EC 466/2001 and Codex Alimentarius (2001) levels in all samples, are from Class B of the Lewis Acids classification, potentially the most toxic group. Cu+ is also from Class B, whilst zinc is catergorise as a potentially less toxic 'borderline' heavy metal. In palak, the exceedingly high levels of cadmium observed are of particular concern.

Cauliflower

The pattern of contamination for cauliflower was similar to palak. Cadmium, zinc and copper contamination exceeded the PFA limits for all sample dates, whilst lead was within PFA limits, but exceeded the EC 466/2001 limits (figures D.2.5 to D.2.8). Cauliflower is not available during the hot dry summer months, when contamination in palak was found to be the highest, but on a comparison for individual winter months, the actual levels of contamination were generally higher in cauliflower than in palak. If much of the contamination results post harvest, the contamination of the edible portion with the exascerbated by the removal of the outer leaves soon after harvest.

Fig. D.2.5.

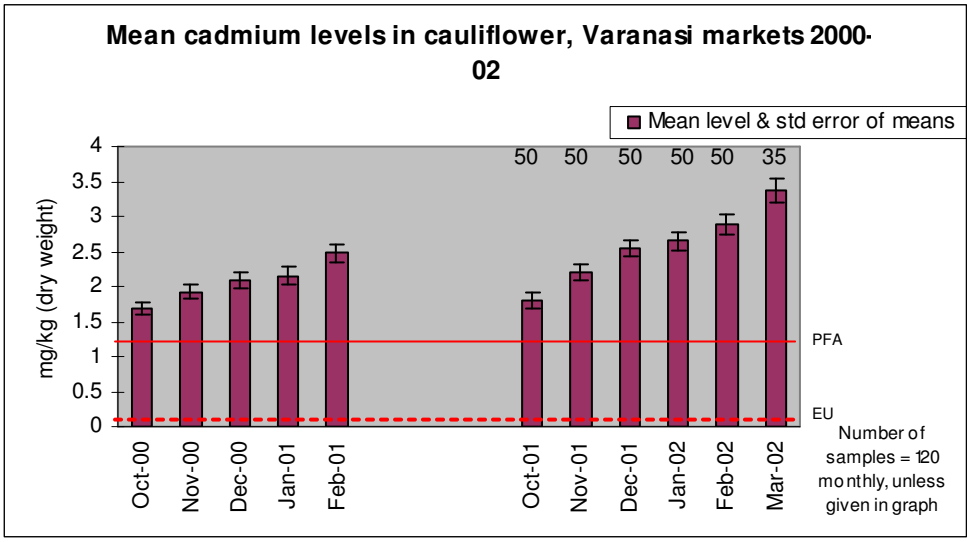


Fig. D.2.6.

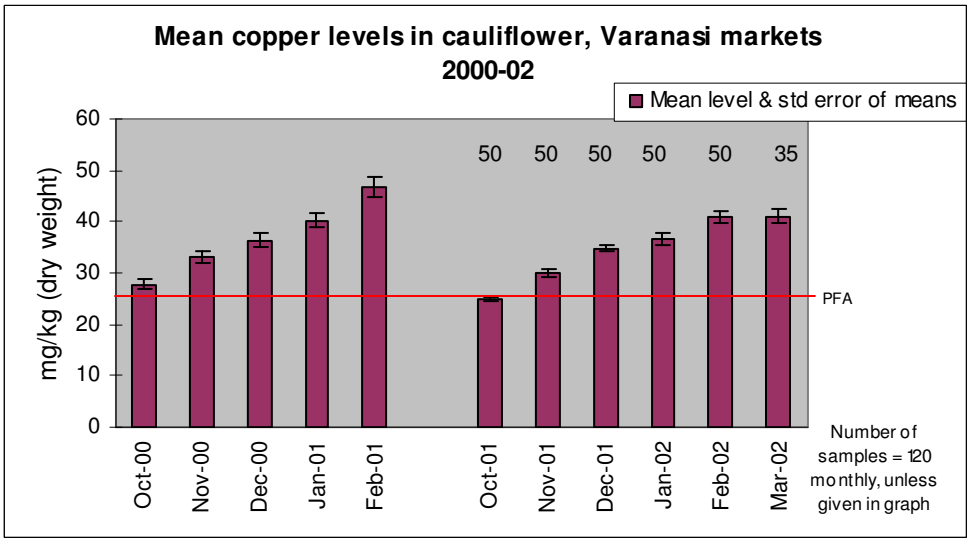


Fig. D.2.7.

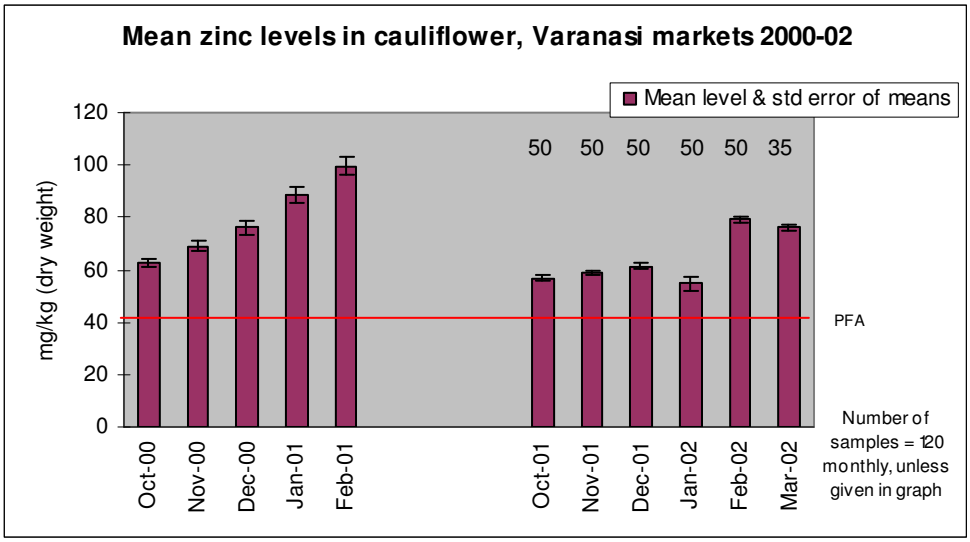
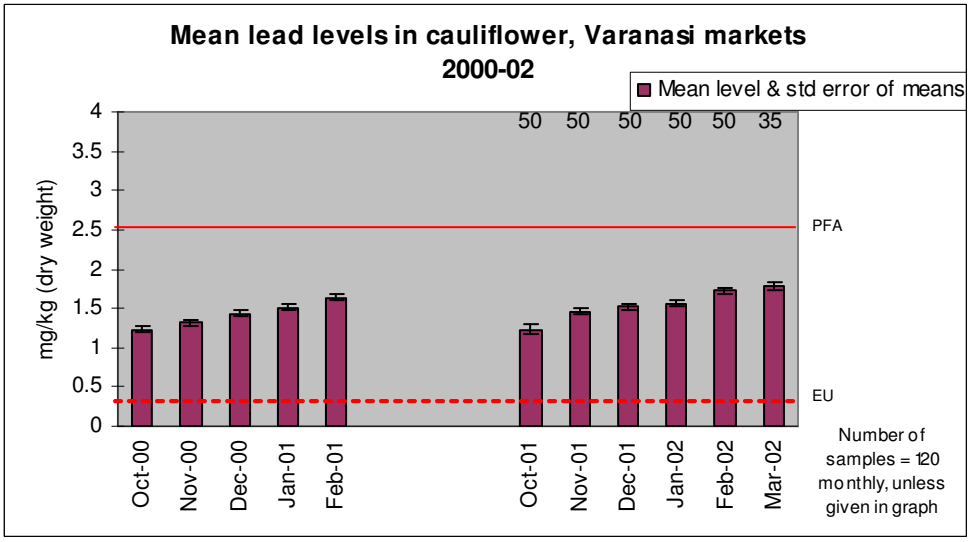


Fig. D.2.8.



Okra

Heavy metal contamination of okra followed a similar pattern to palak in terms of actual levels and seasonal distribution. Once again, all four of the heavy metals were at levels of concern, with Zn, Cu and Cd generally exceeding PFA limits, except during th rainy season, and Pb not exceeding PFA limits, but exceeding the EC limits throughout the year.

Fig. D.2.9.

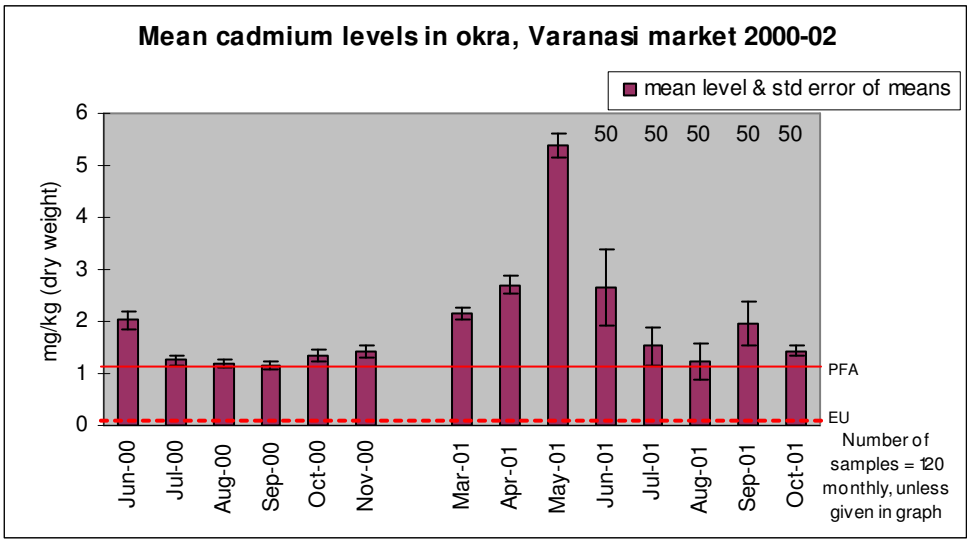


Fig. D.2.10.

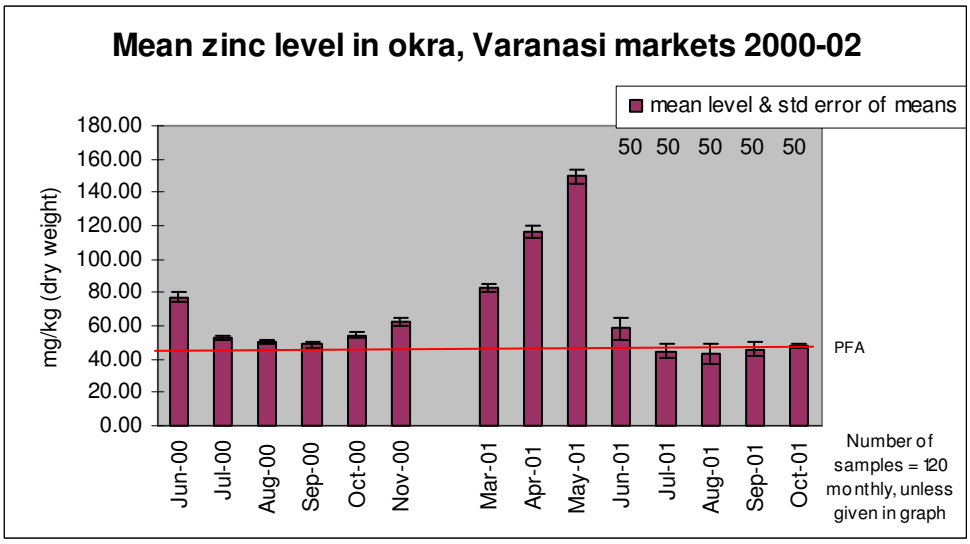


Fig. D.2.11.

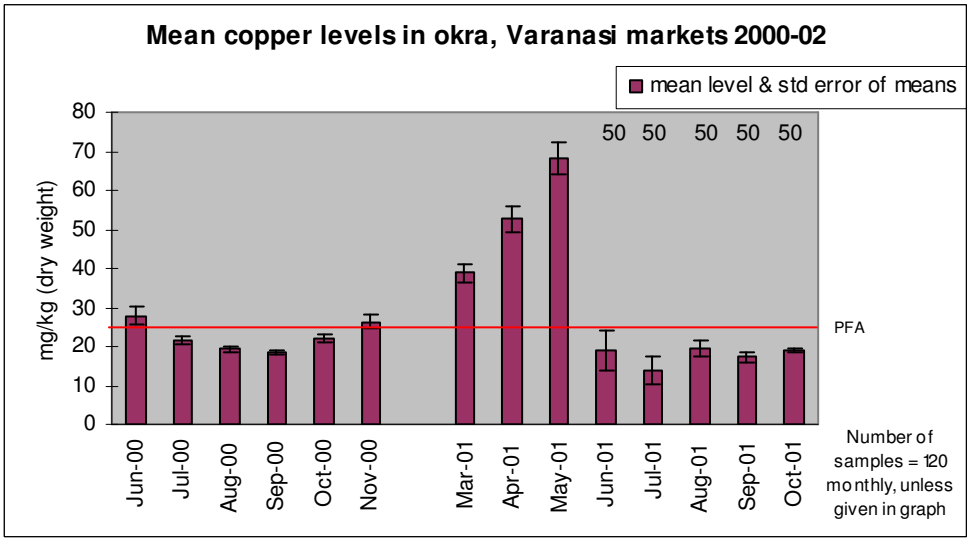
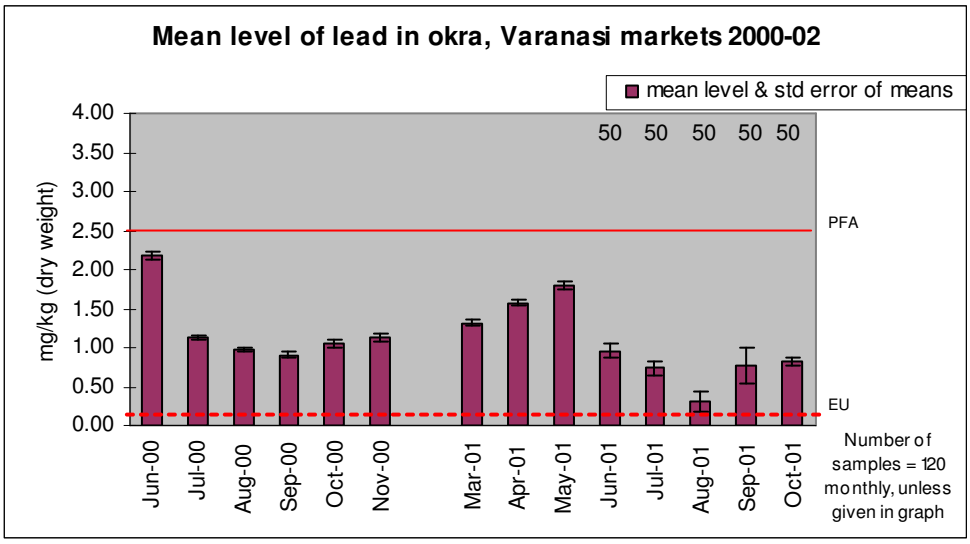


Fig. D.2.12.



II.b. Variation between contamination found at various market sites.
Some trends in heavy metal contamination between sites were apparent. For example, a few retail sites close to industrial areas and large road junctions (sites 22, a retail market close to Chanpur industrial estate and 27,an evening market at Maruadih crossing) did have produce samples that were more contaminated than the other sites. The location of these 'highly contaminated' retail sites suggest that significant contamination might be occurring at the point of sale, and the dust deposition experiments supported this case.

These highly contaminated sites contrasted to retail sites such as the one near the gate to Banaras Hindu University (site 22) which has extensive tree cover and considerably less industrial activity and road congestion, at which relatively low levels of contamination were found. However the source of the vegetables at site 22 was a relatively rural location, so the produce may have been less contaminated at harvest, and at the point that it reached the retailer. We did not have resources within the project to trace particular vegetable 'lots' from the farm gate, and to measure contamination en route – this would have been the only definite means of assessing the extent of HM contamination occurring at various stages of production and marketing.

Another addition to this data, was the sampling of cauliflower from selected retail markets in the morning (7am) and then again from the same retailers in the evening (7pm). This was carried out in Dec 2001 and then again in January and February 2002. On all occasions there was a significant increase in contamination from Cd and Pb during the course of the day. The actual increases observed were in the range 10 to 30%, and may have been due largely to automobile emissions and tyre wear, in addition to local industries.

II.c. Contamination at source in farmers' fields:

In general there was considerably less contamination of vegetables with heavy metals measured at the important field production areas for (each specific vegetable) as compared with the levels measured in the same vegetables in the markets that they supplied. This indicates that a significant amount of contamination probably occurs during transport to the markets or at the point of sale (the suggestion of significant contamination at point of sale is supported by the evidence from out dust deposition monitors at market sites). An example of contamination of palak at important field production sites is provided in the graphs below. Levels did not exceed the PFA limits for any of the heavy metals measured at the field sites,

in contrast to the market samples, where there were exceedences for Cd, Cu and Zn. However, EC limits were still exceeded in all cases.

Fig. D.2.13.

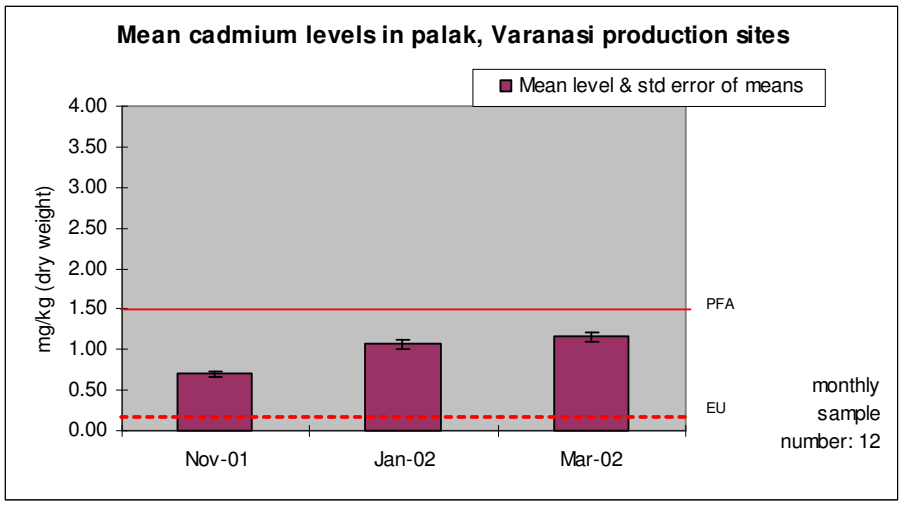


Fig. D.2.14.

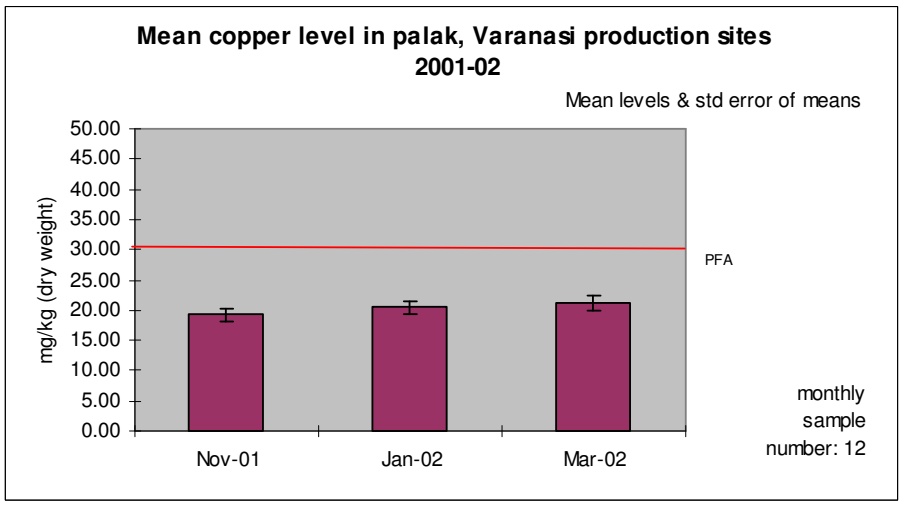


Fig. D.2.15.

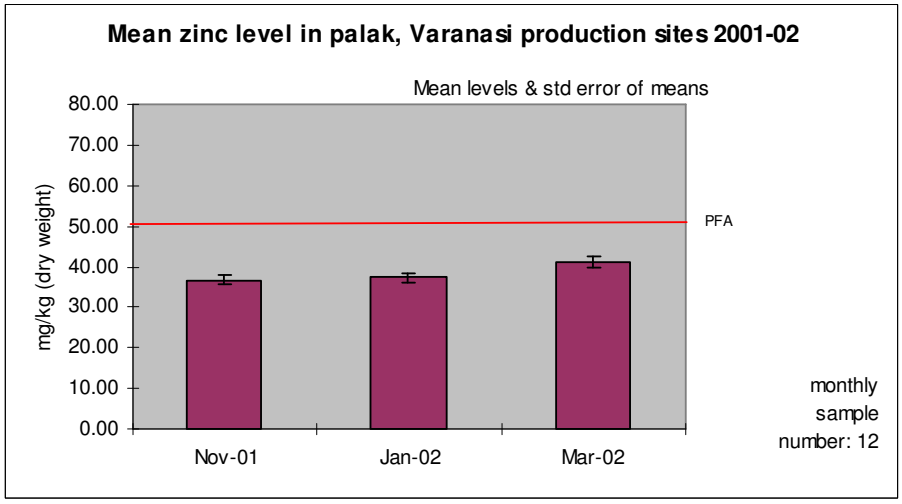
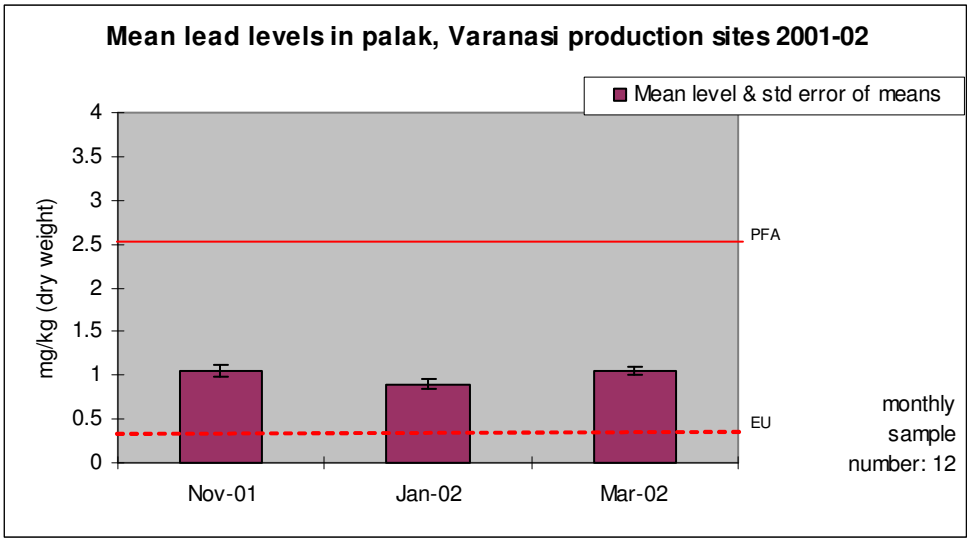
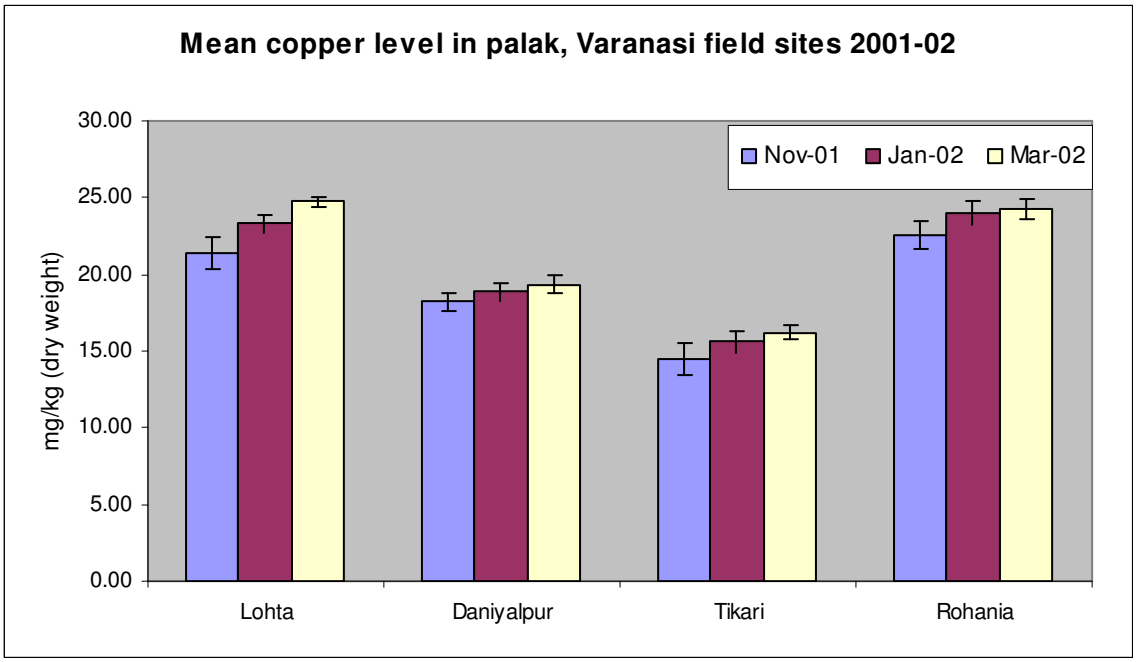


Fig. D.2.16.



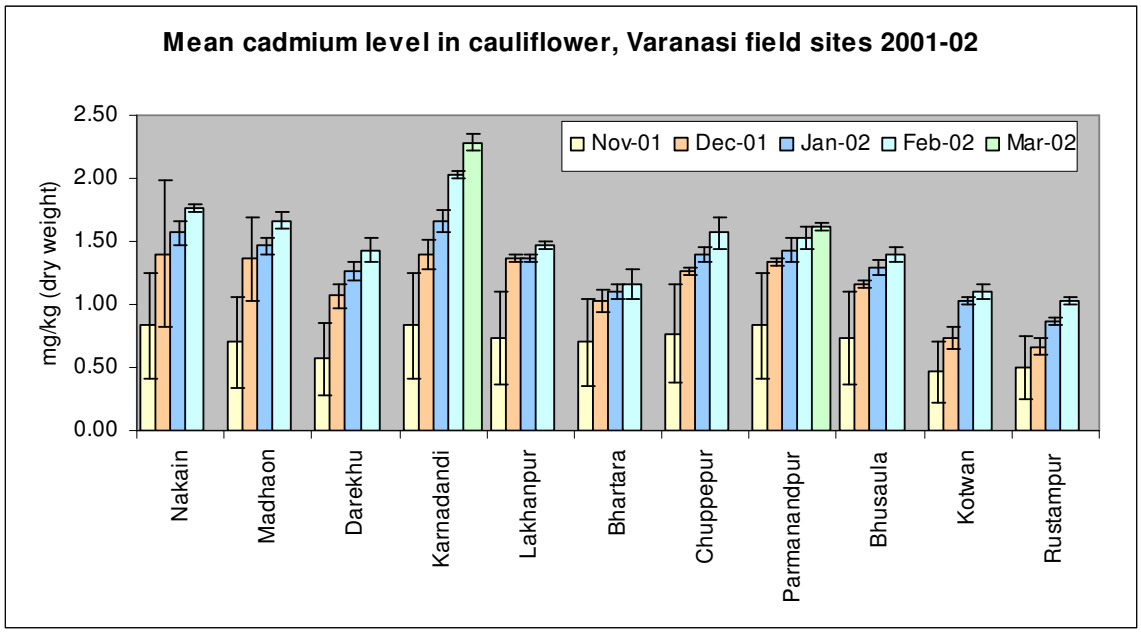
There were some consistent differences between the specific field site areas. An example is given, again here for palak, which indicates the two of the production sites (Lohta and Rohania) are more contaminated with Cu, than the other two that were sampled. The same pattern occurred for the other heavy metals assessed.

Fig. D.2.17.



Similarly for cauliflower, samples from one of the production areas (Karnadandi) were consistently more contaminated with all four heavy metals during the summer months. An example is given here for cadmium

Fig. D.2.18.



These indications suggest that there may be important implications for individual farmers who have no option but to produce food in a particular, more polluted area. If measures for monitoring contamination, with a view to improving food quality in the market chain, were introduced, there may be adverse economic impact on these groups. This could be avoided if systems were improved to establish means of reducing pollution at source, avoiding crop contamination, or removing the contamination prior to sale were available, and information systems were such that these messages could be conveyed effectively.

II.d. Potential for reducing contamination prior to consumption by washing.

The market data for palak indicates that washing can reduce the level of contamination considerably (Table D.2.6.). For example washing twice reduced the contamination of Pb between 25 and 35% across the five markets sampled, this was significantly more than the reduction achieved by one wash (standard household practice) There was no significant further decrease in contamination of any of the heavy metals with a third wash.

Table D.2.6. Reduction in HM levels in Palak after washing (market data April 2002)

Heavy metal	Percentage reduction in heavy metal contamination after					
	1st wash	*Std error*	2nd wash	*Std error*	3rd wash	*Std error*
Market: Chandua Satti						
Copper	10.18	*1.68*	19.52	*1.66*	24.95	*1.62*
Zinc	11.92	*0.97*	15.09	*1.12*	17.22	*1.28*
Cadmium	14.44	*1.48*	22.64	*1.54*	26.60	*1.99*
Lead	20.09	*1.81*	32.57	*4.96*	36.13	*2.65*
Market: Kabirchora						
Copper	13.29	*1.52*	17.92	*1.95*	20.44	*2.07*
Zinc	32.71	*1.29*	38.63	*2.17*	40.70	*2.57*
Cadmium	17.80	*1.96*	31.34	*3.83*	39.34	*4.60*
Lead	14.04	*1.32*	26.61	*3.03*	28.79	*3.05*
Market: Chandpur						
Copper	19.38	*10.7*	26.53	*1.57*	28.96	*1.46*
Zinc	32.98	*1.84*	45.42	*2.18*	52.94	*1.18*
Cadmium	39.28	*3.61*	61.87	*2.29*	65.76	*1.65*
Lead	16.50	*1.84*	25.97	*2.29*	33.79	*4.39*
Market: Rathyatra						
Copper	18.04	*2.93*	23.61	*2.58*	27.39	*2.02*
Zinc	33.45	*2.24*	43.66	*2.97*	50.73	*2.95*
Cadmium	21.71	*2.33*	33.03	*2.66*	40.02	*5.66*
Lead	18.68	*3.56*	28.30	*3.02*	31.74	*4.17*
Market: Lanka						
Copper	9.04	*1.10*	15.74	*1.23*	18.75	*1.19*
Zinc	27.39	*1.66*	36.34	*1.61*	43.21	*2.67*
Cadmium	22.78	*3.75*	30.82	*4.49*	36.22	*4.20*
Lead	24.7	*3.47*	35.67	*4.07*	45.15	*3.64*

II. HIGHLIGHTS OF OUTPUTS FOR DELHI

II.a. Contamination at market retail sites

Palak

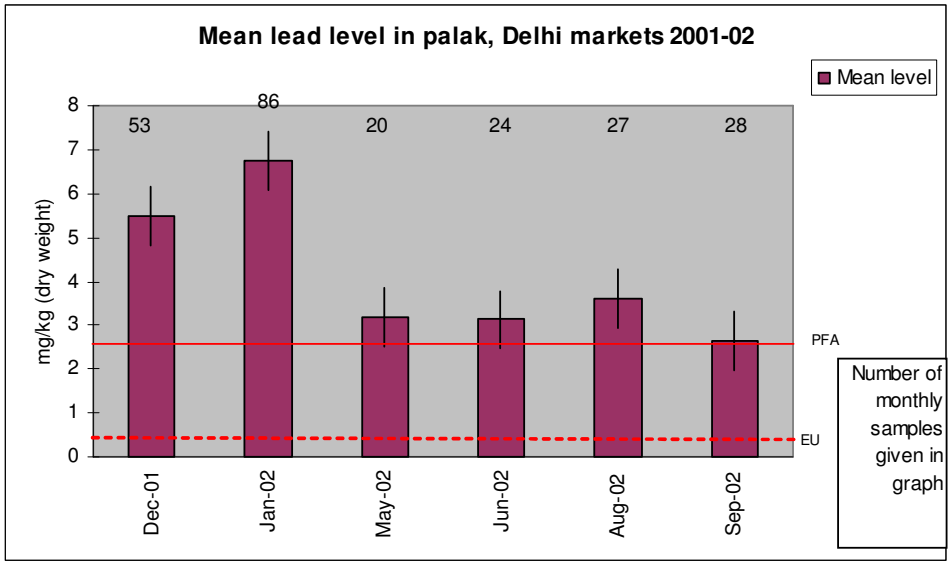
There were some difficulties with sample analysis for Lead and Cadmium in Delhi. The first laboratory that IARI utilised produced analysis results that differed markedly from the results obtained from the same sample when analysed at a number of other laboratories for quality control (these included the BHU laboratory, the privately run SGM laboratory or the International reference laboratory (NRM limited) that we used in the UK) In addition results obtained from the standard reference material were not at all consistent with the known concentrations of heavy metals in the samples. As a consequence the results obtained from the initial IARI laboratory for Lead and Cadmium are not included in presentation or subsequent analysis of results.

The contaminant of greatest concern in Delhi was lead. 74% of the samples analysed exceeded the PFA limit for lead, and lead contamination was apparent at all the market sites examined (fig D.2.19). Unfortunately there was insufficient data to ascertain seasonal variation in contamination at Delhi markets with any certainty. At field production areas, levels of Lead did not generally exceed the PFA limits, suggesting that significant contamination may occur due to aerial deposition during transport and/or at the point of sale.

Palak is known to be a bioaccumulator of Lead i.e it will (in appropriate conditions) take up Lead from contaminated soil and water through the root system to a greater extent than many other plants. Washing experiments were important in helping to determine the

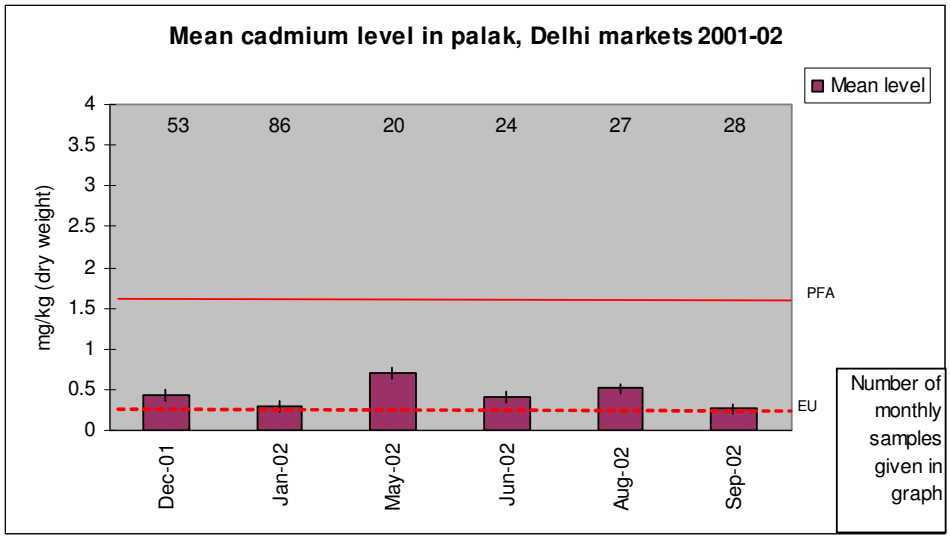
proportion of contamination that is likely to be due to aerial deposition, as opposed to plant uptake through soil and water. A subsample of the palak plants from market sites was washed in water prior to heavey metal analysis. A major reduction in contamination was observed - amounting to 28% for one wash, 53% for two washes and 55% for three washes. This is very comparable to the data from the washing experiments in Delhi that suggested that it was beneficial to wash produce twice, but that a third wash did not confer and additional benefit in terms of reduction in heavy metal contamination. These results are valuable, in indicating that when clean water is available, heavy metal consumption could be reduced by encouraging people to wash vegetables twice. Figure D.2.19 shows data from 238 samples (all analysed at the NRM laboratory Bracknell, UK) showing extent of Pb contamination in Palak at six market sites July 2001 to June 2002.

Fig. D.2.19.



For cadmium, the same sample selection indicated no exceedence of PFA limits, but the majority of samples exceeding the prescribed EC limits.

Fig. D.2.19.



For copper and zinc, over 600 samples were successfully analysed and checked. For copper there were no exceedences of permissible limits, whilst for Zinc, 21% of the samples analysed exceeded the PFA limits.

D.2.3. IMPACTS OF AIR POLLUTION ON THE NUTRITIONAL QUALITY OF SELECTED HORTICULTURAL PRODUCE IMPORTANT TO THE POOR - A BRIEF EXAMPLE

This aspect of the experimental work was not included in our wider systems perspective on crop quality assurance, and did not feature in the majority of our stakeholder consultations. However, a sound basis for pursuing this has been established.

I. THE IMPACTS OF AMBIENT AIR POLLUTION ON THE NUTRITIONAL QUALITY OF CARROT IN PERI-URBAN VARANASI.

Introduction

This experiment was carried out to evaluate the impact of ambient air pollution on carrot (*Dacus carota* var. Pusa Kesar) plants using open top chambers (OTCs) ventilated with ambient (NFCs) or charcoal filtered air (FCs) at a sub urban site of Varanasi, India.

Adverse effects of air pollution on biota and ecosystems have been demonstrated world wide. Much experimental work has been conducted on the analysis of air pollutant effects on crops and vegetation at various levels ranging from biochemical to ecosystem levels (Saxe, 1991: Krupa *et al.,* 1995). Earlier, it was believed that any damage done to the vegetation would be confined to the isolated areas of high arial pollution like those in the vicinity of large industrial emissions. However, increased regional transportation have caused the pollutants to be more efficiently dispersed leading to reductions in localized high concentrations and increase in rural areas (Hassan *et al.,* 1995; Agrawal *et al.,* 2003). Regional air pollution may cause significant yield losses on sensitive crops (Wahid *et al.,* 1995; Krupa *et al.,* 1995; Agrawal *et al.,* 2003). The instrumental and bio-monitoring of air pollution carried out at sub urban sites have shown that often the major phytotoxic agents are present at levels above the threshold of plant damage (Wahid *et al.,* 1995 a & b; Agrawal *et al.,* 2003). It has been observed that ozone concentrations are higher in sub urban and rural areas as compared to the urban areas, whereas SO_2 and NO_2 concentrations are higher at urban sites (Hassan *et al.,* 1995; Wahid *et al.,* 1995 a & b; Agrawal *et al.,* 2003).

The deleterious effects of the pollutants are caused by the production of reactive oxygen species (ROS) in plants, which cause peroxidative destruction of cellular constituents (Shimazaki *et al.,* 1980). Such effects of pollutants on plants include pigment destruction, depletion of cellular lipids and peroxidation of polyunsaturated fatty acid (Castillo *et al.,* 1984). Pollutants can cause leaf injury, stomatal damage, premature senescence, decrease photosynthetic activity, disturb membrane permeability and reduce growth and yield in sensitive plant species (Atkinson *et al.,* 1988; Darrall, 1989; Saxe, 1991).

Open top chambers are most widely used technology for evaluating the impacts of air pollutants on vegetation (Adams *et al.,* 1988; Pleijel *et al.,* 1991; Jager *et al.,* 1994). The merits of this technology include a better control over pollutant exposure to plants by minimally altering the microclimatic conditions. This technology has been extensively used world wide to examine the effects of pollutants on different plant species. It has been estimated that 10% yield reductions occur in corn wheat and kidney bean at seasonal 7 h mean concentrations of 75 – 132, 64 – 93 and 72 – 86 nl l^{-1} O_3, respectively (TERG, 1988). However, OTC experiments with low concentrations of SO_2 and NO_2 (10 and 12 nl l^{-1}, respectively) have shown a 13% increase in the yield of winter barley (Flower *et al.,* 1988). Experiments conducted on the outskirts of Lahore, Pakistan showed that ambient air pollution has caused large yield reductions in local varieties of wheat and rice using OTC's (Wahid *et al.,* 1995 a & b).

This report is the first known result on plant response assessment based on the use of open top chamber methodology for air filtration in India.

Materials and Methods

The study was conducted at Suswahi, a peri urban area of Varanasi, whihc was considered farilty representative of vegetable production locations.

The experiment was carried out between the months of December 2002 and March 2003. This period of the year is characterized by mean monthly maximum temperature ranging between 16.15- 29.8° C and mean monthly minimum temperature between 6.25- 16° C. Total mean rainfall was 26.2 mm of which 89.5% occurred in January. Maximum relative humidity varied from 74.8- 93% and minimum ranged from 35.4- 66%. Wind speed varied from 2.3- 4.14 km hr^{-1}. Soil was sandy loam in texture (sand 45%, silt 28% and clay 27%) and neutral in reaction (pH 7.2- 7.4).

The field was prepared using standard agronomic practices. Farmyard manure was added uniformly during field preparation. Six open top chambers were constructed according to the design of Bell & Ashmore (1986). These chambers have simple basic design and can be constructed easily and rapidly. Chambers are 1.8 m in height and 1.5 m in diameter, consisting of an aluminium framework with polythene walls, with air supplied at three changes per minute via high speed blower. These OTCs have been extensively used in air-filtration studies in a number of locations in south – east England, and Pakistan over the last decade. Three of the six chambers were equipped with charcoal filters and were treated as filtered chambers (FCs) and the other three had empty filters and were treated as non-filtered chambers (NFCs). All the chambers were provided with prefilters to remove dust. During the experimental period, the OTCs were ventilated continuously by passing air through filters. Temperature and relative humidity were 0.1 – 0.2º C and 2 – 4% more in chambers as compared to outside. The light intensity in the chambers was 95% of the ambient level in the open plots.

Seeds of carrot (*Dacus carota* var. Pusa Kesar) were hand sown in rows on December 12, 2002. Germination occurred on December 20, 2002. Subsequent thinning was done manually such that the density of the plants was reduced to 10 plants $chamber^{-1}$. When the plants germinated, fumigation was started and continued till the plants obtained their maximum root length (90 day age). Field was irrigated from time to time to maintain the soil moisture uniformly.

For plant biochemical analysis, parameters such as contents of chlorophyll (Maclachlan & Zalik, 1963), carotenoid (Duxbury & Yentsch, 1956), soluble protein (Lowry *et al.,* 1951), ascorbic acid (Keller & Schwager, 1977) and phenol (Bray & Thorpe, 1954), lipid peroxidation (Heath & Packer, 1968) and peroxidase activity (Britton & Mehley, 1955) were analysed at 60 days after germination (DAG).

Oven dried plant samples were ground in a stainless steel grinder and passed through a 2 mm sieve. These powdered samples were used for determining nitrogen, sulphate-sulphur, total phosphorous, sodium, potassium, calcium and iron contents. Total nitrogen was determined by Gerhardt Automatic N Analyzer (Germany). For determination of SO_4 – S, total P, Ca^{++}, K^{+}, Mg^{++} and Fe^{++} contents, digestion of powdered root and shoot samples was done separately by the method given by Allen *et al.* (1974). Ca^{++}, K^{+}, Mg^{++} and Fe^{++} contents in digested material were determined with the help of Atomic Absorption Spectrophotometer (Model 2380, Perkin – Elmer, USA), whereas SO_4 – S was determined by following turbidimetric method of Rossum & Villaruz (1961). Total P was estimated by method of Williams *et al.* (1970).

Eight hourly monitoring of air quality was done for SO_2 and NO_2 at the experimental site using Portable Gas Sampler following wet chemistry methodologies. Monitoring was done between 8.00 to 16.00 h daily. The instruments were placed successively in the filtered and non-filtered chambers in the centre. The height of the sampling was adjusted to crop height accordingly and varied from 33- 45 cm at the end of the negative growth. SO_2 was estimated by the method of West & Gaeke (1956), NO_2 by Merrymann *et al.* (1973) and O_3 by Photometric Ozone Analyzer (Model 400 A, API, Inc., USA). The significance of differences between treatments was calculated by student t- test.

Results

Concentration of gaseous pollutants

Air quality monitoring of non-filtered chambers showed that high concentrations of SO_2, NO_2 and O_3 were percent at the experimental site. In the filtered treatment, daily mean concentrations of SO_2, NO_2 and O_3 were less as compact to the non-filtered treatment by 88, 83.8 and 89.5%, respectively (Table 1). The air monitoring data collected during the entire experiment (December-March) suggested that SO_2 and NO_2 concentrations were higher during the earlier part of the experiment i.e. during the germination and vegetative growth of plants. O_3 concentration was, however, higher during the latter stage of the experiment (February-March), which was the time of root filling in the plants.

Nutrient concentrations

Total nitrogen content of roots in NFCs was significantly lower (14.73%) as compared to those in FCs (Table 5). However, in shoots significant increase of 15% in N content was observed in the plants growing in NFCs as compared to those of FCs (Table 5). Total phosphorus content increased significantly by 57.14 and 73.6% in roots and shoots, respectively of plants in FCs as compared NFCs (Table 7). Sulphate sulphur content was significantly higher in plants growing in NFCs as compared to those in FCs. The increase was 329.41 and 255.02% in roots and shoots, respectively of the plants of NFCs.

Mg, Ca, Fe, and K contents showed higher values in plants of FCs compared to NFCs. Mg, Ca, Fe and K contents respectively decreased by 57, 42.5,40.5 and 40.58% in the roots (Fig. 5) and by 35.2, 48, 50 and 44.2% in shoots of the plants of NFCs as compared to those growing in FCs (Fig. 5).

The experiment performed in the open top chambers clearly suggests the adverse effects of ambient air pollution on plants growing in the sub urban areas of Varanasi. The air quality data indicate that SO_2, NO_2 and O_3 were present in concentrations high enough to cause growth reductions in carrot plants. Gaseous pollutants showed considerable monthly variations during different stages of the plants. High levels of SO_2 and NO_2 observed at the experimental site may be associated to its close proximity to the national highway from Delhi to Howrah experiencing heavy vehicular transportation. During the earlier stages of experiment, when the temperature and light intensity were comparatively lower, NO_2 showed higher concentration than O_3. However, during the latter stages of the experiment, increase in temperature and high light intensity favoured the formation of O_3, thus O_3 concentrations were higher. Agrawal *et al.* (2003) observed similar concentrations of SO_2 (30 ppb ±1.14) and NO_2 (33.8 ppb ± 3.20) at a site closer to the present experimental site. However, O_3 concentration (11.3 ppb ± 1.34) was lower as compared to those in the present study. Hassan *et al.* (1995) have also observed higher levels of ambient oxidant in rural areas of Egypt.

Table D.2.7. Monthly Mean concentrations (ppb) of different pollutants at the experimental site in filtered (FCs) and non filtered (NFCs) chambers. (Mean ± 1S.E.)

Month	SO_2		NO_2		O_3	
	NFCs	**FCs**	**NFCs**	**FCs**	**NFCs**	**FCs**
December	40.33 ± 1.29	4.58 ± 0.48	39.58 ± 0.90	5.58 ± 0.55	35.33 ± 1.16	3.83 ± 0.36
January	39.32 ± 0.71	4.68 ± 0.23	41.48 ± 0.70	7.48 ± 0.39	35.48 ± 0.76	3.26 ± 0.18
February	36.57 ± 0.54	4.79 ± 0.21	38.14 ± 0.63	6.96 ± 0.41	38.96 ± 1.15	3.75 ± 0.22
March	33.61 ± 0.48	3.87 ± 0.20	35.71 ± 0.41	5.06 ± 0.21	43.74 ± 0.56	5.16 ± 0.24

Ascorbic acid is known to provide stability to the plant cell membranes during pollution stress and scavenges cytotoxic free radicals, which can otherwise cause lipid peroxidation and destruction of membranes (Dindsa *et al.,* 1982). In the present study, the plants growing in NFCs showed an increase in ascorbic acid content. This increase might be a consequence of substantial oxidative stress. Lee *et al.* (1984) reported accumulation of ascorbic acid content in plant cells after pollutant exposure. A similar result was obtained by Varshney & Varshney (1984), where resistant species showed increase in ascorbic acid content, whereas sensitive species showed decline. Carrot plants seem to increase defense level by enhancing ascorbic acid content in response to air pollution stress. Stimulation of total phenolics due to pollutant exposure has also been reported earlier (Howell, 1974). Accumulation of phenolics in leaves may reduce carbon fixation and ATP synthesis, and may stimulate the respiration and disintegration of chloroplasts (Howell, 1974). Protein concentration decreased significantly in the leaves of the plants grown in non filtered chambers. Deepak & Agrawal (2001) have shown reductions in protein content of two cultivars of soybean at SO_2 concentration of 60 ppb for 8 h daily for 70 days. Agrawal & Agrawal (1990) observed a reduction of 39 % and 6.8 %, respectively in *Vicia faba* and *Cicer arietinum*, 30 days after exposure of 99 ppb O_3 for 2 h daily.

Nitrogen content in the plants increased significantly in shoots, but decreased significantly in the roots of the plants growing in NFCs as compared to those growing in FCs. NO_2 has been shown to be absorbed in and assimilated into various organic nitrogen compounds leading to elevated foliar nitrogen content (Sandhu & Gupta, 1989). Wellburn *et al.* (1981) have shown that presence of SO_2 inhibits reduction in nitrate in leaves, which may further interfere with assimilation of SO_2, and hence nitrogen content decline. O_3 has been shown to reduce nitrogen concentration in plants (Agrawal & Agrawal, 1990). Rajput & Agrawal (2004) showed significant reductions in N content of seed of *Pisum sativum* grown in ambient air of Varanasi. Interestingly, in roots, a contrasting response was observed which suggests that the absorbed N from NO_2 was retained in shoot only and did not translocate to roots in plants growing in NFCs. Nutrients such as Mg, Na, Ca, Fe and K in both root and shoot fractions of plants showed significant decrease in plants growing in NFCs as compared to those in FCs. This response may have been caused by the combination of factors such as changes in root development pattern due to air pollution stress and reduction in soil nutrient absorption due to disturbed plant growth. Reductions in K and Ca contents of SO_2 exposed plants have been reported for *Vicia faba*, *Cicer arietinum* and *Glycine max* (Keller & Jager, 1980).

Table D.2.8. Nutrient concentrations (mg g^{-1} dry weight) in carrot plants growing in filtered (FCs) and non filtered (NFCs) chambers (Mean ± 1S.E.)

Characteristics	Root		Shoot	
	NFCs	FCs	NFCs	FCs
Total Nitrogen	2.54 * ± 0.08	2.99 ± 0.01	1.09 * ± 0.03	0.95 ± 0.01
Total Phosphorus	0.09 ** ± 0.005	0.21 ± 0.01	0.10 ** ± 0.008	0.38 ± 0.02
Sulphate sulphur	0.73 * ± 0.04	0.17 ± 0.01	1.35 * ± 0.20	0.38 ± 0.12

Note: Level of significance from FCs* = p< 0.05; ** = p< 0.01; *** = p< 0.001; ^{NS} = Not significant

SO_4 – S concentrations increased significantly in root and shoot portions of the plants grown under NFCs as compared to those under FCs. Sulphur accumulation in plants growing in SO_2 enriched environment is a well-known phenomenon (Dekok, 1990). SO_2 enters mainly through stomata, dissolves on cellular moist surfaces of mesophyll cells and is hydrated into sulphurous acid. The rapid dissociation of this acid leads to SO_3^{2-} and HSO_2^- ions which are subsequently oxidized to less toxic sulphate in course of detoxification (Huve *et al.,* 1995). Pandey & Agrawal (1994) also found sulphate accumulation in leaves of three woody transplants grown in the urban environment of Varanasi.

The present experiment clearly suggests that the gaseous pollutants were present in concentrations high enough to cause unfavourable changes in the nutrient quality of the plants. The combined effects of all the three pollutants may have acted synergistically in causing the unfavourable impacts.

The open top chambers remain in place, with personnel trained to carry out further studies with a wider range of vegetable crops. Assuming that significant adverse impacts continue to be found - this raises the possibility of investigating cultivars for polluted areas that may be less sensitive to the impacts of pollution and possibly to investing agronomic means of reducing the impact of pollutants.

Our study also measured air pollution levels at numerous other production sites around the city. This data could be used to identify 'hazard' areas in terms of potential to reduce the nutritional quality of crops grown in the area. The mapping task would depend upon more experimental data to determine dose-reponse relationships for the nutrient content of particular crops against pollutant exposure. The complex synergisitic relationships between pollutants.

In the absence of this further evidence, our study does point to yet another reason for to controlling air pollution emissions at source, and considering the impacts of resiting polluting industries to peri-urban areas.

D.3. NATURE AND LOCATION OF INDUSTRIAL SOURCES OF GASEOUS AIR POLLUTION AND AIR BORNE HEAVY METAL POLLUTION?

Introduction

Heavy metals are stable and persistent as they cannot be degraded or destroyed. The concentrations of individual metals in living tissues are ordinarily very low and must be maintained within narrow limits to permit the optimum biological performance of most organisms (Allen, 1989). Human activities including the increased use of metal-containing products by the public are the major contributors to increased levels of heavy metals in the environment. The major sources of heavy metal environmental contamination in Varanasi are industry (atmospheric deposition and water pollution), agriculture (e.g. pesticides, fertilisers), vehicle emissions and waste disposal on land.

This project focuses mainly on industrial contamination, although there are references to vehicle emissions and other sources as relevant to contamination of peri-urban vegetables in the supply chains that we examined. One particular issue of concern is the potential contamination of Lead (from resuspended roadside dust - this is despite the fact that only unleaded petrol has been available for purchase since 2000) and contamination from cadmium (the wearing of vehicle tyres is one source) during transport of vegetables to the market and at the point of sale.

The key role of this particular aspect of the study is to illustrate (for the purposes of discussion with stakeholders and for policy debate) the nature and extent of polluting industries which can be associated with heavy metal pollution in the city. Some important issues that the work highlights are as follows:

- The types of industries that can be associated with particular heavy metal pollutants in case study areas.
- The discrepancies between the official data and the reality of the number and type of polluting units.
- The importance of partnerships, context, trust and timing in gaining reliable information about industrial pollution (leading to effective abatement and adaptation strategies)
- Those peri-urban areas where there is likely to be a threat to food safety as a result of aerial emissions of heavy metals. (In practice of course industrial effluent is also likely to pose a threat in these areas)

One of the reasons why basic evidence to link local industries with heavy metal pollution was required was that a number of local government officials felt (on first consultation) that there was no evidence to indicate that heavy metal pollution from industries was an issue of concern. This information was essential background in terms of assessing both, the need to, and feasibility of. addressing heavy metal pollution at source.

The major research questions addressed were as follows:

- What is the nature and location of industrial sources potentially contributing to gaseous and air borne heavy metal pollution in Varanasi and Delhi?
- What are potential hazard areas in the two case study cities where important vegetable production areas are located in the vicinity of polluting industrial activity (particularly those associated with aerial emissions of heavy metals)?
- What are the other potential hazard points in the vegetable supply chain, in terms of additional contamination with heavy metals from aerial deposition?

D.3.2. RESEARCH ACTIVITIES

Whilst broadly similar research activities were undertaken in both cities, different approaches were used depending on the local conditions.

I. VARANASI:

Our planned approach involved working as closely as possible with local authorities, particularly with the Uttar Pradesh Pollution Control Board (UPPCB).

The research began with a basic list of registered industrial units in Varanasi. In 1999, the UPPCB registered 3,505 industries in and around the city. The main industries are manufacturing of metal products (514 units), chemicals and chemical products (292), electrical apparatus (247), food and food products (116), textiles (917), printing of saris and hosiery threads (409), transport equipment (106), coal and coal products (94), beverages (24), printing presses and paper products (168), furniture and fixtures (68) and leather/fur/rubber products (34), together with 516 units of miscellaneous activities. The main heavy metals associated with these industries are presented in the table below. Most of the industries also use coal-burning furnaces that will emit air-borne heavy metals.

In Varanasi, industrial activity is small and medium in scale, with the exception of the Diesel Locomotive Works (DLW) on the west side of the city where chromium plating is an important activity. Figure D.3.1 indicates the location of the major industrial locations in the city and Table D.3.1 displays the major industries and the heavy metals associated with them.

Fig. D.3.1. Varanasi: industrial and agricultural areas.

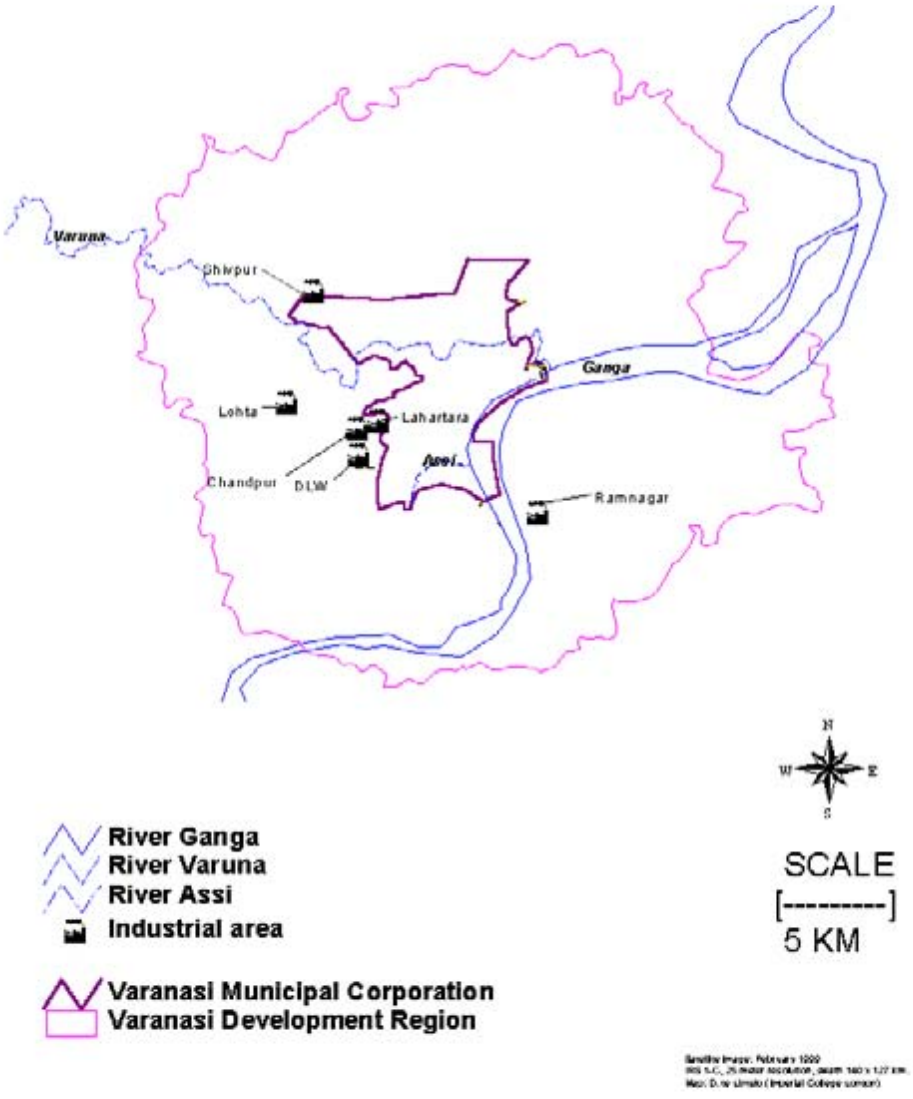


Table D.3.1: Types of air pollution associated with industrial activities prevalent in

S.No	Industries	Pollutants
1	Metal products	
a.	Aluminium	Fluoride, SO_2, NO_2, and Heavy Metals
b.	Steel	SO_2, NO_2, and Heavy Metals
c.	Brass	SO_2, NO_2, and Heavy Metals
d.	Copper	SO_2, NO_2, and Heavy Metals
2.	Chemical and chemical products	
a.	Soap and detergents	SO_2
b.	Pharmaceutical chemicals	Organic vapour and SO_2
3.	Printing of saree and hosiery threads	SO_2 and NO_2
4.	Coal and coal products	
a.	Bakeries	SO_2, NO_2, and Ash (Heavy Metals)
b.	Household use	SO_2, NO_2, and Ash (Heavy Metals)
c.	Use of coal in tea shops and restaurants	SO_2, NO_2, and Ash (Heavy Metals)
d.	Dye of sarees	SO_2, NO_2, and Ash
e.	Use of coal in small-scale industries	SO_2, NO_2, and Ash (Heavy Metals)
5.	Transport equipments	
a.	Automobile servicing	SO_2, NO_2, HC, CO, Heavy Metals
6.	Miscellaneous	
a.	Plastic, polythene and elastic	SO_2, NO_2, Organic vapours and Heavy Metals
b.	Tiles	Fluoride, SO_2 and Particulate Matters
c.	Carpet	Particulate Matters
d.	Jari work	NO_2, Heavy Metals
e.	Brick kilns	Fluoride, $SO_2$and Heavy Metals
f.	Building constructions	Particulate Matters and Heavy metals

Note: Other major pollution source is transportation i.e. major and minor road, crossings, narrow roads between buildings etc. The major pollutants are NO_2, SO_2, HC, CO and a secondary pollutant O_3.

Whilst the UPPCB data gave us an indicator of the types of industries present in each of the major industrial areas in Varanasi, it was felt necessary to carry out our own primary data collection, which would involve surveys of all industries present, whether officially registered or not. Estimates of the number of unregistered industrial units vary greatly, but a number of local respondents suggested that they may exceed 6,000 units.

A mapping process was facilitated by prior review of the British Survey of India maps -the most accurate resource depicting a large part of the infrastructural layout of the city. With these maps as a basis, our team undertook systematic walks and liaised with factory owners, workers and bystanders about industrial activity in and around the 6 industrial areas of the city (Ramnagar, Chandpur, Lohta, Lahartara, Shivpur and DLW) during February 2001. Whilst it is realised that individual or minor clusters of small scale industries operate all over the city, our activity focused on identifying and mapping industrial units at the 6 major industrial estates in Varanasi. These major clusters of industries are generally located in the vicinity of agricultural fields. Other clusters of specific industries, such as silver plating, tend to be located in the old part of the city centre (Chowk, etc).

Enquiries were made about names and main activity of industrial units and subsequent mapping showed their location in each of the 6 areas.

It should be noted that brick kilns were not included in our survey. This was due to time and resource constraints. Brick kilns do exist in significant numbers in the agricultural fringe areas of the city and are also associated with heavy metal emissions.

II. DELHI:

In Delhi all the regulated industrial activity takes place in 28 official industrial estates. In addition to these, many small scale industries operate illegally in residential or industrial areas.

In order to obtain background information on industrial activity, secondary data concerning the presence of and types of industries was to be taken from the National Capital Region Planning Board, Departments of Industry and Industrial Development Boards in Delhi and Faridabad. This data was supported by field case studies of selected industrial areas located in the vicinity of vegetable production areas.

However, in December 2000, the Supreme Court of India forced the government to implement its 1996 order concerning closure of illegally operating industries. Industries were identified on the basis of non-conformity with the Masterplan of Delhi urban planning guidelines. Thousands of these units were closed by the local authorities. As a result, it was not an appropriate time to be seeking information about industrial units, and understandably tentative enquiries by our research team were greeted with suspicion.

Accordingly, it was decided to focus the survey on permanent, officially registered industrial areas, conducting case studies in the Okhla area of Delhi and in the Faridabad industrial complex. We worked in collaboration with local industrial associations to do this.

Faridabad/Ballabgarh, located immediately across the southeastern border of Delhi NCT is one of the ten largest industrial complexes in the country, with 12906 registered industrial units in 1999 (Singh, RB, interim report November 2001). Consultation were carried out with 5 Industrial associations.

Okhla in southeast Delhi is an area combining industrial activity and agricultural production (villages Aaligaon and Madhanpur Khadar being the nearest). In this location, 4 distinct industrial estates operate:

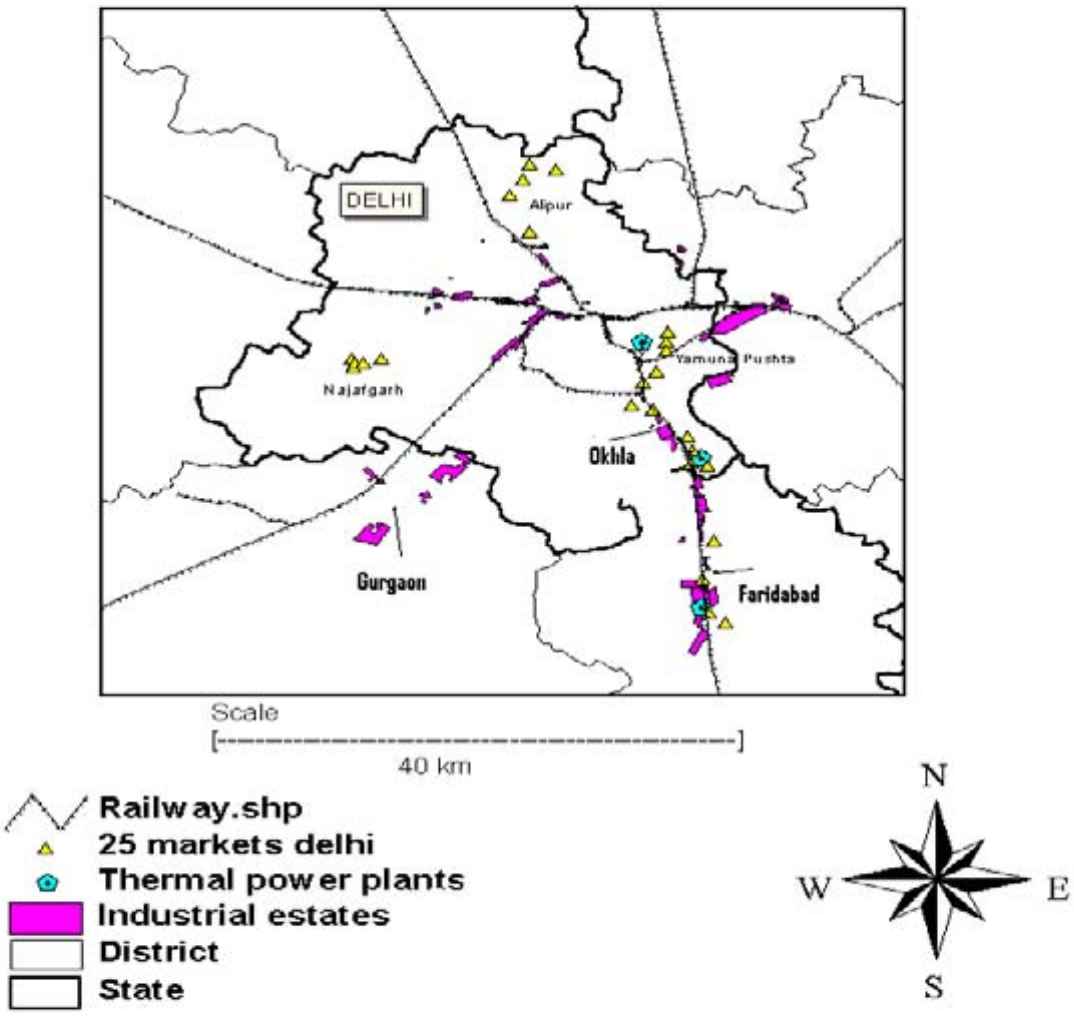
- Okhla Industrial Estate Phase I
- Okhla Industrial Estate Phase II
- Okhla Industrial Estate (also called Phase III)
- Mohan Cooperative Industrial Estate.

Whilst the latter is a private initiative, Okhla phase I-III were developed by the Delhi State Industrial Development Corporation.

Consultations with the member-secretary of Okhla Industrial Association revealed that 80% of the existing units in Okhla Phase I, II and III and Mohan Cooperative are association members, totalling 2705 units. Contrary to Okhla, the membership penetration levels in Faridabad are rather poor. The 1757 industries that are members of the 5 industrial associations in Faridabad, amount to only a 14% fraction of the total number of industries located in the area. Thus, the general representation of all industrial activity in our data is likely to be higher in Okhla than in Faridabad.

With limited involvement of government agencies (as it was a particularly sensitive time with regard to industrial siting) and lack of resources for more extensive field work, local industrial associations were approached to understand the nature of industrial activity in the areas. Membership directories provided the necessary detail of location, type of activity and products manufactured, and subsequent random walks through the respective industrial areas confirmed the actuality and reliability of the membership directories. Product types were subsequently used as a rather crude indicator of potential air and heavy metal emissions.

Fig. D.3.2. Delhi NCT: 25 market sampling sites, industrial areas and land use



Satellite image: 19 February 1998, IRS-1C, 25 metre resolution, swath 140x127 km.
Map digitised by RMSI, adapted by D.J.H. te Lintelo

Hazard areas

In this case the term 'hazard areas' is simply used to identify those areas where vegetable cultivation and industrial activity (which is likely to result in significant air pollution and heavy metal emissions) are taking place in each other's vicinity. The data gathered, and networks developed during this process, do however provide an valuable basis for more detailed assessments such as source-pollutant-impact relationships in the future.

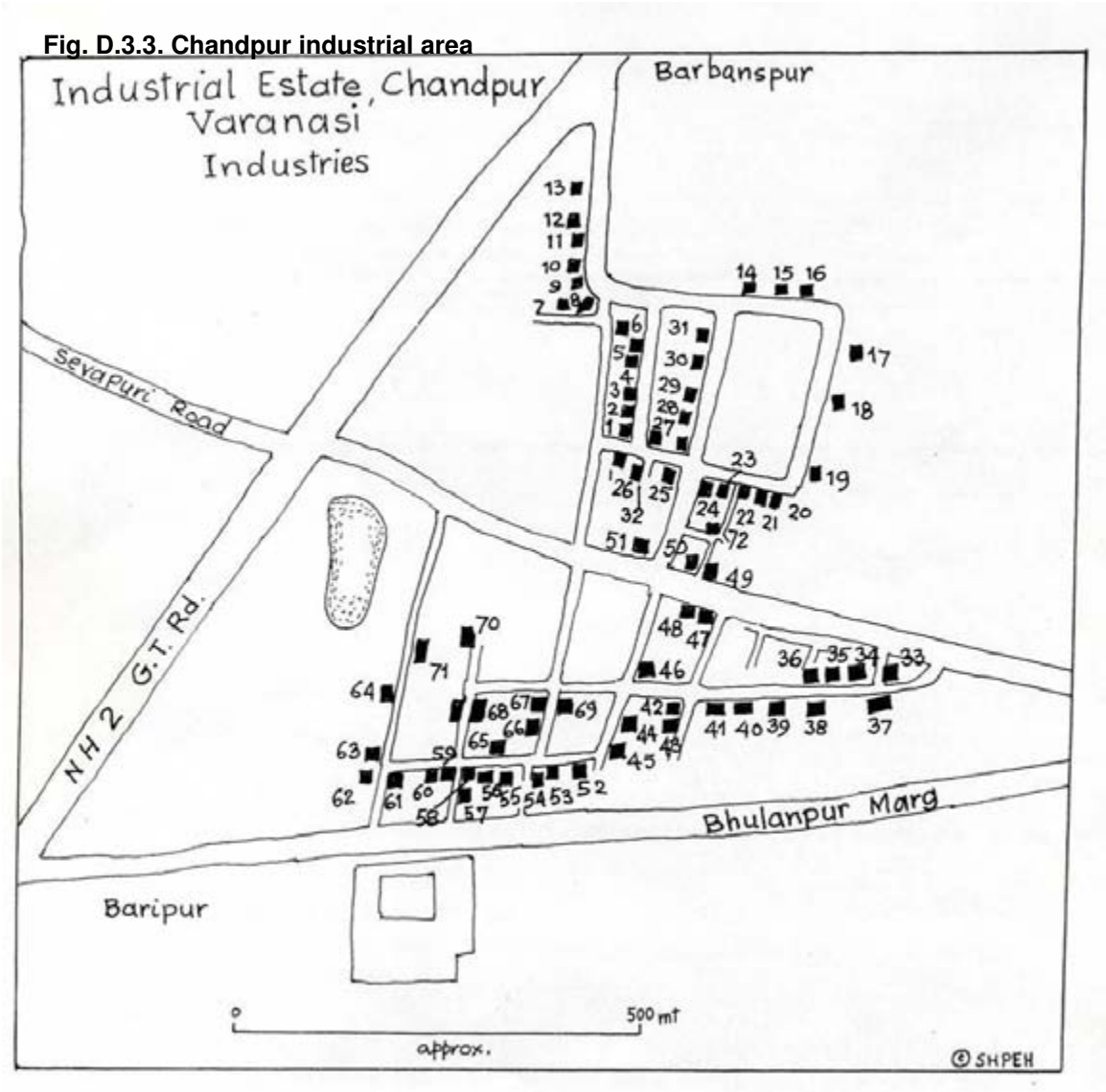
D.3.2. OUTPUTS

I. VARANASI:

For each of the six industrial areas shown in figure D.3.3, a detailed map was produced of the location, type and relative size (scale of production) of individual industrial units. An example is provided below for the Chandpur industrial estate.

A detailed list of all industries was made and these were located on individual maps. An example for the Chandpur industrial area is as follows:

Fig. D.3.3. Chandpur industrial area



1. Bajrang Aluminium Industry: Utensils of aluminium (HM risk)
2. Kapoor Carpets: Manufacturer and exporter of exclusive carpets and thin carpets
3. Joy Narayan Spring Manufacturer: Springs and washers (HM risk)
4. Sardar Udyog: Agricultural implements (HM risk)
5. Banaras Sari: Making Banarasi Sari, printing and dyeing (HM risk)
6. Saving Gram Udyog: Plastic roll (HM risk)
7. Ravi Fan: Manufacturer of table and ceiling fans (HM risk)
8. Surya Chemicals: Ink and paints (HM risk)
9. Banaras Krishi Udyog: Agricultural tools (HM risk)
10. Supreme Ice-cream (C.19): Ice-cream
11. Matal Printers (HM risk)

12. Ravi Poly Pack: Polythene (HM risk)
13. Star Battery (C. 26): Batteries
14. Jayco Tyres: Cycle parts, wires
15. Kothari Models: Plastic jars
16. Banaras Agro Industries: Agricultural implements
17. R. Narayan & Co. : Utensils of aluminium
18. Banaras Beads Ltd. : Carpets
19. Amar Ujala: Newspaper distribution
20. Punjab Auto Industry Pvt. Ltd.: Auto parts
21. MTK Ball & Roller Bearing: Chrome steel precision manufacturer by metal technology corporation
22. Shanti Chemical & Engineering Works: Chemicals
23. Indian Silk Export: Cotton and silk products, packing and export
24. Amco Biscuits: Biscuit making
25. Parijit Chemicals: Phenyl tablets
26. Overseas Carpet: Carpet polishing, packing, export
27. Kaiphone Wire: Maker of aluminium wire
28. Dev Food Products: Making bread rust and related products
29. Pearless Carpet Palace: Govt. recognised export house; manufacturer & exporter of exclusive carpets
30. Carpet & Co: Carpets
31. Pabthara Plastic Products: Plastic polythene
32. Hindustan Tacks Manufacturing Co. : Mono filaments, raps, mosquito net, curtain, etc.
33. Aluminium India (D.18): Fan, plate
34. K. R. Carpet: Making carpet, and exporting too
35. N. K. Industries: Agricultural implements
36. Punjab Iron and Foundry Works: Agricultural implements
37. Contenus India: tin containers
38. Kiroy Electronics: Electronic balances
39. Lakshmi Agricultural Engineering: Agricultural implements
40. Raksha Confectionery: Candies, toffees
41. L. G. M. Fragrance (D. 37): Fragrance, scent
42. Amit Khadi Gramodyoga (D.28): Pickles, jellies
43. M/s Shri I.P. Packaging Pvt. Ltd.(D.29): Paper boxes and packing materials
44. Rajput International (D.9): Carpet making & exporting
45. Shree Nathji Co.: Plastic moulding and boxes
46. Chemicals & Pesticides & Co.: Chemicals, pesticides, grease
47. M/s Aircool Ltd. (D.21): Table fan
48. Hindustan Liver Ltd.: Carpet division
49. Shri Vindhyavasini Engineering & Rolling Mills; Hand pumps
50. M/s Lala Bandhulal & Co.: Agricultural implements, hand pump and table fan base
51. Globe Confectionery: Candy, toffee, etc.
52. Meghdoot Engineering : Making furniture goods
53. Hem Electric Manufacturing Co. Ltd.: Cable wires
54. Prehem Electric Manufacturing Co. Ltd.: Automobile electric equipment & Diesel loco spares
55. Premier Industrial Products (D.5): Plastic sheets, bags, plastic goods
56. Trekon Export (D.6) : Carpet making & exporting
57. Amit Export (D.7): Carpet making & exporting
58. Kataria Plastic: Polythene bags and other products
59. Bharat Engineering Co. (P.16): water pumps, repairing services
60. Jyoti International (P.15): Carpet making & exporting
61. Vandana Cement Pipe: Cement pipes
62. Ratan Chemicals: Paints and dyeing
63. Diamond Printing: Printing and dyeing Saris
64. Mala Jarda Udyog (P.7): Making tobacco items
65. Anand Food Products: Bread and rusts
66. Anand Food Industry: Biscuits
67. Maruti Engineering Works: Transmission line steering tools and accessories and other related machine tools
68. Ajay Iron & Steel Works: Chopping machine, oil presser, agricultural implements
69. Pragati Industries (E.21): Carpets

70. Great Eastern Industrial Corp. Ltd. : Parts of table fan and related items
71. Swastik Prints (P.3): Printing and dyeing Saris
72. Preetam Khanna Carpet: Making and exporting carpets

At least 50 of the 72 industries listed here could be associated with heavy metal pollution.

A similar pattern existed for the other areas:

Shivpur - 14 units identified, 11 of which can be associated with heavy metal pollution;
Lohta - 10 units identified, 6 associated with heavy metal pollution;
Ramnagar - 70 units identified , 42 associated with heavy metal pollution;
Diesel Locomotive Works area - 3 units, all of which are associated with heavy metals;
Laharatara - 23 industrial units, 15 of which can be associated with heavy metals.

Table D.3.2 below provides a summary of the major types of industries in specific industrial areas in Varanasi and the key heavy metals that they are associated with (courtesy of Kerry Price). Each of these industrial sites was in close proximity to important agricultural production areas, and market outlets, and thus pose a potential threat to food safety through heavy metal contamination.

Table D.3.2. Major industries in specific industrial areas in Varanasi and the key heavy metals associated with them

Industry	**Industrial area**	**HM**
Textile and dye/printing works (incl. carpets)	Shivpur, Lohta, Chandpur, DLW	Al, Cr, Sn, Zn
Metal works	Lohta, Chandpur, Ramnagar	As, Cd, Cr, B, Cu, Mn, Ni, Pb, Zn
Food manufacturing and packing	Lahartara, Chandpur	Ni
Chemical works incl. pharmaceutical companies	Ramnagar	Al, As, Ba, Cr, Cu, Pb, Zn
Plastic works (incl. rubber)	Chandpur, Ramnagar	Cd, Co, Cr
Coal production	Ramnagar	As, Cd, Cr, Cu, Pb, Zn
Engineering works	Shivpur, Lahartara, Chandpur, Ramnagar	Al, As, Cd, Cr, Cu, B, Mn, Ni, Pb, Zn
Agricultural tools and machinery parts	Lahartara	Cd, Cr, Cu, Pb, Zn
Paper manufacturing	Lahartara, Chandpur, Ramnagar	Cd, Cr
Cement and ceramic works	Lahartara, Lohta, Chandpur, Ramnagar	As, Cd, Cr, Cu, Ni, Pb, Zn
Other (Brick kilns, lubricants, fragrance manufacturing)	Chandpur, Ramnagar	Pb
Oil industries	Shivpur	Cr, Cu, Ni
Cigarette producing companies	Shivpur, Chandpur	Al
Chemical works incl. pesticide manufacturing	Chandpur	As, B, Ba, Cd, Cr, Cu, V, Mn, Ni, Pb, Zn
Chromium plating	DLW (one very large unit)	Cr
Timber products and treatment works	Ramnagar	As, B, Cr, Cu, Pb, Zn

II. DELHI:

Industrial activity in and around Delhi:

Table D.3.3. Major industrial estates and broad types of polluting industrial activities in Delhi

Industrial Estates	Polluting Industry types
Wazirpur Industrial Area	Plastics, Soup units, Chemicals, Dyes, steel rolling and pickling units
G.T. Karnal Road Industrial Estate	Engineering, Plastics, Chemical units
Lawrence Road Industrial Estate	Paint , Steel rolling
Najafgarh Road Industrial Estate	Rubber processing, Chemical plant, Vegetable oil, Pesticides wood based furniture
Kirti Nagar Industrial Estate	Wood based furniture, Automobiles, chemical plants
Anand Parbat Industrial Estate	Engineering, Pickling, Automobile
Narela Industrial Area	Engineering, Plastics
Jhilmil Industrial Estate	Plastics , Chemical unit, Rubber industry
Shahadara Industrial Estate	Wire unit, Engineering, Chemicals
Nangloi Industrial Area	Plastics, Wire Units
Okhla Industial Estate	Wooden Furniture, Sanitary Fittings, Chemicals, Dyeing.

Source: Singh, R.B., interim report March 01.

a. Case study 1: Okhla

Okhla houses a wide range of industries, trading and service sector companies that are located within the vicinity of approximately 3-10 km of the agricultural area around Aaligaon and Madhanpur Khadar villages. Okhla Phase I and II are the largest areas and contain the greater number of industries, when compared to Phases III and the Mohan Cooperative Estate.

Of 1184 members located in Phase I, 19% manufacture textile and textile products, 12% metal products and 8% plastic, polythene and elastics. Whilst also in Mohan Cooperative, a relatively small industrial zone immediately adjacent to vegetable production areas, textile industries dominate (15%) there are also several metal product and chemical and chemical product manufacturers (7% each). Agricultural villages are surrounded by these industries to the western side, the coal fired Badarpur thermal power station to the south.

b. Case study 2: Faridabad

Compared to Okhla, the Faridabad area provides a more traditional industrial scene, with fewer service oriented businesses and office complexes. The Faridabad cluster is dominated by a large majority of small scale industrial activity (officially defined by investments in plant installation and machinery to the value of less than 10 million rupees) and operation of non-registered units.

The 172 medium and large-scale registered industries in Faridabad are typically engineering and allied industries (37%), electrical and electronics (15%), whilst 11% produce chemical, rubber and plastic products.

The 12734 small-scale industries registered at the Faridabad District Industrial Centre are dominated by almost seven and half thousand machinery and metallurgical units (59%) that make metal works, transport equipment (tractors), machinery, as well as chemical, rubber and plastic industries (17%). Thirdly textile and allied products account for 7% of the total small-scale industries, including dyeing and textile printing units.

As the government data cannot be disaggregated for areas close to vegetable cultivation the researchers investigated industrial association membership directories which do enable such analysis. Whilst these organisations cover a limited percentage of all working units, actual membership is a fair representation for the overall industrial types in the area. A majority of members (57%) fall into the category of machinery and metallurgical industries, closely resembling the general population of industries in the area (59%). Similarly, 17% of members and population fall in the category of chemical, rubber and plastic products. Third largest identifiable group with 7% of the population was textile and allied products, whilst associations derive 3% of their members from these industries.

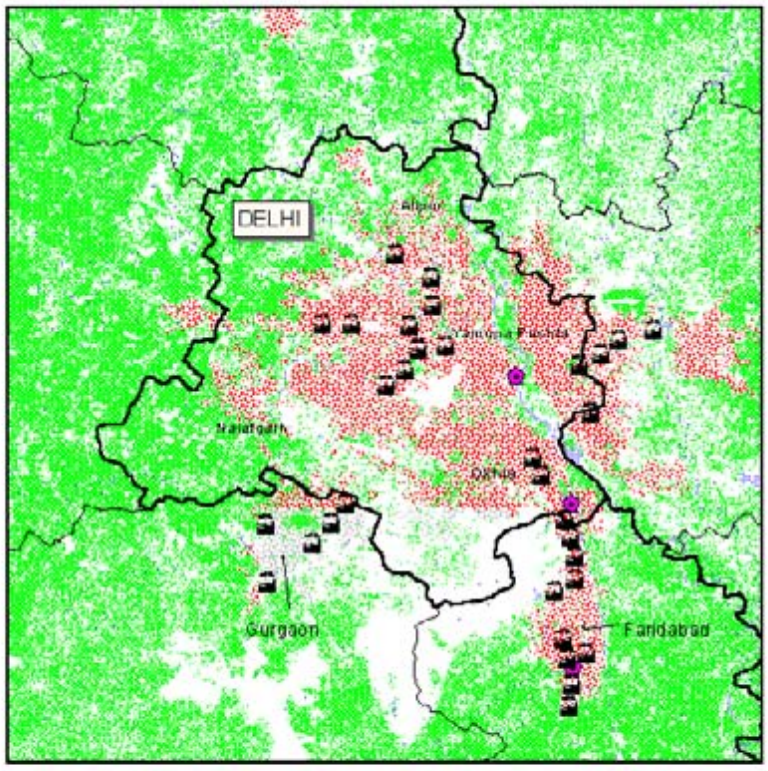
The membership data from the associations has been analysed and verified for selected pockets in areas nearest to vegetable cultivation (within a range of 7-10km), such as the villages of Unchagaon, Machhgarh and Chandawali.

Small-scale industries are known to be less actively regulated by the Pollution Control Boards, which targets the larger units. In addition to the 'recognised' industries there are many unregistered illegal units.This prolific existence of non-registered, unregulated units in Faridabad, is also likely to have attracted units recently relocated from Delhi.

The lack of regulation combined with a dependence on outdated technology is likely to result in very significant pollutant emissions from small scale industries. The president of the Faridabad Small Scale Industries Association regards the area as a 'virtual slum for small scale industries', and there are no basic infrastructural facilities such as sanitation, electricity, sewerage etc. Within this environment it is extremely difficult to engage with small scale industrialists. Part of an effective pollution abatement plan would involve an extensive programme of consultation and participation with these 'small scale' polluters, to understand the opportunities and constraints of various pollution control measures in the context of local livelihoods (both benefitting from and adversely affected by polluting industrial units).

Fig. D.3.4.

'Hazard areas':
agricultural production and industrial activity
in and around Delhi



Scale
[----------]
40 km

Major industrial activity

Thermal power plant

State

District

Land use types

Water

Urban

Agricultural land

N
W E
S

D.4. Existing policy mechanisms for food safety awareness and quality assurance

Introduction

Heavy metal contamination in fresh vegetables marketed and grown for and by the urban and peri-urban poor in Delhi and Varanasi (our own research findings) and other Indian cities like Mumbai and Kolkata (Tripathi et al, 1997; Santra, 2003) is reported exceeded established 'safe' limits.

The following two sections of this report assess the extent to which the policy environment in India is conducive both to engagement in this issue (and the stakeholders affected by it) and to tackling the problem effectively. In section D4, the current mechanisms for food safety awareness and quality assurance are examined, and their suitability explored with respect to providing solutions for food safety problems in urban and peri-urban vegetable systems. In section D5 of this report opportunities for change and enhancement of existing mechanisms are explored, particularly by integrating food safety concerns across related policies and programmes that currently operate in isolation; this will include agriculture, environment, health and nutrition.

In this context the 'policy environment' includes the organizations and institutions with relevance to the issue of food safety; the relationships between them and the interface with wider society and current social and economic and political concerns. There are some aspects of this overall system that have greater emphasis in this project; particularly the interface between scientific research into newly emerging and largely recognized issues that will disproportionately affect the poor and the policy making process.

Research activities

The approach to analyse policy mechanisms for food safety awareness and quality assurance had two distinct objectives:

1. To analyse current policy that affects food safety: understand key government policies, their contents, major policy instruments, institutional and legal frameworks in place and the formal division of responsibilities between organisations directing and implementing government policies.

2. To analyse key policy processes: to assess the governance context, to map stakeholder networks in and outside the fold of the public sector and identify opportunities where scope exists for changing policy. Stakeholder dynamics are assessed through an investigation of formal and informal mechanisms of interaction between and within government, private and NGO sectors that shape direction and outcomes of food safety policy.

The analysis of policy and policy processes is based on a combination of consultations with policy makers, consumer group activists and the Indian research community supported with investigation of relevant secondary material such as policy documents and the legislation regarding food safety. A 'snowball approach' – was successfully used to identify key stakeholders at decision making, but also implementing levels, donor agencies and research establishments. An initial set of stakeholder interviews identified other relevant organisations and policy makers,

whilst research outcomes from other project components guided further targeted consultations. There were over 50 consultations in Delhi and 15 in Varanasi.

Research outputs

Public sector mechanisms dealing with food safety are not new in India. Government activities dealing with food safety have existed since the early years of Indian independence and some of these are still in place. For instance, the Prevention of Food Adulteration Act 1954 remains one of the predominant frameworks within which the Indian State deals with food safety.

However, unlike (for instance) the National Health Policy, National Water Policy and the National Agriculture Policy, a 'National Policy' that deals comprehensively with food safety issues in all stages of the food chain has not been formulated in India yet. Bhatt (1992) suggests that underlying causes are:

- Lack of appreciation of the nature and extent of food safety problems in India
- Lack of awareness on the impacts on health and economic development
- Limited consumer demand for food safety
- Lack of coordination between different government agencies involved with food safety and quality control
- Limited allocation of resources such as manpower and finances
- Limited training facilities at universities and for food inspectors

Whilst clearly a lot has changed in India since 1992, not least the growth of the urban middle-classes, a sprawling and increasingly powerful consumer movement and growing attention of policy to food safety issues, fact remains that currently no integrated food safety policy exists.

Although food safety is part of the National Health Policy, which considers food quality control "of paramount importance to achieve Health for All by 2000 A.D." (Ministry of Health and Family Welfare, 2000b), food safety aspects are governed by a range of different legislation and policies. For instance, initiatives can target food production, marketing or processing, but will not consider food safety in the context of food chain integrity. Legislation and other policy initiatives are implemented by various bodies at not only central and state level, but also by local authorities such as the Municipal Corporation of Delhi. Accordingly, complex institutional frameworks operate vertically through administrative layers but also horizontally between government sectors.

D.4.1. FOOD SAFETY POLICY AND POLICY INSTRUMENTS IN INDIA

Policy instruments dealing with food safety[1] have long been dominated by a set of legislation that created the framework for a command and control based approach to quality assurance. Accordingly key laws define a range of mandatory food product standards, which are enforced through sample testing and legal litigation in case standards are crossed. Other laws stress food manufacturing process standards, which again depend on a mechanism of tests and check ups. Such control mechanism are assisted by licensing schemes which require companies or sellers to pay a license fee in order to be *legally* in business and subsequently are subject to

[1] In this chapter, no attention is given to the Indian debate about safety of GM crops and biotechnology.

sample testing by the authorities. However, since the 1990s private sector mechanisms for food safety such as certification and labeling have been increasingly introduced, and their importance is growing, not least because of new demands due to national and international trade liberalisation.

Current food safety policies apply a combination of policy instruments to achieve their goals. The main instruments are summarised according to their type (regulation, information provision, economic) and nature (voluntary; obligatory) in Table D.4.1.

Table D.4.1. Food safety policy instruments in India

Type of instrument	Instrument	Nature	Means of operation
Regulation	Licensing fees	Obligatory	Entry barrier for industrial units to start legal manufacturing of food products
	Product standards	Obligatory	Standards specified in PFA Act (1954); FPO (), MPO (1973), MMPO (1992) Control Orders including mandatory 'Indian Standards'
		Voluntary	Eco-mark; AGMARK; Indian Standards; AIB (for export markets) years…
	Process standards	Obligatory	FPO, MPO, MMPO
		Voluntary	Eco-MARK; HACCP; quality systems; environmental management systems for food industry
	Prohibitions	Obligatory	Ban on sales of cut fruits during summer in Delhi NCT
Economic incentives	Subsidies	Voluntary	- 50% discount on technology import for implementing HACCP in food processing industries
	Excises	Obligatory	Reduced excise duties for export of processed fruit & vegetables
	Differential taxation	Obligatory	Income tax reductions in export oriented zones for -amongst others- food industries
Information provision	General awareness raising	Voluntary	Awareness raising campaigns: PFA
	Product labelling	Voluntary	Exclusive labelling opportunity of food products that comply with FPO (since 2002); AGMARK, ECO-MARK, ISI, etc
	Information generation	Voluntary	Citizens and consumer organisations can collect samples for analysis at the government laboratory on the basis of Section 12 of the PFA

I. REGULATORY POLICY INSTRUMENTS

Four major types of regulatory policy instruments are used in India for enhancing food safety: mandatory product standards; mandatory process standards; licensing and prohibitions and voluntary product and process standards.

I.a. Mandatory national food product standards: PFA

The Prevention of Food Adulteration Act remains the most comprehensive piece of legislation that protects Indian citizens from unsafe food. The historical focus of the PFA, incepted in 1954, has been on food adulteration rather than contamination whilst little awareness exists about environmental pollution impacts on food safety (pers.comm KS Wahi, director PFA Directorate Government of Delhi, 2003).

No product standards are specified for *fresh vegetables*, thus vegetables fall under the purview of a general clause, which sets maximum permissible limits for the heavy metals copper, zinc, cadmium, lead, tin, mercury, methyl-mercury and arsenic.

PFA product standards are enforced through a sample collection and testing system at state level, involving about1500-1600 food inspectors in the country. The Government of Delhi NCT employs about 25 inspectors, who in theory would have to cover the whole range of food items available in the markets. Considering a lack of resources the policy of the Directorate is to focus on particular types of products based on two key criteria:

- These products are regularly used in every household, to ensure maximum relevance
- These products pose a significant threat to vulnerable people, like the elderly or children.

Hence, currently the main items of interest are edible oils, milk, packaged drinking water and aerated water and spices (pers. comm. KS Wahi, director PFA Directorate, 2003).

With respect to fresh vegetables, thus far at market sites "*no testing is conducted as there is no evidence about heavy metal contamination*" (KS Wahi, director Prevention of Food Adulteration, Government of Delhi, pers. comm, 2003). Similarly, no samples are collected for agricultural produce at farm sites, but the underlying reason is different. As the PFA is based on contracts between seller and buyer, where the first is assumed to guarantee the quality and safety of the product, the Act does not provide the government with powers to sample agricultural produce at field sites. It would be impossible to determine whether the farmer had the intention to sell the product –therewith becoming legally liable- or whether the produce was intended for home consumption.

Food product samples are taken by the government inspectors on the basis of random sampling or on the basis of complaints (pers. comm, H.K. Awasthi, VOICE and KS Wahi, 2003). Whilst sample collection is normally done by government inspectors, PFA Section 12 also bestows the right to collect samples for analysis of any article of food at the government laboratory to individual citizens and registered consumer organisations. Typically, traders raise attention about the suspicious quality of competitors' products and in other cases consumer complaints can induce the inspectors to target their sampling. In both cases, the Directorate gives complainants the option to remain anonymous. Rumours and media reports may also induce investigations by the Delhi PFA Directorate. For example, over the last 3 years persistent rumours surfaced regarding the dipping of fresh vegetables in pesticides, oily substances and artificial colouring for attractive presentation to consumers. The PFA Directorate decided to collect samples of okra from Azadpur market, but did not find any cases and was satisfied that the rumours proved insubstantial (Wahi, pers. comm, 2003).

After sample collection, local government public analysts test one replicate sample at a state food laboratory, which are established in 72 locations all over India. If required, a second replicate of the sample may be send to another public analyst for re-analysis. Whatever the result, the vendor is intimated and the report of analysis must be made available to the applicant. In case the sample is found adulterated, the food inspector, individual or consumer organisation must use the report for launching criminal litigation. The vendor has a right to appeal, for which the third replicate sample may analysed at a Central Food Laboratory (of which there are four in India) for a deciding opinion. Subsequently, the criminal court can take further action through financial penalties and/or jail sentences. Stakeholder consultations have however highlighted that, to date, no important legal cases under the PFA (or other acts) are known to regard adulteration or contamination of vegetables (pers. comm KS Wahi, A. Bhatt and Vaidyanathan, 2003).

I.b. Other mandatory product and process standards: Control Orders and 'Indian Standards'

The Essential Commodities Act, 1955 gives powers to the Central Government to issue nationally applicable Control Orders to control production, supply, distribution, safety and quality of essential commodities ranging from cement to cereals. On this basis, several food safety guidelines and product and process standards for food processing industries have been issued.

Standards set by Control Orders must operate within the minimum PFA limits, but can be more specific or stringent. It is mandatory for all manufacturers of milk, milk products, meat products and fruit & vegetable products to obtain a license under the respective Order, for which an annual fee is paid.

In addition to the mandatory food standards of the Control Orders and the PFA, the Bureau of Indian Standards can declare selected 'Indian Standards' (which are otherwise voluntary) to be mandatory, on considerations of public health and safety. Such items include infant milk foods, infant formulae, milk powder, food colours, and food additives.

I.c. Voluntary standards, certification and labelling

While key Indian food laws such as the PF Act (1954) and PFA Rules make use of policy instruments with command and control approach, recent legislation and private sector initiatives have a more voluntary approach in addressing food safety and quality issues.

Independent voluntary product and process standardisation and certification systems exist for processed food and raw agricultural produce. In all schemes in India, successful completion of certification entitles recipients to use special labels on the products to signal quality characteristics to consumers. For instance, the Fruit Product Order label is regarded as 'a symbol of quality to the general public' and signals to manufacturers "its mandatory nature" (Ministry of Food Processing Industries, 2002).

Table D.4.2. Food product and process certification schemes in India

Certification scheme (year of establishment)	Product type	Certifies	Certifying/controlling body	Use of label
PRODUCT				
AGMARK	163 raw agricultural products, inc. vegetables	Grading and quality standards	Ministry of Agriculture, GoI	Yes
FPO (2002)	Processed fruits and vegetables	Product and process standards	Ministry of Food Processing Industries, GoI	Yes
Indian Standards	Processed foods	- Raw material quality parameters - Hygienic processing conditions - Packaging and labelling	Bureau of Indian Standards/PFA bodies	Yes
ECO-MARK	Processed foods	Environmental criteria for process and product	Ministry of Environment and Forests/CPCB/BIS	Yes
Organic food; EU Good Agricultural Practices[2]	Raw agricultural products, esp. f&v	- International voluntary standards specifying lack of or limited agro-chemical residues in products. Especially relevant for export markets.	Private companies	Yes
ISO 9000 and 14000	General	Quality systems and environmental management systems	Bureau of Indian Standards	Yes

Certification of food production processes in India entails especially HACCP and ISO quality management systems.

- **HACCP certification**
  HACCP certification services in India are offered by the public and private sector. The multinational SGS is the biggest HACCP certifying agency in India with competition from the British Standards Institute, the German TUV and the Indian public sector Bureau of Indian Standards (pers. comm J. Singh, SGS 2003). Whilst many of the HACCP certification concerns export products, it is increasingly used for products aiming at domestic (luxury) food markets, like airline catering. Its potential for application is however not limited to such branded luxury products. Several Indian research institutions have also explored the possibilities of applying a HACCP analysis to the domestic informal food sector. For instance the National Institute of Nutrition (Bhat, 2003) and the All India Institute of Hygiene and Public Health (Chakravarthy, 2003) have recommended HACCP based interventions for safety of popular street foods, paneer and other dairy products consumed by the urban poor.

  Currently HACCP is not included in the Prevention of Food Adulteration Act, but the Government of India is keen to make HACCP mandatory for food processing industries. The GoI is also due to notify that, from end 2003 or 2004, all exporting

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food industries in India must be HACCP certified (pers. comm J. Singh, SGS 2003).

- **ISO quality and environment management systems**
  Since 1991, the Bureau of Indian Standards has run a quality systems certification scheme (as per ISO 9000 series of standards) for the Indian food industry (BIS, 2002). Environmental Management Systems (EMS) are certified by BIS in accordance with IS/ISO 14000 Series Standards that demonstrate the organisation's capability for compliance/conformity to the legislative and regulatory requirements for prevention of pollution and the protection of the environment.

I.d. Prohibitions and licensing

Licensing is a common policy instrument to control the establishment of food processing and distribution industry. National level licensing obligations apply to, for instance, fruit & vegetable, meat and milk processing industries. National, State and local level legislation can also specify conditions to be fulfilled by manufacturers in order to obtain a licence to permit conducting business that does not compromise public health. The Municipal Corporation of Delhi, for instance, issues licenses to meat-shops and butchers.

In extreme cases, local governments have announced bans on sales of high-risk food. For example, the selling unpacked mustard oil got banned in 1998 as a direct result of the mustard oil adulteration scandal. Another main example in this respect regards the threat of outbreaks of cholera in Delhi during the summer and the rainy season of 2002. As part of a package of interventions, a six-month ban was announced on the sale of cut fruits and other articles of food exposed to dust and flies.

II. POLICY INSTRUMENTS FOR INFORMATION PROVISION

National, regional as well as local government agencies promote, to a limited extent, the raising of awareness about food safety amongst the general public.

The National Health Policy (section 2.22.1, 2002) recognises that 'there is an increasing expectation and need of the citizenry for efficient enforcement of reasonable quality standards for food' and the Ministry of Health and Family Welfare considers food safety awareness raising a responsibility of the Central Government (2000a). However, several other central agencies are working on food safety as well. For instance, the ministry of Food Supplies & Consumer Affairs designates food adulteration as one of the themes that require awareness raising amongst consumers through television and radiobroadcasts (pers. comm, S. Reddy, 2003). Some national research institutes also organise public food safety awareness raising activities. The Central Food Technology Research Institute[3] in Mysore, Karnataka conducts public awareness programmes in villages and towns of Karnataka and neighbouring states. During these programmes, food adulteration and its implications would be explained and simple tests to detect some of the most commonly found adulterants would be demonstrated to the public. Videocassettes on these aspects

[3] CFTRI is one of the prime research organisations in India which conducts research into human health impacts of food safety and surveys food additives, pesticide residues, heavy metal & microbial contaminants, colors, sweeteners etc.

are made in English as well as various local languages such as Kannada, Telugu, Tamil, Malayalam and Marathi.

Nation-wide, consumers are increasingly provided with information about the safety of food products through a range of labels backed up by government developed or promoted schemes for mandatory and voluntary certification (see table above). Other examples of the increasing importance of labeling regard the 2000 amendment of the PFA Act (i.e. Packaged Commodity Rules) which makes the visible display of the expiry date of branded food products obligatory in all India. Another PFA amendment specifies that all vegetarian and non-vegetarian food items and cosmetics must be labeled accordingly with a simple label coloured in green (vegetarian) or brown-red (non-veg/animal produce) from 2002.

At the State level, under the PFA Rules for Delhi (2002), one of the powers and duties of the state Food Health Authority is 'to interact with consumer organisations to create public awareness about the food safety and quality or misbranding of food articles'. Awareness raising activities include general information provided at their website. A recent PFA Directorate concern about unhygienic conditions around food stalls in slums has started a new initiative in September 2002 to increase awareness about food safety amongst schoolchildren in slum areas and people in nursing homes and hospitals. The PFA Directorate envisages schools to set up teacher-parent associations dealing with improving the environmental conditions of surroundings of schools and hygiene in food stalls. To this effect, about 6000 letters were sent to public and private schools and the Education Departments in MCD, NDMC and Government of Delhi (pers. comm, KS Wahi, 2003).

However, the PFA Directorate of the Government of Delhi perceives difficulties in setting up awareness raising programmes for vegetable vendors. Due to a Supreme Court order limiting the amount of hawkers operating in Delhi to only 24000, any initiative of the PFA Directorate acknowledging the existence and working with vendors would be deemed as a contravention of the SC order, punishable with jail. The Director of the PFA in Delhi explained that for this reason PFA could not collaborate with a WHO programme to increase awareness amongst street food vendors about food hygiene (pers. comm, 2003).

Local municipal governments can also play an important role. For instance, the Municipal Corporation of Delhi (MCD) has raised awareness about personal and food hygiene since 1995 as part of an annual action plan 'PREVENT', which is developed in consultation with public health experts and administrators. Efforts are especially aimed at reducing food and water borne diseases like cholera and gastro-enteritis, which have a major impact on the health of the urban poor. MCD awareness programmes are implemented in 12 decentralised zones through advertised messages (in English & Hindi) in newspapers, cinema slides and hoardings on buses and at the roadside, while posters are put up at public places.

III. ECONOMIC POLICY INSTRUMENTS

Few economic policy instruments are used to promote food safety and the existing ones are predominantly aimed at the food-processing sector and therewith will have little direct impact on poor Indian consumers.

One interesting example is Government taxation discounts, which are used to attract food processing companies to settle in special 'export oriented industrial zones',

incorporated within the agreement are conditions that promote food safety. For instance, the Marine Products Export Development Authority has made HACCP certification compulsory for marine food industries operating in such 'export oriented industrial zones (Bhat, 2003).

The Ministry of Food Processing Industries also subsidises 50% (with a limit of Rs.1 million) of costs of implementation of QA mechanisms including HACCP and ISO-9000 certifications, as it considers HACCP to be 'extremely desirable in view of the changing scenario in the international trade'.

Economic instruments are also used to benefit farmers, but currently none of these aims at improving food safety. On the contrary, it could be argued that subsidies for cheap fertilisers effecting (excessive) use could have harmful effects on food safety. In the recent past the Government of Delhi has promoted application of sewage sludge manure as a fertiliser by means of special farmer discounts of 1/3rd of the price (M. Lal, pers. comm., 2003). A study conducted jointly by the Central Pollution Control Board and the Indian Agricultural Research Institute indicates that this sewage sludge manure contains high levels of heavy metals like chromium and lead (N. Gupta, IARI, pers. comm, 2003).

D.4.2. INSTITUTIONAL FRAMEWORKS GOVERNING FOOD SAFETY POLICIES

Key legislation dealing with the quality and safety of food produced, manufactured and traded is set by Parliament and responsibilities for the implementation of the PFA, Indian standards and Control Orders rest with both central and state governments. In some cases local governments can also take measures concerning food safety.

I. CENTRAL AND STATE INSTITUTIONAL FRAMEWORKS REGARDING PFA FOOD STANDARDS

The Prevention of Food Adulteration Act, 1954 and the Prevention of Food Adulteration Rules, 1955 are administered by the Ministry of Health and Family Welfare of the Government of India. Also located in this ministry is the Codex Alimentarius Cell. The Joint Director of the Directorate of Prevention of Food Adulteration implements the Act supervised by the Director General of Health Services. The latter also chairs the Central Committee of Food Standards (CCFS) the key policy making body that sets PFA food standards in India. This committee officially has 51 members consisting of representatives from the States, industry and corporate sector, NGOs, as well as relevant central ministries. In practice however, bi or tri-annual meetings consist of about 12 members, as few states send representatives (pers. comm K. Singh, VOICE, 2003). Members can have a significant influence in the standard setting process, as prior to CCFS meetings, agendas are circulated and comments invited from all members for discussion. Minutes of the meetings are sent to states and central government departments, on which basis relevant ministries propose draft notifications. Draft notifications are subsequently send to and reviewed by a range of stakeholder organisations and individuals. Their written comments inspire renewed discussions in the CCFS, leading to a decision about new food standards that needs notification in the Gazette of India to become law.

Implementation of the PFA is entrusted to the State Governments and Union Territories, who set up Food Health Authorities to this effect and can also develop more specific legislation within the framework of the national act. In Delhi NCT, the Directorate of Prevention of Food Adulteration (Department of Health and Family Welfare) has responsibility for implementation of the PFA Act and Rules. Its director is notified to function as the 'Food Health Authority'. Decentralised implementation takes place in the 9 districts in which Delhi is divided, each having 3 subdivisional magistrates (SDMs), who are responsible for local administration. All the 27 SDMs are empowered to function as Local Health Authority (LHA) and supervise a team of Food Inspectors.

In Varanasi, district authorities based in the city would be responsible as local food health authority administering the PFA, but according to Dr. A. Kumar, medical superintendent of Banaras Hindu University if there is any organisation "it must be dormant" and "practically ineffective" (pers. comm, 2003).

II. INSTITUTIONAL FRAMEWORK REGARDING BIS 'INDIAN STANDARDS' AND ECO-MARK

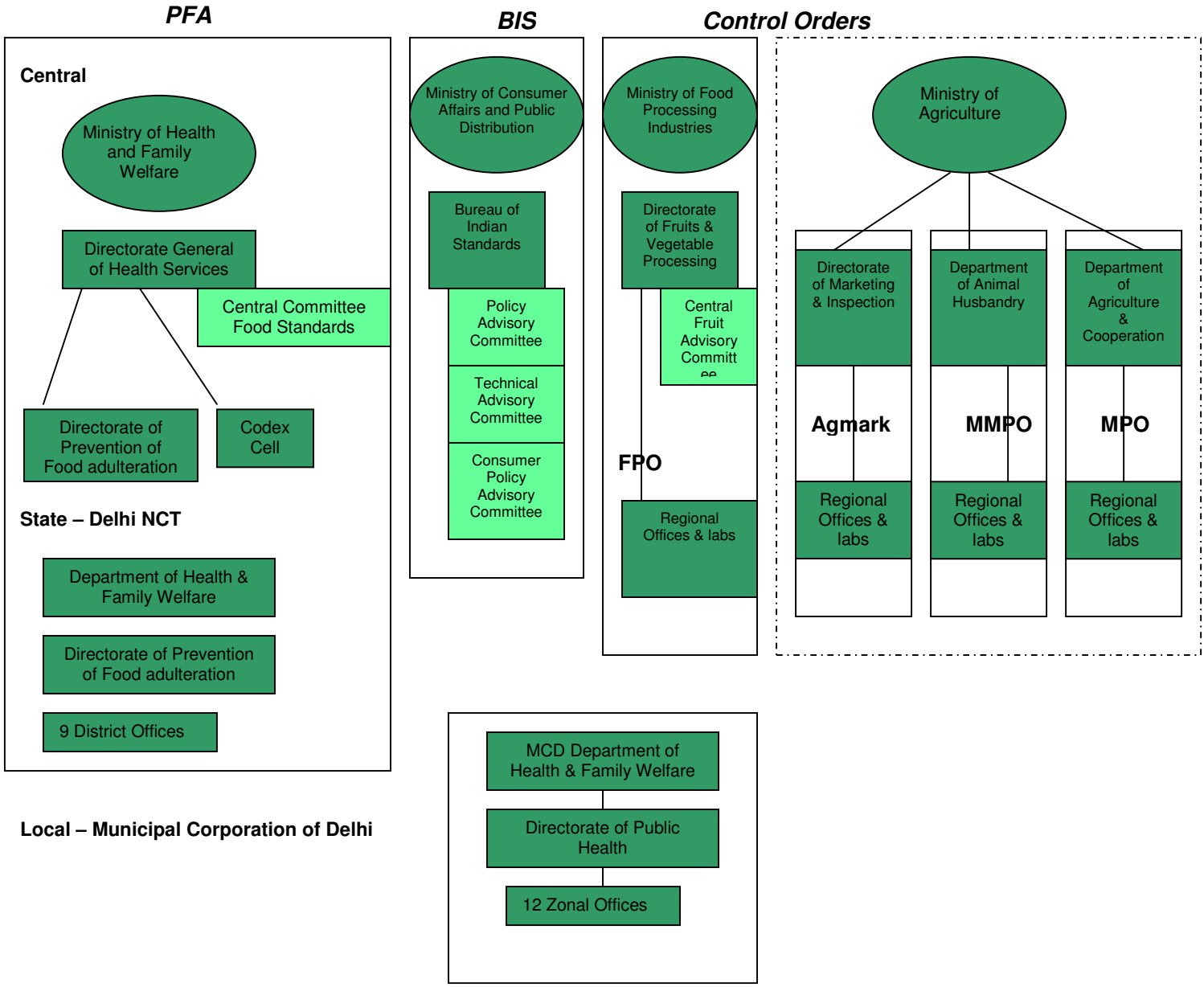
Although the PFA is the highest Act and lowest common denominator in terms of the tolerance levels of standards, other central government statutory bodies dealing with food safety can develop more (but not less) stringent mandatory standards. The Bureau of Indian Standards -a semi-autonomous statutory body controlled by the Ministry of Consumer Affairs and Public Distribution- can draft new mandatory food safety standards, after which the PFA is amended to incorporate these. Normally, BIS reviews standards every five years (pers comm, S. Reddy, Dept of Consumer Welfare, GoI, 2003).

Whilst the Bureau of Indian Standards grants licences to companies that comply with voluntary Eco-mark and 'Indian Standards' checks licensee's performance through regular surveillance, surprise inspections and testing of factory and market samples, PFA implementing bodies enforce compulsory 'Indian Standards'. Whilst the Eco-mark standards are developed, designed and promoted by a Steering Committee in the Ministry of Environment and Forests together with a Technical Committee in the Central Pollution Control Board, BIS implements the certification scheme.

III. LOCAL GOVERNMENT INSTITUTIONAL FRAMEWORKS FOR FOOD SAFETY

In some cases local governments can also take measures promoting food safety in order to prevent the spread of diseases like cholera. In the summer of 2002 cut fruit sales were banned in Delhi by the Municipal Corporation on the basis of the MCD Act, 1957. Such activities are highly localised. Whilst an example is given in the figure below for the Municipal Corporation of Delhi, in Varanasi no specific legislation or activities are undertaken at the municipal level concerning food safety. Consultations with officials of the MCD highlighted that municipal activities regarding food safety and hygiene are perceived to be independent, not conflicting with the PFA-mechanism and therefore do not entail much co-ordination between the agencies.

Figure D.4.1.: Central, state and local government food safety bodies in India



IV. INSTITUTIONAL FRAMEWORK FOR CONTROL ORDERS AND AGMARK

Quality assurance inspections for industrial meat production, milk and milk products and fruit and vegetable processed products are directly administered by the Central Government, however independently by different ministries and government bodies. The Fruit Products Order is implemented by the Ministry of Food Processing Industries through the Directorate of Fruit & Vegetable Processing at New Delhi and its regional offices located at Delhi, Mumbai, Calcutta, Chennai and sub-offices at Lucknow and Guwahati. Within the Ministry of Agriculture, the Department of Agriculture and Cooperation administers the Meat Food Product Order (1973) and

the Department of Animal Husbandry & Dairying the Milk & Milk Products Order (1992).

Statutory advisory committees (for instance Central Fruit; Meat Food Products; Milk and Milk Food Products Advisory Committee) are the policy bodies that amend Control Orders. The committees consist of technical experts, government administrators from different central government departments, representatives from state governments as well as industry representatives.[4]

The Agmark voluntary standard for agricultural produce is governed by the Directorate of Marketing and Inspection of the Ministry of Agriculture (Government of India) as per the Agricultural Produce Grading and Marking Act (1937).

D.4.3. POLICY IMPLEMENTATION: OPPORTUNITIES AND CONSTRAINTS TO ADDRESS AIR BORNE HEAVY METAL DEPOSITIONS ON VEGETABLES

In this section, the suitability of the existing policy mechanisms will be explored with respect to providing solutions for food safety problems in urban and peri-urban vegetable systems.

I. AN ASSESSMENT OF THE CURRENT REGULATORY APPROACH

Whilst food safety policy in India is dominated by a command and control approach, the extent of coverage of mandatory standards and the enforcement mechanism of sample collection and testing are limited.

The focus of many of the mandatory and voluntary standard certification schemes has been on the organised food sector, especially processing industries. Even within this sector, implementation of the Orders is haphazard, inspections limited and product standards (such as heavy metal contents in food), which must be followed by all food processors are rarely adhered to by local players.

The reality in India -as in many other developing countries-, is that a large share of the food economy is highly informal and fragmented. Such informal suppliers consist of and cater to the needs of the poor.

Food quality assurance in highly informal economies through control regimes is complicated and expensive due to the high level of fragmentation and the relative lack of transparency of the market structure. For instance, in Delhi, Mother Dairy supplies 30% of milk to consumers, the government Delhi Milk Scheme 11%, large private dairy companies 16% and the remainder of milk is supplied through small scale businesses that generally cater to the needs of the poor (Chatterjee, 2000). Indeed, as per the Milk and Milk Products Order small dairy units do not require obligatory licensing schemes for sales, and only 31% of the national production capacity is registered under the MMPO (V. Kurien, chairman, National Cooperative Dairy Federation of India in: Frontline, 2002).

[4] For instance, the Meat Food Products Advisory Committee consists of amongst others Agricultural Marketing Adviser of the Department of Agriculture (Chairman); Animal Husbandry Commissioner; Director General of Health Services; Executive Director, Food and Nutrition Board; Director, Central Food Technological Research Institute; two officers of State Governments and two persons from among the manufacturers community.

In 2000, the Meat Food Product Order administrators issued a mere total of 173 licenses to manufacturers operating all over India. Considering that India has a meat eating population of a hundreds of millions, it appears that the bulk of the meat sector is also operating outside the scope of (the food safety provisions of) the relevant Order.

A similar case can be made for fresh vegetable production and retailing, with an even higher share of the informal sector and even less bulking functionaries than in the milk business. Whilst currently no control order schemes exist for fresh vegetables systems, the feasibility and desirability of such a potential scheme for the informal sector may be questioned from a poverty perspective. Licensing systems for small milk or vegetable producers and vendors may severely affect their livelihoods, as it may not be possible for these groups to pay advance-licensing fees, or recover these from customers.

Box 1: Mustard oil adulteration: the case for prosecution

As a response to dropsy deaths mustard oil adulteration scandal, in 1998 the Delhi PFA Directorate sampled 332 samples. Out of these 185 were found to be legally suspect and prosecuted. In 2003, the Courts have acquitted 35-40 cases on the basis of non-corroborating second sample testing results in the Central Food Lab Calcutta, whilst the remainder of cases are still pending in court (pers. comm. KS Wahi, 2003)

Hence without Control Orders, the main food safety system in place for the informal vegetable production and trading sector would be the PFA. However there are many shortfalls in the PFA system in terms of its applicability to the vegetable trade.

Formal sample collection by the authorities is limited by the small number of inspectors, cost implications, competition amongst the goods to be selected and the formulation of rules.

The PF Act does give individuals and consumer organisations the right to submit samples for testing at the PFA lab, but in practice this rarely happens. In Varanasi, food samples are only analysed in scientific and government research institutions (pers. comm, Dr. A Kumar, 2003). In Delhi, administrators and consumer activists suggest that the lengthy PFA legal process is responsible for the lack of interest. In exceptional cases, PFA litigation can be completed within a year, but many cases are known to continue for 7 or more years (pers. comm, KS Wahi, AK Awasthi, K Singh, 2003). For this reason an otherwise active consumer organisation like VOICE has never exercised this right, let alone individual consumers. I

Box 2: Multilateral support for food safety programmes in India

The World Health Organisation has supported the Government of India in 1998-2001 with financial support to improve the analytical capacity of government labs and training programmes are conducted for food inspectors working in States/U.Ts as well as recognised consumer organisations on Food Safety and Quality Control.

Sample collection by individuals and recognised consumer associations is also marred by procedural requirements that could give scope for practical obstruction of this process by vendors. For instance, the purchaser has a legal obligation to:

- Obtain a cash memo/receipt from the shop keeper and obtain the signature of a witness and the vendor on it
- Identify the name and address of the supplier who has supplied the sample commodity.
- Give notice in writing to the vendor at the time of purchase of the intention to have an article analysed.

It is clear that this process is not designed for the informal vendors and hawkers' economy.

Once samples are collected and forwarded to the state food laboratory, problems may occur in the food analysis. The 1995 Venkataramaiah Task Force review of the PFA expressed concern about poor physical infrastructure and lack of qualified analysts. Under-funding is an underlying cause. Multilateral organisations are now strengthening the capacity for food safety analysis in India (see box).

Poor technical capacity is an essential problem: according to consultations with government officials responsible for implementation of the PFA, up to 80% of those accused are acquitted on technical grounds. However, in a significant number of cases, there are also suggestions of corruption. Out of 100 appellate cases, about 40% get dismissed after re-analysis of the sample at the Central Food Lab at Calcutta, resulting in acquittal of the accused (2000, M. Srivastava, pers.comm). Some accused food manufacturers use legal loopholes to avoid liability. For instance, as Section 17 PFA (1954) suggests, cases can be fought through a nominee; junior employees of companies are often appointed as nominee, therewith becoming eligible for prosecution in place of senior colleagues.

Box 3: Air borne contamination: a natural cause?

PFA Section 12 states that a product for sale is *not* deemed to be adulterated if this happened 'solely due to natural causes and beyond the control of human agency'. Hence, would air borne heavy metal pollution be a 'natural cause' enabling vendors to invoke this clause to prove their innocence? Legal experts made clear that although no PFA jurisprudence has developed in this respect, it is unlikely that this clause could be successfully invoked (pers. comm., A. Bhatt, Environmental Justice Initiative, 2003) especially if precautions like covering produce are taken (pers. comm,, HK Awasthi, VOICE, 2003).

The food industry's perspective of the PFA is rather different. There is concern about a considerable time lag between receipt of analysis reports from the PFA lab and final launching of prosecutions, therewith affecting the analysis of the replicate for appeal because of quality deterioration (Gupta, 2000).

The PFA prosecution system also raises important issues. The PF Act summons the responsible implementing authorities to criminally prosecute all cases where food is adulterated or contaminated in contravention of the declared quality standards. The PFA does not have the legal mandate for simple investigative studies. The PFA administration also does not have the liberty to consider the issue or extent of blame, in contrast to the judiciary. Thus when vegetables would be sampled from vendors and found highly contaminated with heavy metals, it is the vendors themselves who would be criminally prosecuted. But, vendors cannot be currently expected to know about the contamination thus a dilemma arises, it would not be morally or legally permissible to attribute reasonable blame.

Even if these functional difficulties with the current system were overcome it would be extremely difficult to introduce a command and control system like the PFA-mechanism to vegetable retailing or trading - as it would be seen to undermine the livelihoods of the traders and retailers (pers. comm, KS Wahi, A. Bhatt, AK Awasthi, S. Reddy, 2003). The poor informal food economy represents a large bank of voters and it was considered that any politician that will undermine these people's livelihoods will be risking their political career. Secondly, such as system would be seen to conflict with existing government policy that tries to encourage small scale entrepreneurs to earn income as a poverty alleviation strategy.

II. AN ASSESSMENT OF THE CURRENT VOLUNTARY APPROACH

Voluntary tools increasingly complement command and control measures for QA. Whilst this study has not investigated comparative pricing and accessibility of the urban poor to certified produce, consumer organisations point out that such schemes have been successful in increasing consumer confidence in the quality and safety of goods, even though the standards are not always adhered to (pers.comm, Awasthi, 2003). Clearly there is also a lot of scope for increased awareness amongst consumers about these QA products, particularly amongst rural citizens (pers. comm. K. Singh, 2003). According to K. Singh of VOICE, such enhanced awareness amongst consumers about the lack of quality and safety of currently sold produce could give scope for introduction of a voluntary standard for fresh vegetables (pers. comm, 2003). People in the certification industry are however sceptical about the potential of voluntary standards for domestic markets.

Systems of voluntary standard certification in the country are not always successful, for a number of reasons. For example:

- Certified products available in the markets sometimes fail to meet the requirements.
- There are inconsistencies in the implementation of voluntary product standards
- There is widespread existence of pirated products

Grading of produce under the AGMARK scheme has not been taken up by extensively by farmers. The Ministry of Agriculture considers the large number of other central and state government marketing organisations that follow their own grading standards to be a key problem here. In addition, inadequate availability of testing facilities is not only a problem for implementation of the PFA but also for AGMARK grading.

Voluntary process standards for food industries have also come under some scrutiny. According to Bhat (pers. comm, 2003) actual implementation of HACCP in food industries in India is fairly poor. Even were it is compulsory like some marine food industries, certified companies don't comply fully and have partially implemented HACCP systems. Certification agencies like SGS disagree, averring that this is probably more the exception than the rule, and that large certifying bodies -who dominate the Indian market- are much less affected by possible pressures from the customers in contrast to smaller certifying companies (pers. comm, J. Singh, 2003).

D.4.4. OPPORTUNITIES FOR NEW FOOD SAFETY POLICIES: TOWARDS HARMONISATION OF LAWS AND A FOOD SAFETY REGULATORY AUTHORITY?

Food safety legislation has been under review by various Ministries in the last decade, indicating a general awareness about the importance of improving food safety. Task Force and Expert Committee strategy papers indicate the direction of the debate about new food safety policy, however their recommendations are only advisory in nature.

A 1995 Task Force to the Ministry of Health under the chairmanship of E.S. Venkataramaiah reviewed the PF Act and recommended a change in emphasis away from detection of adulteration and prosecution to good manufacturing practices.

More radical changes were proposed by a 1998 Task Force to the Prime Minister's Office headed by three captains of industry (under the chairmanship of Nulsi Wadia). It advocates formulating a Food and Agro Industries Management Policy, therewith:

- Replacing existing fragmented bodies and consolidation of all the departments under a single ministry for agriculture, fisheries and food, along with a single body of legislation too be administered by a "Food Regulatory Authority" (FRA)
- Replacing the Central Committee of food Standard (CCFS) by a FRA Governing Body for more expeditious decision making.
- Revising the PFA through simplification of sampling procedure and the procedure for nominees, inclusion of a time limit for prosecution, prescription of standard methods of analysis, revising penalties according to the gravity of offences and providing of adequate/infrastructure and laboratories.
- Harmonisation of 'Indian Standards' with quality norms of Codex and WTO.

The Ministry of Food Processing Industries in its draft Processed Food Development Bill 2001, also proposes simplification of rules and regulations and the harmonisation of existing standards and food laws for a uniform regulatory approach to food quality and safety in the interest of industry. Food Product Orders are also in the process of being unified, supported by the food industry which experiences that due to the multiplicity of laws food factories are visited by a number of inspectors from different departments, leaving room for multiple harassment, conflicting approaches, administrative delays etc (Gupta, 2000).

However, whilst the debate about food safety policy in India is gaining momentum, decision-making for institutional policy changes has been slow. Significantly, the only recently adopted policy that addresses food safety, the National Health Policy 2002, has not made any significant diversions from previous policy, lacks references of decision-making reforms, sustains the command and control approach to food safety. Awareness raising campaigns about food safety issues amongst consumers, traders, processors, manufacturers or producers are not focus areas of government efforts. In the words of the National Health Policy 2002 (Ministry of Health and Family Welfare, 2002), policy aims at:

- Better capacity for enforcement of the regulations, with progressive strengthening of laboratory facilities and technical expertise.
- The Policy envisages that ultimately food standards will be close, if not equivalent, to Codex specifications.
- Food standards will be tightened up at a pace which will permit domestic food handling and manufacturing facilities to undertake the necessary upgradation of technology so that they are not shut out of this production sector.

Decision-making about the future institutional governance of food safety may well have been slowed down because of the continuing battle for control over a future 'hegemonistic' food safety body, between the wide range of organisations from central and state governments currently involved in the administration of food safety. In such a context one can appreciate that a future truly comprehensive Food Safety Act is still a "long way off" (pers comm. K Singh, food safety officer VOICE, 2003).

D.4.5. CONVERGENCE OF INDIAN FOOD SAFETY NORMS WITH INTERNATIONAL NORMS

Unified international food control systems are important for developing countries to establish and capture international trade flows (pers. comm, S. Rajasekar, 2003) and this is recognised by Indian policy makers. The National Health Policy signals that the government is aligning with important international trends in food safety policy, in which food standards converge towards international norms. Codex standards are increasingly accepted as the benchmark.

Agricultural policies in India now strongly support the foreign exchange earning capacity of exports and the government realises that increased quality consciousness amongst farmers and processors will be crucial for the export potential of India's horticultural crops (Banerjee, 2002).

A key issue is whether this process of harmonisation towards Codex will strengthen domestic food quality standards and more specifically heavy metal contamination standards for vegetables in India.

Despite being a member of World Trade Organisation and signatory to the Sanitary and Phytosanitary agreement (1994), India has ***no legal obligation to adopt Codex standards relevant to HM contamination of crops***. The SPS treaty designates Codex as one of the sources for recognised international standards for use in resolving trade disputes between countries and permits nations to have different standards if scientifically justified (Centre for Science in the Public Interest, 1997).

In fact, rather than automatic adoption of Codex norms, several alternative ways are open for development of food safety standards for India:

- India can sign bilateral agreements for enhanced exports to selected countries
- Regional standards can be proposed to Codex jointly with other WTO members for important products for which no Codex norms exist. For instance regional Codex norms were developed for instant noodles as proposed by Thailand, Indonesia, China and other South-east Asian countries (pers. comm, KS Wahi, 2003).
- National food standards can remain in place. The SPS treaty allows countries to make use of the clause "other legal factors" which countries can invoke to retain national standards that are incongruent with Codex standards. Such factors could be culturally determined or have a more technical nature. For instance, Codex has accepted a more liberal sulphur residue norm for Indian sugar, caused by a bleaching process applied to brownish Indian sugar (pers.comm, S. Reddy, 2003).

However, countries risk WTO arbitration when other member countries consider India's standards as a barrier to trade being non-scientific and not required for protection of public health. As currently Indian standards are tolerant, this is unlikely though.

In contrast to the Indian general standard for heavy metals applying to all foods (if not further specified in the PFA), Codex general heavy metal standards do not exist and Codex standards refer to specific food stuffs: indeed, distinct standards exist for leafy vegetables and root vegetables. Accordingly, India can choose to adopt certain Codex standards, whilst leaving others. Accordingly, ***initial adoption of Codex standards*** in India ***is likely to focus on export-oriented products*** (pers.comm, KS Wahi and A. von Hildebrand, WHO, 2003).

Fresh vegetables are particularly important for domestic markets, much less for exports. Nevertheless, increased importance of fresh vegetables for exports (as supported by the Government of India Horticulture Department) could trigger an adoption of stringent Codex standards which would be then be automatically applicable to domestic markets. Introduction of tighter export standards for products could also provide VCOs with leverage to demand application of the same to domestic consumers. Consumer demand for food safety is evident and consumer organisations are able to galvanise public opinion to this effect, as people will not accept to be treated like second-class consumers (vs. foreign consumers). Similarly,

improved food safety standards for luxury goods like mineral water –demanded by middle and upper class consumers -, will change the tone of the general food safety debate and spin-offs will dissipate to non-luxury goods, thus benefiting the poor (pers. comm., A. von Hildebrand, WHO, 2003).

Most export-oriented products are processed. But even in this respect, spin-off effects may benefit domestic consumers, as few processing industries are completely dependent on the export markets and partly produce produce for domestic markets. However, enhanced quality of processed food is clearly not going to affect the safety of food consumed by the poor, as processed foods are not generally a part of their consumption portfolio. Other spin-off effects of (partial) introduction of international food safety norms and practices may accrue if mechanisms can be devised to enhance learning by urban and peri-urban farmers about safer production practices from export oriented farms, or integrated supply chain farming systems. Currently though, no such institutionalised mechanisms seem to exist.

Expecting that India will indeed slowly move towards acceptance of Codex norms for vegetable produce, it is important to notice that *only one heavy metal standard is currently set by Codex* for contamination of vegetables, and this regards Lead. Whilst this standard is much less tolerant than existing Indian PFA standards for lead, the PFA standards cover a much wider range of 7 heavy metals: cadmium, zinc, copper, mercury, arsenic, etc. It is unclear whether selective tightening of some (Pb) and/or partial erosion of other heavy metal standards in India could co-exist in a future food safety policy, which aims to harmonise with international standards?

D.5. POTENTIAL FOR IMPROVING FOOD SAFETY AWARENESS AMONGST KEY STAKEHOLDERS

Introduction

In section D.1 of this report we outlined specific types of interventions in the vegetable marketing chain that might enhance food chain integrity and help to improve the quality assurance of fresh produce. We recognised the types of institutional arrangement that might be required and the potential impacts on various stakeholder groups. Having examined the heavy metal contamination of fresh vegetable produce in Delhi and Varanasi in some detail (sections D.2 and D.3), we were aware of specific technical measures to improve safety, and could use this as a case study for more detailed examination of the types of policies and programmes that would support the required interventions in the vegetable marketing chain.

We began by looking at the potential for existing food safety policies and programmes to address issues of this kind. In section D.4, we discussed how food safety policy in India has focussed almost entirely on the formalised industrial economy, with emphasis on processed food, and with little or no recognition of food safety concerns relating to fresh produce. There is very little interaction between the institutions and actors (across government ministries, disciplines and sectors) necessary to address current and emerging food safety hazards in an effective manner, and a complete lack of a pro-poor perspective. Enhanced awareness amongst stakeholders (including government, the private sector, NGOs and civil society) about heavy metal contamination of vegetables, its impacts, causes and means of prevention (through public policy and private sector mechanisms) will clearly be an essential prerequisite to affect positive change.

In advanced economies, increased consumer awareness of the incidence of contaminated food products and of the associated health risks, has been the principal factor that has boosted demand for safety as a food quality attribute. Information (and incentives) are also likely to play a part in QA mechanisms, especially in India, where the regulatory environment is weak.

In section D.1 (ii, iii and iv) we examined current awareness of food safety amongst poor producers, consumers and market intermediaries. It is clear that there is limited awareness about food safety, and almost no recognition of a link between environmental pollution and food safety (with the exception of some vegetable growers). We also gathered empirical evidence to support the supposition that it is the poor consumers (those who are more likely to be subject to environmental health hazards) who are less aware of the potential health hazards of food contamination.

In order to become an effective tool for change, strategies for food safety awareness must engage institutions that are currently working on associated issues. This engagement will come, in part, from linking evidence of environmental pollution impacts on food safety with other key priority issues that affect the livelihoods of stakeholders (for example child health and nutrition). This must in turn be contextualised for policy makers and planners in the light of current social, economic and political constraints.

In section D.4 we described the key policy making bodies and policy stakeholders directly associated with food safety in India. This section, looks beyond this; to

identify *complementary mechanisms* for raising awareness amongst policy makers and amongst other stakeholders that are not currently at the centre of food safety policy making - such as poor consumers, producers, tradesmen and polluters.

A pro-active judiciary plays an important role in steering government policy (in addition to legislative and executive powers) and its outcomes in India. Therefore, in this case, the extent and potential of judicial interventions - including public interest litigation- to ensure food safety presents additional opportunities, which were also examined in our research.

D.5.1. RESEARCH ACTIVITIES

Acknowledging the multisectoral nature of food safety hazards, we aimed to identify specific synergies between heavy metal food contamination issues and existing environmental, food safety, nutritional and other public health concerns.

Our research efforts focused on the identifying mechanisms that could be used to raise awareness about the impacts of urban and peri-urban environmental pollution on food safety. With limited resources, our priority focus was consumers. The rationale was that consumer awareness was the driver for wider stakeholder engagement. We have reported briefly on relevant consultations with producers and polluters.

In addition to the research into mechanisms for increased awareness at the grass roots level, it should be emphasised that strategies for increased awareness amongst policy makers, planners, local authorities, researchers etc. were a central part of the activities of our research and policy advocacy teams. This is demonstrated in part by our extensive programme of consultations, workshops, briefing papers, press coverage etc.

I. CONSUMERS

The consumer movement in India is an increasingly influential stakeholder group with good linkages with public sector policy-making bodies. Our initial research activities focused on government *consumer welfare policies,* which are of potential benefit to all food consumers, including farmers, traders and polluters. Consultations with the key consumer organisations, legal experts and government officials have highlighted current policy, institutional frameworks and successful and replicable practices to influence policy and raise consumer awareness. Secondary information supported the analysis.

Voluntary consumer organisations are influential towards policy advocacy, but most of these are consisting of and working for the middle-classes, and few are targeting poor consumers as the primary beneficiaries. We thus focused attention on other groups, such as development NGO's who are already working closely with the peri-urban poor, but do not currently focus on food safety issues (we were not able to identify any such group that currently works on food safety). We focussed our research on obtaining an understanding of NGO approaches to public health awareness raising amongst the urban poor, with a view to drawing lessons for adoption of an effective food safety agenda in the future. An initial pilot study of three

non-governmental organisations in Delhi (Mamta, Sharan and Action India) was organised. These organisations were selected on the basis of established working relationships with the local partner in charge, Toxics Link/Srishti. The pilot studies were conducted through discussions with staff managing the health programmes, field visits and exploration of background materials provided.

Having obtained this initial understanding, it emerged that the activities of Mamta would warrant an in-depth case study with clear possibilities of involvement of the urban poor. Accordingly a workshop was organised in collaboration with Mamta in a slum community in Tigri Janta Jivan resettlement camp, at the fringe of Delhi. Tigri contains around 7000 households totalling approximately 50000 people. It is an unauthorised slum, in which electricity, water supply and sanitation facilities are not provided by the government. 25 Local Muslim women attended the workshop amongst which several women representing local community based organisations that are supported by Mamta. The objectives were to:

- Understand existing activities and approaches used by Mamta for public health awareness raising
- Raise community awareness about washing of vegetables for reduction in heavy metal contamination
- Consult with the local community about priorities for raising awareness about food safety issues, and preferences with regard to methods of achieving this.

As general public health awareness raising approaches of NGO's were assessed, simultaneously government sponsored programmes relevant to the urban poor were explored for capacity to raise awareness about food safety. Whilst there is no food safety policy which targets urban poor consumers, opportunities do exist to incorporate simple food safety related messages in existing outreach programmes to the poor, such as those aimed at encouraging increased nutritional awareness and the consumption of vegetables.

Subsequent research activities focused on analysing government policies and non-governmental activities aiming to increase *nutritional awareness* and to improve *vegetable consumption* amongst poor urban communities. A review of secondary material combined with discussions with government policy makers and NGO representatives identified two key government schemes:
→ Anganwadi/Integrated Child Development Services
→ Community Food and Nutrition Education Scheme
Field visits and additional consultations with policy makers and grass roots implementing officers supported our assessment of the potential for inclusion of relevant food safety messages in such programmes.

II. Farming communities

Mechanisms to improve food safety awareness amongst farming communities in UPU areas of Delhi and Varanasi have been assessed through extensive participatory field studies and supporting surveys from our team of geographers (section D1). These provided an overview of the actual information support mechanisms in place and their perceived effectiveness, according to local farmers in and around Delhi and Varanasi.

This was complemented by a review of horticultural and agricultural policy documents, with supporting policy consultations, to understand the institutional

mechanisms designed to provide this type of support, and the alternative (top-down) perspective on the extent to which they were available to poor farmers. The basic checklist of issues from the perspective of government provision of advice and support included the following:

III. Polluters

Finally, current *air pollution and environmental* policy, institutional mechanisms and policy instruments were studied. Ultimately policies to tackle pollution at source could be among the most effective approaches to combat air borne heavy metal contamination of vegetables grown in urban and peri-urban areas.

D.5.2. RESEARCH OUTPUTS

I. INSTITUTIONAL FRAMEWORKS SUPPORTING CONSUMER AWARENESS IN INDIA

I.a. Consumer rights and legal protection in India

Consumer rights in India have quickly developed in the last 2 decades and so have the consumer movement and government consumer welfare policies.

The Consumer Protection Act grants consumers and consumer organisations the legal rights to seek redress of their grievances arising out of the violation of existing laws intended for their protection. The Act is compensatory in nature[5] and recognises that consumer grievances can relate to amongst others, the sale of unsafe goods, which are hazardous to life and safety.

The Act is adjudicated through a new highly decentralised three-tier Consumer Court system, whose jurisdiction is determined by the cost of the goods and services involved.

Despite a backlog of cases, consumer courts have proven to be a fairly quick and efficient way of dispensing consumer justice, especially for the bulk of cases fought at the local level.

I.b. Consumer policy: institutions and policy instruments

The Consumer Protection Act is centrally administered by the Department of Consumer Affairs in the Ministry of Consumer Affairs and Public Distribution.

Legislative, economic and information providing policy instruments are used to enhance consumer welfare. Policy instruments for information provision are particularly important. One of the main objectives of the Ministry of Consumer Affairs and Public Distribution is to raise awareness amongst consumer about their legal rights. However, the Ministry does not give special emphasis to any particular target groups of consumers, such as the poor, and consultations clarified that no particular activities are conducted for food safety. Similarly, local governments in Varanasi do not execute specific programmes to increase consumer awareness about food safety, benefits of vegetable consumption or other public health issues (pers. comm., Dr. A. Kumar, Medical superintendent BHU, 2003).

I.c. The role of the consumer movement in raising food safety awareness

The consumer movement has grown rapidly since the spurt of legislation at the end of the 1980s. Since then, the number of consumer organisations in India has increased from about 80 to more than 1500 in 2001 (Verma, 2002). Voluntary Consumer Organisations (VCOs) address consumer issues regarding a wide range of goods and services, including protection from exposure to unsafe food. In fact, the most prominent organisations appear to be well spread over the main regions of the country. Some of these congregate in the Consumer Coordination Council, New Delhi. Whilst in Varanasi there are no active consumer organisations, VCO's like the Consumer Education and Research Centre (Ahmedabad), VOICE (Delhi), CGSI (Mumbai), CUTS (Jaipur/Kolkata) and CAG (Chennai) all work on food safety issues. Some are even equipped with sophisticated laboratories to test the quality of food items and other consumer goods. Consumers and policy makers are made aware about their findings through a mixture of campaigns, lectures, publication of newsletters and the Internet.

In Delhi, the Voluntary Organization in Interest of Consumer Education (VOICE) has advocated consumer issues since 1983 and VOICE tests common food products like mineral water and salt in external labs. It publishes a bimonthly bulletin: Consumer Affairs and provides free legal counselling to its members. According to Mr. KC Chaudhary, product testing officer of VOICE: "consumer awareness is the only way" to improve food safety in India (pers. comm, 2003). Hence, VOICE lectures in schools and it is campaigning for inclusion of PFA, consumer rights and Codex in the national educational curriculum. VOICE's food safety officer Mr. Kamaljit Singh envisages that environmental pollution has to be part and parcel of the agenda of VCOs because consumer awareness about pollution impacts on food safety is negligible. More awareness could be created by TV advertisements, as visual messages are more powerful than just spoken or written ones. A message of vegetable washing could for instance be presented on the Doordarshan public television.

In addition to the voluntary consumer organisations several environmental non-governmental organisations also test food products for quality and safety. The Centre of Science and Environment in Delhi has set up a professional laboratory in 2000 for public causes and has amongst others tested bottled mineral water and vegetable samples for pesticide residues (pers. comm, NK Satija, head of lab, 2001). As part of a larger environmental project in schools, Tata Energy Research Institute (Delhi) tested drinking water samples for heavy metal traces (pers. comm, R. Uma, 2000). Other organisations like Toxics Link (Delhi) have sporadically obtained food samples for testing in external commercial laboratories, for instance for foreign matter in spices (pers. comm. R. Agarwal, 2000).

I.d. Policy advocacy by consumer organisations

Consumer organisations have been influential in policy advocacy through lobbying, sometimes backed up with comparative product testing and in other cases through legal litigation.

Recently, overcoming opposition from the food industry, VOICE successfully lobbied for inclusion of a 2002 amendment in the Prevention of Food Adulteration Act, which specifies that all vegetarian and non-vegetarian food items and cosmetics must be labeled accordingly with simple green or brown-red (non-veg/animal produce) logos. It is expected that other products like pharmaceuticals will follow suit (pers. comm, K Singh, 2003).

Lobbying has resulted in consumer organisations gaining footholds in the corridors of government policy making. Post-1986 legislation established not only important consumer rights; it also enhanced participation of consumer organisations in important decision-making fora regarding food safety issues. For instance, the BIS Act (1987) ensures consumer participation in the development of new food product standards and certification schemes. Several consumer organisations are hence represented in statutory government policy-making committees (see table).

Table D.5.1. Participation of VCOs in food safety policy making bodies

Consumer organisation	Decision-making body	Responsible for
VOICE (Delhi)	BIS food standards committee	Decides about voluntary 'Indian Standards' for food
Common Cause (Delhi)	BIS Committee on Consumer Policy	Discusses impacts of new initiatives at BIS on consumers
VOICE (Delhi) and CERC (Ahmedabad)	Central Committee for Food Standards	Determines PFA food standards in India, inc. heavy metals
VOICE (Delhi) and CAG (Chennai)	National Codex Committee	National policy positions are formulated for Codex
VOICE (Delhi) and CAG (Chennai)	Informal National Codex 'shadow committees'	Follow developments at Codex and prepare policy positions for National Codex Committee
CGSI, CERC, VOICE, Common Cause	National Consumer Protection Council	Promotion and protection of consumer rights as laid down in 'Section 6 ' of the Consumer Protection Act, 1986
CGSI (Mumbai)	Maharashtra State Consumer Protection Council	Promotion and protection of consumer rights
CUTS	Technical Committee on Eco-Mark, Ministry of Environment and Forests	Decides on the technical standards for Eco-Mark certified products

Consumer organisations are also well represented in 'Codex shadow committees', which act as a policy preparation forum to establish the Indian position on topics proposed for Codex Alimentarius Commission meetings. Voluntary Consumer Organisations are also involved in other ad-hoc policy committees. For example, currently VOICE advises the GoI about changes in legal penalties for breaking the PFA laws on adulteration. There are suggesting an important and highly relevant distinction between substandard produce and adulterated produce (pers comm., K. Singh, 2003).

Legal litigation also offers potential for consumer organisations to further consumer rights. Food safety cases can be fought in:

- Consumer courts (under Consumer Protection Act)
- Criminal courts (under Prevention of Food Adulteration Act)
- Supreme Court (through Public Interest Litigation)

Consumers and consumer organisations can pursue litigation simultaneously in criminal courts under the PFA and civil courts under the CPA (pers. comm, KS Wahi, 2003). Heavy metal contaminated vegetables would certainly be eligible in the consumer courts constituting 'Sale of unsafe goods, which are hazardous to life and safety' under the CPA (Pers comm. P. Venkatesan, 2000). However, according to B. Vaidyanathan, secretary Consumer Protection Council Rourkela, there have not been any major cases fought against sale of unsafe food products in the consumer

courts (pers. comm., 2003). Several factors are responsible for this: a) tardy and difficult legal process, especially under PFA b) negligible consumer awareness about such issues c) impossibility for ordinary consumers to identify a hazard (contamination with heavy metals or pesticides is neither visible nor easily verifiable).

Public Interest Litigation is another option, but few efforts have been made to use this avenue to improve food safety. Key to successful PIL application to the Supreme Court is a solid body of evidence, which for instance in the case of heavy metal contamination of vegetables is hard because very little information exists in the public domain (pers. comm, HK Awasthi, A. Bhatt, 2003). Very recently, in March 2003, a relevant PIL to the Supreme Court by the Delhi NGO Srishti regarding pesticide residues in food products has been accepted (pers. comm, C. Gonsalves and R. Agarwal, 2003).

I.e. Potential of NGO's to enhance food safety awareness amongst the urban poor

Although our initial screening highlights that neither in Delhi, nor in Varanasi do grassroots NGOs work specifically on food safety issues, the potential of the non-governmental sector to work with and for the poor is well recognised. Hence, it was decided to obtain an understanding of NGO approaches to public health awareness raising amongst the urban poor, using a case study of four non-governmental organisations in Delhi: Mamta, Sharan, Nutrition Foundation of India and Action India.

Table D.5.2. Profiles of case study NGOs

NGO	Area	Topics	Target group	Dissemination method
Action India	Nandnagari, Seemapuri, Jahangirpuri (all Delhi)	health, education, micro-credit solid waste management	Women	* Self help centres * Workshops
Sharan	Sultanpuri (Delhi)	Health, micro-credit	drug-addicts and AIDS victims	* Household visits * Health centre * Peer education
Nutrition Foundation of India	Purana Nangal, Srinivaspuri (Delhi)	Nutrition and health (research and education)	All people with nutritional problems – deficiency or excess	* Community health centres * Exhibitions, lectures demonstrations, diet counselling (at headquarters)
Mamta Health Institute for Mother and Child	Sangam Vihar, Tigri (Delhi) U.P., Haryana, Rajasthan, Karnataka, West Bengal	Health, community empowerment	Women, adolescents, children	* Door to door visits * Health centre * Peer education * Street plays, drama * Health camps * Household visits

These organisations apply different strategies -sometimes simultaneously- to communicate health information to their target groups:

- Open clinics in health centres and medical doctors visits
- Health camps
- Group meetings and workshops
- Door-to-Door information disseminating
- Targeted household visits

- Peer-group education
- Street play and drama

Many of the organisations (Mamta, Sharan, NFI) working on health issues provide medical services and in these health centres information is given by staff, but also passively by way of posters and brochures in waiting rooms. Larger, but irregular events like health camps for free eye-check ups etc. also provide opportunities to engage with local communities.

Some NGOs like Action India organise regular monthly workshops for local womens groups from lower income groups, like Jahangirpuri in North Delhi. Meetings take place in 'Sabla Sangh' self-health centres supervised by Health Coordinators with the help of community workers in the areas (pers. comm, Mamta Das, programme manager, 2002). Building on a long-standing relationship of trust with the communities, information is discussed and disseminated using simple hand made posters (photo available). Health Coordinator Ms. Sudha explained that the attraction of the programme is that local women can consult the coordinators on many health issues, are provided education in traditional ayurvedic medicine, self-diagnosis and disease prevention and can do this in a familiar context with other women living in the area. Hence Health Coordinators often function as a social worker.

One of Action India's health programmes relates to modern and traditional food consumption practices, nutritional advice and food hygiene: "Apni Rasoi". Under this programme, Action India propagates good nutritional practices. Action India staff commented that food safety messages like washing vegetables thoroughly twice or thrice could easily be incorporated in ongoing activities (pers. comm, M. Das, 2002).

MAMTA Health Institute for Mother and Child provides an interesting case of how different dissemination approaches are combined. Mamta started in 1991 with a medical clinic but now believes that health services provide just an entry point for further development and capacity building programmes (pers. comm, Prashant Pastore, Programme Manager, 2003). Accordingly in Tigri resettlement camp in South Delhi (housing a heterogeneous community of 7000 households) Mamta runs a health centre, 10 adolescent day centres, 1 community library and 5 adult education centres. Mamta increasingly creates and sustains Community Based Organisations, whose members are trained as 'community mobilisers'. These identify the poorest households and educate their peers in the slum about important public health and development messages (current focus is the "Integrated Adolescent Development Programme towards Women's Empowerment".). Project officer Ms Kalpana explained that Mamta uses several pathways of information dissemination:

- Most importantly, <u>peer groups/community mobilisers</u> who employ various methods like:
    - **i.** Door to door visits are conducted daily by approximately 15 community mobilisers (women and men). Every day discussion topics rotate from a range of topics. Twice a week community mobilisers meet and give feedback from the community with Mamta project staff. This can be followed up by targeted visits, for instance to appeal to parents to give permission for their adolescent daughters to receive peer education.
    - **ii.** Health camps deal with particular aspects of health and are free to participate in.

iii. Street plays & community dramas conducted by community mobilisers are a popular traditional means to convey health messages to large crowds.

- The Health Centre provides clinical services and patients are exposed to health messages in these centres
- Awareness meeting with Communities in the different local centres

Dr. Ravi Chandran and Mr. Pastore perceive that combining food safety messages with peer education programmes could be powerful means of disseminating such information (pers. comm, 2003). It would also fit well with their new community food and nutrition programme, in which people will be trained to start small food enterprises selling highly nutritious foods (like chickpea- jaggery sweets high in protein and iron).

Tigri Community Workshop

On the basis of our discussions, Mamta invited the project team to organise a workshop in one of the Tigri community centres:

- To present our preliminary research findings
- To receive feedback from a poor community
- To learn about successful demand lead means of engaging with the community about food safety messages, in particular heavy metal contamination in vegetables and the potential of washing to reduce this

In an informal atmosphere, 25 (Muslim) women in age group of approx. 20-65 years (including several community mobilisers) participated. Community mobilisers chose to inform women about the workshop, as they were the household members responsible for food preparation and cooking. Mutual introductions were followed by participant discussions about vegetable consumption habits, their nutritional importance, heavy metal contamination and associated health effects, prevalent vegetable washing practices and the importance of eating clean vegetables relating to the potential of reducing contamination through thorough washing.

The women related that commonly consumed vegetables are: potato; palak, mustard leaves and other green leafy vegetables such as fenugreek (methi); peas; cauliflower and cabbages, okra, etc. Important vegetables for raw consumption as a salad are: tomatoes, radish and carrot. People recognise the nutritional benefits of consumption of vegetables, like vitamins, minerals and protein (for instance in bengal gram/channa). About half of the women present cook vegetables in the morning and again in the evening. The other half only prepares food in the mornings. Palak is mostly washed, than cut and washed again in a pan or vessel. As running water is not available, washing is done in vessels/pans etc. Surprisingly, the women declared that scarcity of water is not a problem for washing twice or even more often if there would be a need, then water scarcity would not be a problem. Women told us that *"we are ready bring water from anywhere and wash the vegetables not three but four times, if it keeps the health of our children good".*

Subsequently, the participants were asked whether they would have any recommendations how more awareness should be raised in their community about the problem of vegetable contamination and the washing solution. Specific **recommendations** included:

- The participating women said they would inform their neighbours, family and friends about the importance of thorough washing their fresh vegetables.

- More workshops like this one, where community mobilisers and community members are made aware about food safety problems. It was asserted that if the moderators are outsiders, rather than regular trainers from Mamta, people will show a keener interest in attending.
- Community mobilisers should be trained, whom would forward messages through their door to door visits to households
- Spreading awareness during religious festivals, mela's and health camps. People stated that if a message is tied to a memory of a special day in the year/in their life, it will be better remembered and therewith will sustain its impact.
- Posters and other visual materials could be put up at important community gathering places
- Participants also suggested that the message of vegetable washing should not be restricted to the women but should be carried out to men also, as they are the main decision making body in households.

II. INSTITUTIONAL AND POLICY FRAMEWORKS SUPPORTING NUTRITIONAL AWARENESS AMONGST THE URBAN POOR

Nutritional diseases such as iron deficiency induced anaemia, vitamin A deficiency related blindness and energy malnutrition are well-recognised as public health problems that disproportionally affect the poor in India. Indian governments acknowledge that the nutritional status of its population needs to be improved through a range of short-term measures that address immediate nutritional needs and long-term measures that recognise the need for institutional change.

The vision of the government is that nutrition problems need to be tackled through a multi-sectoral approach. A National Plan of Action on Nutrition hence recommends the integration of nutritional concerns raised in the NNP into action through 'sectoral plans' for departments like agriculture, food supplies, education, health, environment, urban development, women and child development. The sectoral plan for health specifies as one of its objectives to protect consumers through improved food quality and safety and to promote appropriate diets. Sectoral plans for agriculture aim to promote vitamin A and iron rich foods through improved horticulture extension systems and the government now also promotes kitchen gardens in anganwadi centres and schools (H.P. Singh, 1998).

Improved nutritional awareness leading to better consumption practices is a long-term aim of the Government of India. To effect such change, the 1993 National Nutrition Policy (NNP) promotes nutrition awareness raising, dietary diversification and horticulture production and consumption at family, school and community level. The National Nutrition Policy is implemented through the '*National Nutrition Mission*' (2000), which together with the *Integrated Child Development Services* forms an essential government outreach system put in place for nutritional awareness raising amongst the poor in India.[6] Considering that nutrition awareness messages are closely related to food safety awareness issues, in this section these two

[6] The Nutrition Mission has its own organisational structure for implementation, distinguishing it from a range of national level nutritional programmes implemented through existing government institutions, like the Primary Health Care system (i.e. National Nutrition Anaemia Control Programme) and the Integrated Child Development Scheme (i.e. National Programme for Prevention of Nutritional Blindness). Whilst other nutritional intervention programmes such as the Food for Work programmes and the national (Revamped) Public Distribution System also operate through customised organisational arrangements, these don't aim at nutritional awareness raising or educational activities, hence are not included in any further detail in this report.

decentralised outreach systems are explored for potential to carry relevant food safety messages to the urban and peri-urban poor.

I.a. Integrated Child Development Services

The Integrated Child Development Services Services (ICDS) is a well-established scheme that provides a package of health and education services (pers. comm, Savita, 2003).

Table D.5.3. ICDS: a profile

Key services	Nutrition and health education, immunisation, food supplementation, health check ups, referrals and non-formal pre-school education
Target groups	Children below six years of age, pregnant women and nursing mothers residing in poor villages and urban slums
Coverage	India: >4200 development blocks: millions of expectant and nursing mothers + 25 million children < six years of age Delhi: 3842 Anganwadi centres; 23 urban slum and 5 peri-urban projects

Health care services cover children under 6 years of age and include ante and post natal care of (prospective) mothers and infants. Nutrition services include supplementary feeding; nutrition and health education (including dietary advise) for women; distribution of prophylaxis against anaemia and Vitamin 'A' deficiency; Growth monitoring and nutrition surveillance of children.

Anganwadi centres are the grassroots level institutions that deliver the services of the ICDS, each run by an Anganwadi Worker (AWW) along with a helper and catering roughly to 100 to 120 children. Posts are reserved for women who receive a small honoraria of Rs. 550,- and Rs.200,- per month.

Since its inception in the mid-seventies, ICDS has successfully contributed to a decrease in the prevalence of malnutrition among pre-school children and decreased infant mortality rates. However, field visits highlighted that the ICDS system has its drawbacks:

- Underpaid, overburdened and unmotivated workers and high absence rates (pers. comm, R. Chandran, Sushmita, 2002)
- Corruption in food supplies and irregularity provision of stale or low quality food. Beneficiaries claim that except for the bread nothing is edible.
- With lack of storage space, bulk food supplies are kept unprotected and exposed to weather and sometime stray dogs, cats and pigs.
- Monitoring systems are dysfunctional. Although demonstration officers are entitled to have an official vehicle to ensure higher mobility for monitoring, no vehicles have been available for the last 10 years in Delhi (pers.comm., U. Kadian, 2001).
- Many AWWs and Helpers are not from the village where they need to work.
- Being a top-down service delivery programs, communities are only recipients of the goods and the services and have little say on the quality of these.
- The coverage of the targeted population is approximately 40% (pers. comm, PC Sharma, 2003)

In Varanasi, the Anganwadi scheme had been a "total failure" (Dr. A. Kumar, Medical superintendent BHU, 2003).

I.b. National Nutrition Mission

The Food and Nutrition Board (FNB), a semi-autonomous body resorting under the Department of Women & Child Development (Ministry of Human Resource Development, GoI) implements the National Nutrition Mission. Research and development programmes of the Food and Nutrition Board aim to create nutritional awareness and promoting nutrition. Whilst policy decisions are made centrally, implementation is to a large extent the task of the respective State/Union Territory Governments, Departments and State Nutrition Boards (Ramji, 1994), with support of local NGO's.

Table D.5.4. National Nutrition Mission/Food and Nutrition Board: a profile

Key services	Nutrition education and development of training material; training in home-scale preservation of fruits and vegetables; awareness campaigns; development and promotion of nutritious foods; fortification of foods; monitoring of supplementary feeding at anganwadis and food analysis and standardisation
Target groups	Poor women and adolescent girls in rural, urban and tribal areas
Coverage	All India

One of the most important activities of the Nutrition Mission is to provide education regarding basic aspects of food, nutrition and health. Primary target groups are poor women and adolescent girls, but the FNB also extends its training to ICDS officers, anganwadi workers, lady health visitors, auxiliary nursing midwifes and NGOs (Pers. comm., Mr. Kripal Singh, Deputy Technical Advisor FNB, 2001). Nutritional awareness campaigns are supported through publication of printed material, radio programmes, participation in health mela's etc.

III. LINKAGES BETWEEN ICDS AND NUTRITION MISSION

The central Department of Women and Child Development administers both the Nutrition Mission and the Integrated Child Development Scheme through two distinct, though partly overlapping administrative structures.

The FNB operates through a central technical wing, four regional offices at Delhi, Mumbai, Calcutta and Chennai and field units called Community Food and Nutrition Extension Units (CFNEUs) located in 27 States and UTs. In Delhi, there are five of these units. Whilst CFNEUs operate at the regional level, ICDS is a more extensively decentralised system, operating in most of the country's districts at the village and urban slum level. Both systems are however supervised by state and ultimately central government steering.

Anganwadi workers link up with lowest tier officials of the Primary Health Care system (the public health system in India), such as Lady Health Visitors and Auxiliary Nursing Midwifes. Anganwadi workers report to a 'Supervisor', who directly coordinates activities with 'Technical Assistants' in the CFNEU system. CFNEU officials also assess the quality and regularity of supplementary feeding at Anganwadis, with regard to type of food, storage, amount and acceptability of food preparations given to beneficiaries, safe drinking water and general hygienic conditions.

III. POTENTIAL TO INCORPORATE FOOD SAFETY MESSAGES IN NUTRITION PROGRAMMES

Although nutrition policy currently predominantly associates food safety with food hygiene, policy makers and consumers acknowledge the growing importance of food safety issues. Accordingly, food safety messages aiming to reduce heavy metal contamination of vegetables can be highly complementary to national and local government policies that address food, nutrition and public health issues, in particular where vegetable consumption is already promoted. Whilst the references to improving food safety concerns in the National Nutrition Policy emphasise strengthening of the Prevention of Food Adulteration machinery (GoI, 1993), there appears to be scope to expand this narrow approach. Policy makers in the Government of Delhi for instance state that food safety is already part of the mandates of FNB, ICDS and the CFNEUs and these systems can as such convey food safety awareness messages (pers. comm, PC Sharma; Savita, 2003).

Despite its shortcomings, the ICDS has certain areas of strength that make it a potentially powerful mechanism to convey food safety messages to the poor:

- The highly decentralised program operates in rural, peri-urban and poor urban areas and is conducted by local workers (Anganwadi workers & helpers);
- The programme is focused on the poor; two-thirds of the covered population comprises of Scheduled Castes, Scheduled Tribes and other backward communities;
- A very broad coverage all over India
- The program enlists the help and participation of local voluntary organisations;
- The programme integrates a range of development needs (nutrition, health, education) and has close linkages with other government agencies such as the Primary Health Care system and the nutritional policy implementing agencies.
- Conceptually any simple food safety message relating to aspects of health, food hygiene or nutrition can be incorporated into the nutrition education component of the programme.

The CFNEU system also poses good opportunities for inclusion of food safety awareness raising amongst grassroots beneficiaries like women and adolescent girls. Key policy advocacy could aim at the Food and Nutrition Board, which advises the GoI and its state level bodies identify new topics for inclusion in the ICDS programme. Besides, the FNB also renders technical expertise for food standardisation through various bodies dealing with food safety, like the National Codex Committee and the Bureau of Indian Standards.
This system also has strong linkages with ICDS through its training mandate. FNB is a major institution providing training and refresher courses for lowest and middle tier government officers such as anganwadi workers, but also trains middle level policy makers and NGOs. Senior ICDS managers (CDPO and ACDPO level) are trained by the National Institute of Public Cooperation and Child Development (Delhi) and this institute would decide about inclusion of any nutritional messages or food safety messages in training material.

Inclusion of simple food safety messages in the training curricula of CFNEUs and NIPPCD could have an important impact on general awareness about food safety and through the ICDS system it would be able to convey this information to the key household decision makers about food: women. Other linkages for extending food

safety information could be: auxiliary nursing midwifes from the Primary Health Care system who operate in urban based decentralised Mother and Child Health Centres that cater to poor populations of something like 5000 people each (pers. comm, PC Sharma, Savita, 2003).

In conclusion, both ICDS and national nutrition mission have well-established implementation mechanisms which could facilitate wide-scale dissemination of appropriate food safety messages to the poor, such as the thorough washing of vegetables prior to consumption.

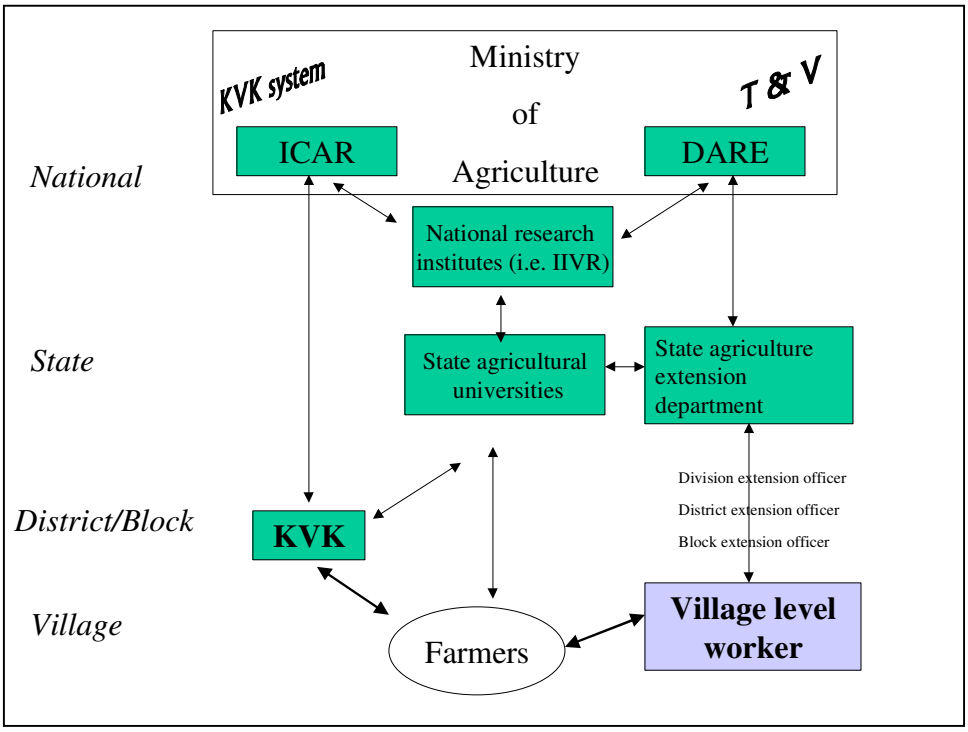
IV. REACHING OUT TO FARMERS: HORTICULTURE POLICY AND FOOD SAFETY

IV.a. Research and extension systems for vegetable farmers

The central Ministry of Agriculture is responsible for two extension systems, that remain quite distinct:

- Training and Visit extension system
- Krishi Vigyan Kendra research and extension system

Figure D.5.1. Public sector extension and research systems for horticulture



Firstly, the Department of Agricultural Research & Extension administers the national extension system, that is implemented at state and sub-state levels applying the "Training & Visit" approach. Under the T&V structure extension officers are posted at state, divisional, district whereas at the sub-district level extension village level workers (Kisan Sahayaks) provide services. Horticulture development is a recognised topic in the T&V curriculum.

Since the 1990s an increasing number of states have abandoned the T&V system, but it still operates in Delhi as per the above simplified diagram. Accordingly, the 50 staff of the Delhi Department of Agriculture promote farmer awareness through seminars, workshops and demonstrations aimed at selected 'contact farmers' who are expected to share their knowledge within other farmer groups. Block development offices distributing fertiliser and seeds also provide contact points with farmers, and another possible channel for food safety messages.

As part of the reforms in Uttar Pradesh, T&V village level workers are now operating as 'village panchayat development officers' but they are also increasingly substituted by men and women para-extension workers (kisan mitras) from two major World Bank funded programmes (Sodic Land Reclamation Project and Diversified Agricultural Support Project). Nevertheless, farmers in Varanasi are, in theory, also educated about best practices concerning vegetable cultivation through training,

meetings and discussions with the district horticulture department (pers. comm, G. Singh 2003).

The Indian Council for Agricultural Research, which consists of a wide range of specialist research institutes[7], runs the second national research and extension system: Krishi Vigyan Kendras (KVK/'Farmer Knowledge Centres'). KVK scientists conduct research on their farms and provide demonstrations and training to local farmers and government officials. Research and extension by KVKs in the vicinity of Delhi takes place in Ujwa (Najafgarh), Faridabad, Sonipat and Shikohpur in Haryana and Ghaziabad in UP. Under the World Bank supported National Agricultural Research Project, 'nutrition gardens and cultivation of vegetables' has been identified as one of the thrust areas for KVKs in Delhi and adjoining districts.

KVKs are centrally steered and -contrary to the T&V extension system- have relatively little involvement with state extension administrations (although State departments of Agriculture run a few KVKs). In Delhi for instance, state agricultural department officers informed that there used to be little coordination with the only KVK station in Delhi, which more so has recently been closed due to financial irregularities (pers. comm. M. Singh, 2003).

KVKs are also supported by research carried out at State Agricultural Universities (SAU) which conduct research into feasibility and performance of new varieties under local conditions. In Delhi, for instance the Indian Agricultural Research Institute is an important source of scientific information, but also provides an extension role in peri-urban areas through farm trials, demonstrations, farmers fairs and training programmes. The role of Non Government Organisations (NGOs) in agricultural research and extension activities in Delhi has been limited (Chatterjee, 1999).

Sulaiman and Holt (2002) indicate several limitations in the Indian extension system, which can be applied to its capacity to provide information to farmers regarding food safety issues:

- A traditional focus on productivity and technology transfer, not on providing a support system for sustaining livelihoods (of the poor)[8]
- Poorly trained extension workers
- Low quality of extension information (despite willingness of horticulture farmers to pay for it)
- Low coverage of extension services (confirmed by our PRA studies: see next section)

However, the Delhi Department of Agriculture already foresees the system dealing with food safety issues (M. Lal, pers. comm).

IV.b. Farmers' perceptions on horticulture support systems

The horticulture producers, both women and men mentioned that there was little or no official support system in vegetable production and marketing.

In all study villages, the farmers mentioned that they use family knowledge and past experience for deciding on agricultural inputs. For new varieties they sometimes

[7] For instance, the Indian Institute of Vegetable Research, Varanasi, co-ordinates breeding and testing of new varieties of vegetables in India. Other prominent organisations involved with horticultural R&D include the Indian Institute of Horticultural Research (Bangalore); Central Institute of Sub-Tropical Horticulture (Lucknow) and the Central Institute of Temperate Horticulture (Srinagar).

[8] However, poverty reduction has never been stated as a goal of extension in India and no specific programmes exist (Sulaiman and Holt, 2002)

consult the local Krishi Vigyan Kendra (KVK), but the local shopkeepers are often felt to better informed. Shopkeepers provide advice concerning seed variety, fertilizers and pesticides to be used for different crops. Vegetable growers in the socially advantaged Pandit hamlet of village Chandawali also manage to meet state agricultural extension officers. Information channels are strong especially for the rich farmers who are mobile, havd their own vehicle and are also well connected through telephone and TV. The poorer farmers listen to radios and local discussions. There are no NGOs working in the surveyed villages around Faridabad, and there was no information disseminated on the nutritional content of different vegetables.

Villagers around Varanasi reported that information disseminated by government departments is either non-existent or a minor source of support to horticulture producers. According to the women and men groups, the producers depend on:

- Shopkeepers for 80 per cent of all their information needs related to seeds, fertilisers and pesticides. This information is trusted.
- Other villagers and relatives: 5%
- Block development extension officers fulfil only 5% of their information needs
- Radio and TV, but these are considered to be less trustworthy
- An active village head/ gram pradhan can function as an important information provider for the farmers because often his involvement in workshops, courses and official meetings.
- For marketing purposes farmers receive information from traders in the main wholesale markets.

In the short term, it is these types of mechanisms that would need to be utilised for conveying food safety messages, whilst longer term goals would be to address current shortfalls in local delivery/accessibility of government schemes.

In contrast, in Delhi, a survey of 250 interviews were conducted over a ten-day period in May 2002 in 19 villages in the Alipur (north of Old Delhi) and Najafgarh (south-west) areas of the city highlighted that traditional family knowledge, or prior knowledge was the principal source of information about production practices esteemed by farmers, ahead of technical information from the public extension services. Input suppliers (fertiliser and seed firms) were less important, alongside information from friends and neighbours. Published sources of information such as television, radio and paper media were not rated as important sources of information. Azadpur market traders and officials (wholesalers, commission agents, mashakhores and retailers) were reported as providing insufficient or no information to farmers.

These Delhi results would suggest, that in the short term, the best means of conveying food safety messages to producers may be through the health and nutrition NGO programmes (but there is limited peri-urban coverage) and the CFNEUs. In the medium term, opportunites for working with wholesale market authorities and other market intermediaries could be further explored (as discussed in D1)

V. ADDITIONAL BODIES WHO NEED TO BE AWARE OF THE THREAT TO FOOD SAFETY FROM ENVIRONMENTAL POLLUTION

In this section a brief overview is presented of some key stakeholders from government, industry and not for profit sectors that are already concerned with environmental policy and were involved in/consulted with during the project.

Awareness of the food safety threat from environmental pollution will, in many cases, support ongoing activities aimed at reducing air pollution at source.

V.a. Government bodies

In India, there is a strict division of tasks between federal government and states. Policy areas on the 'State List' of the Constitution of India, including agriculture and industry are the exclusive responsibility of the states. Environmental policy is part of the 'Concurrent List'; it is a joint administrative responsibility of both states and central government (Kuik et al, 1997).

Table D.5.5. Administrative bodies relating to heavy metal pollution and agricultural policies in India

Administrative layer/body	Specific bodies of interest in Ministry/Department	Responsibility affecting pollution and/or agriculture
Central Government		
Ministry of Environment and Forests	Central Pollution Control Board Central Ground Water Board Central Surface Water Board	Sets environmental policy for air, soil and water pollution. Planning of industrial sites. Water quality testing
Ministry of Agriculture	Plant Protection and Quarantine Committee Central Insecticide Board	Agricultural policy, registration of agro-chemicals
Ministry of Urban Affairs & Employment	National Capital Region Planning Board Town & Country Planning Organisation Delhi Development Authority	Urban and regional development policy and land use. Lease of land on Yamuna Floodplain
Ministry of Industry		Industrial development policy
Ministry of Energy		Thermal power plant emissions, fly-ash disposal
State government		
Environment Department	State Pollution Control Boards, e.g. Delhi Pollution Control Committee and UP Pollution Control Board	Environmental policy implementation and enforcement
	Delhi Water Board	Runs effluent treatment plants
Development Department (Delhi)		Agricultural policy Planning for Development of Rural Delhi ('Mini Master Plan')
Agriculture Department (UP, Haryana)		Agricultural policy
Industries Department (UP, Delhi)	Industrial Development Boards	Promoting and developing industrial estates
Urban Development Department	e.g. Haryana Urban Development Authority	Land use planning and (peri-) urban development.
Local government		
Municipalities	e.g. New Delhi Municipal Corporation, Municipal Corporation Delhi, Varanasi Municipal Corporation	May develop peri-urban areas. Run sewage effluent treatment plants.

Consultations with such stakeholders indicate that heavy metal contamination is or has been part of their agenda. For example, awareness already exists at the Central Pollution Control Board which started a project in 2002 looking at the geo-accumulation (soil analysis) and bio-accumulation (vegetable analysis) of trace elements in vegetables and fruits after being irrigated with wastewater. Also, Air borne Pb contamination caused by vehicular pollution was recognised as an important problem in 1995. Since then, Pb in the air has been successfully reduced thanks to the introduction of initially low leaded and later lead-free petrol. In the last

three years, levels have been cut by 85% (pers. comm, S. Makhijani, 2003) and are now thought to be 'well below the national ambient air quality standards' (MOEF, 2002). The issue was however, clearly of concern to the ministry of agriculture, who provide strong support for the involvement of the Indian Agricultural Research Institute as partners in the current project. Our finding suggested that residual Pb (from before the introduction of unleaded petrol - resuspended dust) may be still be a significant direct or indirect threat to human health, and that Pb from industrial sources does still pose a threat. The Ministry of Environment and Forest, were responsive to the findings, and are proactive in follow up (see contribution of outputs section)

In Varanasi, the regional branch of the Uttar Pradesh Pollution Control Board informed that they do not monitor heavy metal levels in water, soil or plants as there is no concern about the levels (pers. comm, Dr. Franklin and RK Singh, 2003). In this case it seems that consumer awareness will certainly be the key driving force for action to address food safety from environmental pollution.

V.b. Non governmental organisations

Activist groups and NGOs in India have the capacity and experience to carry out research and sustain campaigns for pollution control. They have been shown to influence environmental policy very effectively in India. Although many NGOs are active in India, this is far more pronounced in Delhi when compared to Varanasi, where very few NGOs are involved with environmental pollution or agricultural issues (pers. comm., Dr. Sandd, Sankat Mochan Foundation, 2000).

Successful approaches that have been used by NGOs to influence environmental policy and practices include environmental education in schools (for example the Tata Energy Research Institute CAMPS project and the Development Alternatives CLEAN project), environmental monitoring, media campaigns, awards and legal litigation.

Media campaigns are a recognised and effective instrument to galvanise public opinion pressurising government to deal with pollution issues. The Delhi based Centre for Science and Environment (CSE) is one of the key informers of public opinion on environment and development issues in India. It has been one of the most active organisations in informing the public at large about the dangers of air pollution to public health and the right to clean air. Since November 1996 CSE sustains the 'Slow Murder' campaign against vehicular air pollution in Delhi. Inspired by CSE's groundbreaking work, the Supreme Court of India has passed several judgements forcing the government for instance to introduce lead free and low sulphur fuel, which effectively have slowed down the increasing pollution levels.

Over the years, CSE has become member of several influential policy committees, such as the Environmental Protection and Control Agency to the Supreme Court and the Environmental Committee of the Delhi Development Authority that reviews the currently drafted Masterplan 2021 planning urban development in Delhi NCT.

V.c. Industry

A range of organisations represent industries with a key role of lobbying environmental policy makers. They are for instance represented in government committees that set environmental standards such as the CPCB Peer Group Committee.

Some of the powerful industrial associations operating at the national level are:

- Confederation of Indian Industries
- FICCI, Federation of Industrial Chambers of Commerce in India
- PhD Chamber of Commerce
- ASSOCHAM, Association of Chambers of Commerce

Other organisations are organised on the basis of branch, e.g. Indian Foundry Association, and/or location and/or size of industries, such as the Federation of Delhi Small Industries Associations (FEDSIA) and the Faridabad Small Scale Industries Association.

These organisations also communicate changing government policy to its members through training sessions, workshops, briefings etc. This function presents opportunities to inform industries about impacts on the use of heavy metals and excess HM discharges in industrial effluents on food safety. However, it has to be acknowledged that many polluting small-scale industrial units are not organised in membership organisations and therefore may require alternative mechanisms to reach (membership may be as low as 14% in Faridabad)

In an interesting development over recent years CSE has started a special 'Five Leaves' award in which leading industries in selected industrial sectors enter a competition that assesses the environmental friendliness of its products and production processes. The award is handed out annually, offers publicity to large industries and highlights clean environmental practices. These types of schemes may offer another excellent opportunity to both raise awareness of, and begin to address the impact of environmental pollution on food safety.

SUMMARY: HIGHLIGHTS OF PROJECT ACTIVITIES AND OUTPUTS

1. SUMMARY OF KEY ACTIVITIES

The various interacting programmes for this project (that included environmental science, agricultural economics, marketing & consumer surveys, transect studies, participatory research in villages etc.) were designed so that the sum of the activities would produce a comprehensive understanding, not only of the nature and extent of contamination of food crops, and the impact that it may have on livelihoods, but equally the potential role that the various actors in the food chain might have in improving food safety. An important aspect of this work was understanding the existing interactions that existed between the various actors in the food chain and the nature of the relationships that are already present. These relationships are a crucial part of the process for conveying information about food safety and encouraging innovations for improved food safety.

We assessed the actual and potential interactions of specific stakeholder groups in the food chain with policies and programmes (from micro-meso-macro level), that could potentially support the production, marketing and consumption of safer food. We carried out an in-depth analysis of existing food safety policy and programmes - consulting on how appropriate and feasible it would be to extend the remit to include environmental pollution. We also began to examine how effectively the systems operated and what the drivers had been for policy change. We considered, through a process of consultation, what new types of linkages might be required to address food safety in a wider and more comprehensive way, and to make the process more pro-poor. Through this process we feel that we are now in a position to recognise, understand and engage with policies, programmes and networks that could potentially have a role to play in a new more inclusive and integrated approach to addressing food safety issues in India.

2. SUMMARY OF KEY OUTPUTS

I. IMPACTS OF AIR POLLUTION ON VEGETABLE SAFETY AND QUALITY

- Consumers are purchasing vegetables with high levels of heavy metals (HMs) which exceed permissible limits. High levels of Lead (Pb) in spinach marketed in Delhi was a particular concern, and of Cd in Varanasi.
- Legally permissible limits of heavy metals in vegetables, as defined by the Indian Prevention of Food Adulteration Act, 1954 are regularly exceeded. These Indian norms are less strict than international food safety norms like Codex Alimentarius or European Union standards. However, there is no regular testing of heavy metals in vegetables by the designated authorities in India
- Controlled filtration experiments showed that ambient air pollution levels in important agricultural areas around Varanasi can reduce the nutritional quality of vegetable crops important to the poor including spinach and carrot.
- Washing of field samples results in a significant reduction of heavy metal contamination, suggesting that air borne contamination is a major component

of the overall heavy metal load in vegetables. This also provides excellent potential for promoting and facilitating washing to significantly reduce heavy metal consumption.

- Clearly the potential to reduce HM contamination by thorough washing depends on the access that people have to clean water sources, and competing needs for this scarce commodity; this may be a barrier for some of the poorest communities. The capacity to reduce food contamination will be an added advantage of improved water supply and sanitation, which is already recognised as an important poverty alleviation tool.

II. RESEARCH INTO THE ROLE OF HORTICULTURE IN PERI-URBAN LIVELIHOODS

- Vegetable cultivation provides regular income, employment, nutritious food, fodder and in some cases fuel to large numbers of marginal and small-scale cultivators and agricultural labourers in peri-urban areas. Low caste people are the predominant groups engaged in vegetable cultivation and retailing.
- A large proportion of vegetable produce arriving in urban markets come from nearby peri-urban production areas and therefore are cheap and accessible to poor consumers during main production seasons. For example, 72% of palak originates from within Delhi National Capital Territory. Similarly, in Varanasi a majority of produce comes from within 10 km distance of the markets.
    - Nutritional awareness is generally low amongst all members of the households surveyed, particularly the poor. Despite this, authorities are concerned about micronutrient deficiencies (particularly Vitamin A and Iron) and recognize increased vegetable consumption as an important mitigation strategy. In addition, women poor communities in Delhi and Varanasi are aware about the beneficial attributes of palak (spinach beet) consumption during pregnancy and increase their intake.
    - In this context it is very important to stress the potential to reduce contamination by thorough washing, such that fear of contamination will not negatively affect consumption levels of vegetables amongst the poor

III. AWARENESS ABOUT FOOD SAFETY

- Extensive consumer surveys have been completed in both cities highlighting consumer dietary behaviour & perceptions of food safety. The participatory research indicates that the poor recognise food safety mainly in relation to food hygiene and to pesticide & fertiliser use and sewage irrigation. Air pollution is sometimes perceived as a problem if crops are visibly affected thereby impacting on sale prices.
- Poor consumers who are more likely to be subject to environmental health hazards, are not only less able to pay a price premium, but are also less aware of the potential health hazards of food contamination.
- Poor producers relate to food safety for home consumption purposes but are less concerned about produce they market.
- Issues of concern regard: spoiled food, pesticides, crop growth boosting chemicals, post harvest application of pesticides on vegetables and sewage irrigation, but don't relate specifically to heavy metal contamination

IV. DEMAND FOR FOOD SAFETY

- Low income producer groups have a strong interest in food safety when made aware of hazards, but currently have limited means of expressing these to influence policy.
- Poorer consumers who are unaware of food safety hazards are unlikely to demand vegetables that are quality-assured in respect of food safety, such as freedom from contaminants (be they heavy metals from air pollution, or from agrochemical or microbial sources).
- Demand for food safety increases amongst the higher income groups.

V. INTERVENTIONS TO IMPROVE FOOD SAFETY AWARENESS & QUALITY ASSURANCE

The study is a pointer to the inefficacy of current approaches towards ensuring safety of food to the consumer. Clearly food contamination can take place at various stages of the food chain, and food safety needs to be ensured throughout for it to be safe for consumption. Various interventions must be made from cleaner production sites, to transport and marketing (both wholesale and retail) and consumer practices. Current policy relates to food standards, environmental standards, industrial siting, peri-urban agriculture and consumer rights separately and is inadequate to tackle the issue comprehensively.

- Simplification of food safety policy and legislation under a single body is advocated by the food industry and reviewed by the Government of India. At this level demands for a more unified approach to food safety, from farm to fork can be made, taking into account pollution effects on food safety and the implications on the livelihoods of the poor. We have established a basis to support this type of approach.
- Few economic policy instruments are used to promote food safety. The existing ones are predominantly aimed at the food-processing sector and will have little direct impact on poor Indian consumers.
- Increasingly, private sector mechanisms for food safety such as certification and labeling are being introduced and their importance is growing, not least because of new demands due to national and international trade liberalisation.
- Potential for application of HACCP is not limited to branded luxury products, they have been successfully applied to increase safety of popular street foods and could also be applied to fresh vegetables and other important foods eaten by the urban poor.
- National, regional as well as local government agencies also make limited efforts to promote awareness of food quality and safety amongst the general public. This is achieved by demonstrations, radio broadcasts, promoting product labelling and advertisements. Linkages with these authorities should be increasingly exploited to heighten awareness about heavy metal contamination of vegetables and successful ways of reducing risks.
- Considering the difficulties of enforcing food standards for an informal economy of vegetable retailing, opportunities to increase awareness about food safety must be encouraged and a preventive approach taken
- Awareness amongst key stakeholders from government, private and non-government sectors about pollution effects on heavy metal contamination of vegetables will be essential to effect positive change. Two distinct mechanisms to effect this are identified: a) formal food safety policy decision-making bodies involving multiple stakeholders and b) complementary

mechanisms that can involve policy makers and people that are currently not at the centre of food safety policy making, like poor consumers, producers, tradesmen and polluters.

- Several organisations have been identified and informed that are already involved in advocacy regarding food safety policy and are members of food standard setting bodies. Bodies responsible for legislation that affect important food-stuffs consumed by the poor are more accessible than those dealing with processed foods.
- Consumer organisations in India were consulted throughout the research. They are well-organised and some already work on food safety issues such as the Consumer Education and Research Centre (Ahmedabad), Voluntary Organisation in Interest of Consumer Education (Delhi), Consumer Guidance Society of India (Mumbai), Consumer Unity & Trust Society (Jaipur/Kolkata) and Consumer Action Group (Chennai).
- Some consumer organisations are already engaged in food quality testing. They have a need for thorough scientific data on food safety threats, and in the absence of external sources, must generate their own data.Consumers and policy makers are made aware about their findings through a mixture of campaigns, lectures, publication of newsletters and websites. Some have successfully campaigned for educational reforms to include consumer issues.
- Whilst no existing food safety policy explicitly targets urban poor consumers, retailers, traders and producers, opportunities exist to incorporate simple food safety related messages in outreach programmes to the poor.
- Government programmes that closely relate to poor groups and already have a food centred approach concern *nutritional awareness* and promotion of *vegetable consumption.* Key potential exists in the Anganwadi/Integrated Child Development Services and the Community Food and Nutrition Education Scheme.
- The Ministry of Consumer Affairs and Public Distribution considers food safety to be part of their educational mandate and awareness raising programmes and provides small grants to consumer organisations.
- Our field studies of complementary programmes run by non-government organisations and a participatory workshop with a group of women in a slum colony in Delhi highlights innovative ways to successfully reach out to poor consumers and raise awareness about food safety at the community level.
- Mechanisms to improve food safety awareness amongst farming communities in UPU areas of Delhi and Varanasi have been assessed through participatory field studies.
- Current *air pollution and environmental* policy, institutional mechanisms and policy instruments were also studied. Ultimately, policies to tackle pollution at source can be among the most effective approaches to combat air borne heavy metal contamination of vegetables grown in urban and peri-urban areas, and we have identified entry points to do this and drivers for policy change.

VI. SPECIFIC MARKET MEDIATED APPROACHES FOR IMPROVED QUALITY ASSURANCE

- The current mass assembly and distribution system through the wholesale markets is not able to convey signals about food quality other than freshness, nor mechanisms of quality assurance other than visual inspection of produce. Recommendations were made for the future role of regulated markets with suggestions for potential to adopt market systems elsewhere in the country

where farmers have the opportunity to avoid the control of middlemen, and examples of how 'plural' market systems are likely to evolve, giving greater choice of outlet to producers.

- Suggestions were made for entry points for enhancing quality-awareness and production and post-harvest practices among producers e.g Wholesale market authorities such as Azadpur Produce Marketing Committee
- In the long term, the market system is likely to evolve towards more direct sourcing and more sophisticated distribution systems with reduced linkages that may be more efficient and Food safety administration exhibit lower producer-consumer margins. Thus, 'best practice' can be expected to trickle down to the mass market, and NGOs, small business support organisations and legislative instruments that address issues of social responsibility. The innovative practices that emerge will be a likely source of competitive pressure for improvements to the traditional systems.
- The evolution of markets is also likely to lead to a proliferation of premium quality systems such as Safal and the well-coordinated INA model.
- The government authorities at Central and State (Delhi city) level have the means to expedite the evolution of better-coordinated markets. There is a need for better provision of retail market physical infrastructure such as roofs, permanent stalls, facilities and clean access to provide shade, shelter and hygiene in each colony. The retail markets should be physically removed from the roadsides that are likely to be a major source of contamination, not only concerning heavy metals, but also other health hazards (eg microbial contaminants).
- Public sector resources can be made available. Local Area Development funds can be made available and market fees managed through a range of public sector authorities
- Provision of facilities and implementation of economic fees structures payable by traders is likely to expedite the concentration and professionalisation of the food retailing function among dedicated firms. This is likely to lead to more efficient and better-coordinated markets. The 'casualisation' of food retailing is likely to reduce, not without consequences for the smallest retailers, but thereby, food safety standards are likely to rise.
- Produce should not be uncovered in transit to and from markets. Use of tarpaulins is advisable for cycle- and auto-rickshaws that are the principal form of intra-urban transportation, and tend to leave produce exposed to environmental contamination and other quality degradation.

E. CONTRIBUTION OF OUTPUTS

E.1. HOW THE OUTPUTS CONTRIBUTE TO DFID'S DEVELOPMENT GOAL

This project has contributed towards DFIDs development goal of improving the livelihoods of poor people through sustainably enhanced production and productivity of renewable natural resources systems.

In particular the project has:

- Contributed to recommendations for developing and improving public policies on food safety and quality assurance, thereby enhancing integrity in the food chain. It has also contributed to recommendations aimed at improving institutional support available to vulnerable smallholders, traders and consumers to enhance production, marketing, processing and safe handling methods for fruit and vegetables.
- Determined both constraints to, and opportunities for, vulnerable smallholders and traders to participate in safe food systems.
- Increased understanding and awareness of the impacts of environmental pollution on the livelihoods of the poor in urban and peri-urban India.

There are also a number of important 'process' outputs of the project, which will will have equal, or even greater significance in the longer term for a number of DFIDs development goals. We feel these aspects of the work are particularly significant, because the project was completed before the introduction of a new coalition approach for CPHP research projects. The strategic and operation planning for the coalition was particularly challenging, as we were attempting to address a hitherto unrecognised threat to food safety (although affected communities has some concerns relating to it). This adds an additional dimension to the challenge of building partnerships, alliances & networks to tackle a known issue. We believe that lesson learning from this research project would in turn add an important new dimension to the emerging literature on innovations systems approaches to agricultural development.

The partnerships developed during the course of this research have achieved various types of positive outcomes. One such outcome was a team with the capacity to carry out environmental research, not as part of a linear process feeding into traditional dissemination products, but as part of a larger more holistic system, working in the context of local livelihoods and a wider development agenda. The team has the required credibility in scientific terms, but is also engages effectively with local communities and other key stakeholders, and is an active player in policy advocacy. We would be the first to recognise that this 'coalition' is not perfect. There is for example scope for greater intellectual integration. However, team members have made a significant journey – they are now interacting effectively with stakeholder groups that were previously beyond their bounds, and are making this a priority in their work.

Gradually, a larger pool of people are being introduced to new and exciting ways of working in partnerships, to gain a shared vision of development concerns and to begin to address them.

More specifically the development of this project team, and its much wider network of associates, has provided the basis for identifying how linkages might be created

between poor communities and others who can take part in the process of understanding and addressing food safety concerns - and particularly the role of the scientific community within this process.

E.2. PROMOTION PATHWAYS

This research project played a major role in raising awareness of previously unrecognised threats to food safety in India, and in highlighting some of the shortfalls in current policy. We pursued parallel research and awareness raising strategy throughout the period of the research. This strategy included workshops (reported in detail both in section D and in our interim reports to DFID) held both in the field with poor producers/consumers, and with policy stakeholders in Delhi and Varanasi; press conferences; radio and tv interviews; policy briefing papers; and academic papers and presentations.

An important part of our strategy was personal visits and presentations to key personnel. We included in this - local authorities, the DFID Delhi office (meeting with and sending updates to environment advisors and livelihoods advisors on a regular basis), and other development agencies based in Delhi (such as the World Bank environment team). A list (not exhaustive) of policy stakeholders who were personally consulted during the project is included at the end of this section of the report Appendix A.

We had hoped for significant ongoing interaction with other relevant DFID funded initiatives, in India, and more widely. Our attempts to achieve this in India were not very successful, (partly it seemed due to lack of appropriate information management systems to link DFID India project data with DFID central research project data; and possibly lack of resources available to help faciliate these types of linkages). The workshop organized by the CPHP in Harare to discuss food safety projects was particularly useful.

I. DISSEMINATION

We also disseminated emerging findings via targeted email list to international organizations and individuals of relevance.

The project dissemination list is as follows:

I.a. Publications

- Marshall FM & te Lintelo DJH (2001) A methodology for assessing the social and economic implications of pollution effects on urban and peri-urban agriculture: a case study from India. *Urban agriculture magazine no 5,* issue: Methodologies for UA research, policy development, planning and implementation. Resource Centre on Urban Agriculture and Forestry, Leusden, the Netherlands.
- Poole, N.D., te Lintelo, D. and Marshall, F. (2000). Quality assurance mechanisms for air pollution impacts on vegetable systems in India, *Health for the Millions*, July-August.
- Poole, N.D., Marshall, F. and Lintelo te, D. (2000). Quality and safety of vegetables in India. Gate. Lemmens Verlag- & Mediengesellschaft mbH. Bonn**.**

- te Lintelo, DJH, Marshall, FM and Bhupal, DS (2001) Urban food: the role of urban and peri-urban agriculture in India: a case study of Delhi. *Food, Nutrition and Agriculture*, Bulletin of the Food and Agricultural Organisation of the United Nations.
- Poole, N.D., Bhupal, D.S., Marshall, F. and te Lintelo, D. (2002). *Quality assurance initiatives for peri-urban food production in India*. In J.H. Trienekens and S.W.F. Omta, (Eds.), *Proceedings of the Fifth International Conference on Chain and Network Management in Agribusiness and the Food Industry, 'Paradoxes in Food Chains and Networks'*, (pp. 298-314). Conference held at Noordwijk, The Netherlands, 6-8 June. Wageningen Academic Publishers.
- Poole, N.D., Marshall, F. and Bhupal, D.S. (2002). Air pollution effects and initiatives to improve food quality assurance in India. *Quarterly Journal of International Agriculture,* 41(4): 363-385
- Poole, N.D., Spedding, L. and Marshall, F. (forthcoming). Risk management and food safety: global issues for business. *Due Diligence and Risk Management,* 2(4).
- Poole, N.D., Marshall, F., te Lintelo, D., Bhupal, D.S. and Sen, C. (2003). Food hazards and consumer awareness: air pollution effects in India. *Acta Horticulturae,* 604(1): 247-254.
- Poole, N.D. and Marshall, F.M. (2001). *Air pollution: carrots, sticks and private initiatives to improve food quality assurance in India.* Website: http://www.wye.ac.uk/AgEcon/ADU/eaaeannc/poole.pdf, Wye, Kent, UK, Imperial College at Wye.
- Marshall, F. (2003) Peri-Urban Environmental Health in India: Integrated Technical and Institutional Approaches for Addressing Pollution as a Threat To Peri-Urban Agriculture and the Livelihoods of the Poor. Internet conference on ecocity development. Feb-June 2003 website: http://www.ias.unu.edu/proceedings/icibs/ecocity03/papers/marshall/index.html#abst

I.b. Internal Reports:

- Te Lintelo, D (2001) Proceedings of a project partners workshop for (CPHP R7530) held on November 6-7th 2001 in Varanasi, India. 12 pages
- Mukherjee N. (2001) Food safety and quality in Faridabad. Brief interim report on the participatory component of R7530. August 2001 6 pages
- Agrawal, M. (2001) Heavy metal contamination of vegetables in Varanasi – interim report. 20pp
- Te Lintelo, D. (2001) Report on a visit to Delhi and Varanasi – 4-19 May 2001. 5pp
- Poole N. (2001) Report on a visit to Delhi and Varanasi for CPHP R7530 7-24 May 2001 (5 pages). Imperial College at Wye
- Poole N. (2001) Report on a visit to Delhi and Varanasi for CPHP R753029 Oct-8 Nov (4 pages). Imperial College at Wye
- Sen C (2001) Data from Cauliflower marketing surveys. Varanasi October 2001. 12 pages Banaras Hindu University
- Sen C (2001) Summary report on okra marketing surveys in Varanasi. May 2001. 7 pages. Banaras Hindu University.
- Agrawal M (2001) Heavy metal contamination data for Varanasi. November 2001. 74 pages. Banaras Hindu University Agrawal M (2001)
- Bhupal D S (2001) Report on Delhi wholesale market studies. November 2001. 38 pages. Delhi University

- Bhupal D S (2001) Report on Delhi cauliflower 'chasing of lots' survey. November 2001. 22 pages. Delhi University
- Bhupal D S (2001) Report on survey of cauliflower producers. October 2001. 29 pages. Delhi University
- Bhupal D S (2001) Report on pilot surveys of palak, okra and cauliflower marketing in Delhi. April 2001. 10 pages. Delhi University
- Singh R B (2001) Report on industries in Faridabad, Delhi. November 2001, 6 pages. Delhi University
- Singh R B (2001) Report on industries in Faridabad, Delhi. November 2001, 6 pages. Delhi University
- Singh Rana PB (2001) Interim report of market survey and industries in Varanasi. December 2001. 21 pages. Banaras Hindu University
- Singh Rana PB (2001), Supply areas for selected vegetables in Varanasi. December 2001. 7 pages. Banaras Hindu University
- Te Lintelo D. (2002) Overview of collaborative field work activities in Delhi and Varanasi and issues arising, March 21 pages. Imperial College, London
- Agarwal R. (2002) Food and Nutrition Policies and Policy processes in India (with Delhi case studies). January 2001. 41 pages. Shristi, New Delhi
- Srishti/Toxics Link, (2002), interim report 'summary information sources' about public health information mechanisms of government and NGO sectors, 10 pp, Srishti, New Delhi, October 2002.
- Mukherjee, N. (2002), Sustainable Livelihood Analysis (SLA) in Hamlet Morya, Peri-Urban Village Bharthara, District Varanasi, Uttar Pradesh, incomplete draft, 22 pp, December 2002.
- Singh, R.P.B., Interim Report Agriculture and Farmers' Surveys, Village Ramna (Banpurwa), Dt. Varanasi, 11 pp, October 2002.
- Mukherjee, N (2003) Enhancing food chain integrity quality assurance mechanisms for air pollution impacts on fruit and vegetable systems – participatory research component 28/02/03. 89 pp
- Poole, N (2003) The structure, conduct and performance of the vegetable marketing systems in Delhi and Varanasi. 19/06/03. 122 pp
- Poole N., Bell J., Marshall F & te Lintelo D. (2000) Literature review relating to the nutritional status of urban poor in India, the threat of air pollution to crop quality and safety and current mechanisms for food quality assurance.54 pages

I.c. Parliamentary questions:

Several questions were asked and debated in the upper and lower houses of the Indian parliament in April 2003 in response to the release of findings from this research project. The responses by the Ministry of Agriculture have resulted in a series of significant, cross ministerial committees and action plans to assess food safety impacts further.

I.d. Television broadcasts

- AGRAWAL, M. (2001) Tainting vegetables. Television interview. 'Imaging science' DD Metro. 7 June (08:30) 6 minutes. India (National), Repeated on 8 June (09:00) in Hindi. Repeated on DD News three times on 9 June. India (National)
- MARSHALL, M. (2003) Television interview. Aaj Tak Indian (National). National News programme. 26th March. Repeated three times.
- AGARWAL, R (2003) Television interview. Aaj Tak Indian (National) National News. 26th March. Repeated three times.

I.e. Radio broadcasts

- AGRAWAL, M. (2001) Heavy metal contamination in vegetables. Radio interview. Paryavaran Diwas Special (Environment Day Special), Akaswani Radio Station, Delhi. 5 June (20:30) 6 minutes, India (National broadcast)
- AGRAWAL, M.(2002) 3 radio broadcasts by All India Radio took place of an 18 minute interview with Dr. Madhoolika Agrawal titled "Hamara Paryavaran" (=Our Environment) about the air pollution impacts on food safety through heavy metals in Varanasi. The interview was broadcasted thrice, in Hindi:
  12/07/2002; 13:00 hrs: Programme: Vigyan Patrika (=Science Awareness)
  14/07/2002; 08:00 hrs: Programme: Vigyan Patrika (=Science Awareness)
  16/07/2002; 18:30 hrs: Programme: Kisan Duniya (=Farmer's World)
  All India Radio, regional station Varanasi, (Akashwani Varanasi

• Awaiting details of additional 2003 broadcasts

I.f. Web based news articles:

- BBC NEWS, Rajyasri Rao, ''High lead levels' in Delhi spinach', 27-03-03 http://news.bbc.co.uk/go/pr/fr/-/2/hi/south_asia/2891587.stm

I.g. Newspaper articles:

- Sudhir Mishra, 'na roti pahli si, na phalon men purana svad', Hindustan Times, 07-02-02
- Jagran Sanvaddata, 'ozone prabhav se ghatti hai phaslon ki utpadkata', in Dainik Jagran, 06-02-2002
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II. LISTING AND REFERENCE TO SOME KEY DATA SETS GENERATED

- Bhupal, D S (2002). Survey data from 102 respondents in 5 farming areas around Delhi relating to livelihoods and vegetable production & marketing practices.
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- Te Lintelo D., Agarwal R and others (2003) Reports on case studies with 3 NGOs working in poor urban areas in Delhi - including consultations regarding food safety information dissemination approaches and village workshop.
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Our research, created enormous interest in the local and national media and findings were widely debated. Reports were carried on the front pages of most of the daily newspapers (with various ongoing follow-up reviews) and questions were asked and debated in the upper and lower houses of the Indian parliament (April-June 2003). A public response from the ministry of health promised further action after consultation with the ministries of consumer affairs and agriculture and two high level government committees have been established, largely in response to our research findings:

III. POTENTIAL FOLLOW UP

The project recommends the development of a **food safety forum** (which will include participants from government, private, non-government and community based organisations). The forum will have the explicit purpose of developing and testing food safety strategies in Indian cities. Through the activities of the forum the project will ensure that food safety becomes recognised as an integral part of the food chain in India, and that mechanisms exist to engage with policy to address existing and emerging food safety concerns. Case studies linking policies and programmes with specific activities to improve the safety of fresh vegetables consumed by local

communities in Delhi could be used to illustrate and evaluate the potential direct positive impact of these newly identified pathways on the poor.

We have extensive support for this proposa. We have a list of potential participants would would like to be involved. For example, the director of the Government of Delhi Department of Agriculture is one of the key people who stated his intention to be actively involved in a food safety forum. Other strong supporters include the Delhi Development Commissioner who is interested in Delhi establishing itself as a positive example of systems for safe food provision. This enthusiasm is in part because 2003 has been a pivotal year in food safety awareness in India. In addition to our own research, other food safety concerns that have come to the public attention. These have included pesticide contamination in mineral water and soft drinks. A public interest litigation on the right to safe food (filed by our research partner Shirsti) has also been accepted by the Supreme Court of India.

There are ongoing efforts to harmonise food laws in India, and a report by a Task Force constituted by the Prime Minister (under the chairmanship of Shri Nulsi Wadia) advocated active promotion of food safety and quality and made some important suggestions, such as the establishment of a Food Regulation Authority (FRA) to formulate, update and monitor food standards for domestic and export market. This is now being pusued through the development of an integrated food law (which incidentally does not include fresh fruit and vegetables). However, these proposals do not consider the fundamental mechanisms required to bring the appropriate stakeholders together, and to facilitate effective outcomes from joint ventures, and often lack an emphasis on the particular needs of the poor. There is still a tendency for ministries and sectors to act independently.

Various actions proposed by government departments (in response to our research findings) included programmes to create awareness amongst the farming community of food safety issues, suggesting farmers don't grow vegetables that are likely to be contaminated and washing and grading of vegetables in wholesale markets. Many of these actions in isolation run the risk of disadvantaging poor producers and consumers further. There is a clear need to provide continued guidance and support to utilise the current enabling environment and policy responses so far - this will facilitate practical approaches to improved information sharing and integration of policy measures and ensuring a pro-poor emphasis. The proposed food safety forum would consider specific interventions in the context of a wider food safety strategy for Indian cities which would address the technical and institutional constraints involved in supplying affordable safe food to the urban poor, and would engage stakeholders from other appropriate sectors and disciplines.

Appendix I: Policy stakeholders consulted

Organisation	***Contact Person, responsibility***
Government of India	
Ministry of Health & Family Welfare, Directorate General of Health Services	Dr. S.R Gupta, Joint Director, Prevention of Food Adulteration
Ministry of Consumer Affairs and Public Distribution, Department of Consumer Affairs	a) Mr. P. Venkatesan, Deputy Secretary b) Ms. Satwant Reddy, Addl-secretary
Bureau of Indian Standards (Min. of Consumer Affairs and Food Distribution)	Ms. Madhulika Prakash, head of Dept. Food & Agriculture
Department of Woman and Child Development (Ministry of Human Resources and Development)	Mr. B.K Chaturvedi, Secretary
Central Pollution Control Board	Dr. Santosh D. Makhijani, Head of Lab
Food and Nutrition Board, Ministry of Human Resources and Development	a) Mrs. Shashi Prabha Gupta Technical Advisor b) Mr. Kripal Singh Deputy Technical Advisor
Community Food and Nutrition Extension Unit	Ms. Anju Dhal, Demonstration Officer
Delhi Development Authority	Mr. Vijay Risbud, Planning Commissioner
Government of Delhi NCT	
Directorate of Prevention of Food Adulteration	a) Mr. Ashok Bakshi, ex-director (2000) b) Mr. K.S. Wahi, Director c) Ms. Mohini Srivastava, Public Analyst
Directorate of Health Services	Dr. SP Agarwal
Development Department	Dr. Morari Lal Addl. director (Agriculture)
Delhi Pollution Control Committee/ Dept of Environment	Mrs. Naini Jayaseelan, secretary
Department of Social Welfare	a) Ms. Usha Kadian, Community Development Project Officer, ICDS b) Ms. Kanta, Supervisor, Nimri Project c) Mr. Jha, District Social Welfare Officer d) Mr. S.K. Kar Gupta, Welfare Officer e) Mr. M.K. Mishra, Secretary f) Mr. K.J.R. Barman, Joint Secretary, ICDS g) Ms. Sabita, addl.-director, ICDS h) Mr. PC Sharma, Research, training and evaluation officer ICDS
Agricultural Produce Market Committee Azadpur	Mr. Sharma, Chairman
Delhi municipal government	
Municipal Corporation of Delhi, Department of Health	Dr. K N Tiwari, head
New Delhi Municipal Corporation	Dr. Pal, Chief Medical Officer
Other stakeholders	
WHO- South East Asia Regional Office (SEARO)	Mr. Alexander von Hildebrand, Regional Advisor chemical safety
World Bank	a) Dr. Sameer Akbar, environment specialist b) Dr. Bilal Rahil, sr. environment specialist
DFID-India	Dr. Virinder Sharma, environment adviser Dr. Kevin Crockford, rural livelihoods adviser Mr. Simon Croxton, rural livelihoods adviser
Nutrition Foundation of India	a) Dr. C. Gopalan, director b) Ms. Rita Patnaik, project officer

Indian Council for Medical Research	Dr. G.S Toteja, Assistant Director-General
International Life Science Institute, India	Ms. Rekha Sinha Chief Executive Officer
Training Institute for the Anganwadi Workers	
Mother Dairy Fruit and Vegetable Products	Mr. M.G Sharma (legal consultant)
Okhla Industries Association	Mr. Gopal Tewary, administrative officer
Food Research & Analysis Centre	Dr. SK Saxena, Director
Consultant food safety	Dr. RK Malik, ex FAO/WHO and FRAC
VOICE	a) Mr. Kamaljit Singh, Food safety and Codex officer b) Mr. H.K. Awasthi, Legal Manager c) Mr. Chowdhury, Testing officer d) Prof. R.K. Khanna, director
Consumer Action Group Chennai	Mr. Bharat Jairaj, chief executive
Consumer Education and Research Centre Ahmedabad	Mr. S. Yellore, head of lab
Centre for Science and Environment	a) Pranay Lal, head Environmental Health Unit b) NK Satija, head of laboratory
Environmental Justice Initiative	a) Mr. Colin Gonsalves, director b) Aparna Bhatt (Public Interest Litigation lawyer)
Voluntary Health Association of India	Mr. N. Matthew, editor Health for the Millions magazine
'Dipalaya'	Mr. Pradeep, programme officer. NGO involved with implementing ICDS Nutrition Program in Delhi
Tata Energy Research Institute (TERI)	R. Uma, research associate
Indian Agricultural Research Institute	a) Dr. Navindu Gupta senior scientist Division of Environmental Sciences c) Dr N. Singh, head Vegetable Department d) Dr. H.S. Gill, former head of Vegetable Dept.
Mamta Health Institute for Mother and Child	a) Mr. Prashant Pastore, programme manager b) Dr. Ravi Chandran, Sr. programme manager c) Ms. Kalpana, project officer
Action India	a) Ms. Mamta Das, programme manager b) Ms. Sudha, Health coordinator c) Ms. Sushmita, project officer
Ms. Karuna John	senior reporter, The Pioneer
Varanasi region	
Regional officer, UP Pollution Control Board	Dr. RK Singh, Pollution control Board, Varanasi region
Indian Institute for Vegetable Research	Director, National vegetable research centre
District Horticulture officer	District level policy implementation
District Agriculture officer	District level policy implementation
Uttar Pradesh Marketing Board/Mandi Samiti;	Paharia mandi, Secretary, Regulated markets in Varanasi
Chief Medical Officer, Varanasi District	Dr M.P.Singh, Chief Medical Officer
Chief Medical Officer for public health BHU	Dr. Anand Kumar

Appendix II: References:

Please note that the majority of literature utilised by the project is detailed in literature reviews which are available separately.

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