CROP POST HARVEST PROGRAMME

Improving quality assurance systems for fresh fruits and vegetables produced by peri-urban resource poor farmers in Zimbabwe

R7528 (ZB0219)

PROJECT EVALUATION REPORT

1 January 2000 – 30 June 2003
(Extended from December 2002)

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Section A Executive Summary

The purpose of this project was to develop, validate and promote improved quality assurance systems for fresh produce important to the poor. Project R7528 was badly affected by the collapse of the economy and continuing political instability in Zimbabwe. However, thanks to the efforts of the team in Zimbabwe, diversification of work into Kenya and development of strategic activities in the UK the following outcomes were still achieved:

- An improved understanding of producer practice and risks associated with small-scale vegetable production in Zimbabwe and Kenya, and methods for minimising these risks;
- A validated food safety management system for small-scale French bean farmers;
- An improved understanding of the viewpoints and motivations of consumers in low income groups in Harare with regard to food safety of vegetables;
- An improved understanding of the shortcomings of many laboratories in developing countries, especially with regard to complex chemical analyses;
- An experimental system for detection of *E.coli* in fresh produce within 0.5-5 hours using calorimetry.

At the end of project R7528, the level of impact of outputs on the purpose was necessarily limited due to the project having to focus mainly on strategic and adaptive research issues. This was necessary partly to understand the existing systems through techno-economic surveys and contaminant monitoring, and also to develop appropriate measures for minimising risk.

The current project gave emphasis to improving food safety assurance of fresh produce entering domestic markets, using the requirements of export production and tourism as a financial impetus. This concept proved impractical in Zimbabwe, partly due to the collapse of the tourist industry and shift in consumer demand away from quality towards surviving food shortages and economic hardship. However, it became clear that even if Zimbabwe's future had remained bright only communities linked to exporters would have benefited from this approach. Farmers around Chinamhora have no interest in export markets because of the close proximity of Mbare Musika. Likewise no exporter would start operations in Chinamhora because of the risk of export produce and inputs being diverted toward the domestic market.

However, the outcomes from the work in Zimbabwe and Kenya, demonstrated the importance of the export industry for many thousands of households in those countries. European perceptions of the food safety hazards associated with fresh produce grown by small-scale farmers were shown to be largely unfounded, but farmers still faced exclusion from export markets due to risks associated with poor agricultural and management practices on farm.

Section B Project Background

B.1 Administrative data

Period under report: 1/1/2000 – 30/6/2003	Project Leader/Institution: Dr A Graffham, Natural Resources Institute
NRIL Contract Number: ZB0219	Collaborating institution(s) Horticultural Research Centre (Zimbabwe) Horticultural Promotion Council (Zimbabwe) Kutsaga Research Station (Zimbabwe) Agricultural Ethics Assurance Association of Zimbabwe (Zimbabwe) Jomo Kenyatta University of Agriculture & Technology (Kenya)
DFID Contract Number: R7528	**Target Institution(s)** **Government Institutions** – Agritex Ministry of Health (city & national) Horticultural Development Authority (Kenya) Ministry of Agriculture (Kenya) **Private Sector** – Hortico, Selby's, Homegrown-Flamingo
Project Title: Improving quality assurance systems for fresh fruits and vegetables produced by peri-urban resource poor farmers in Zimbabwe	Start Date: 1/1/2000 End Date: 30/6/03 (extended from December 2002)
Research Programme: Crop Post Harvest	Budget (i.e. Total Cost): £241,522
Production System: Peri-Urban Interface	

Section C Evaluating the identification and design stage

This project was developed to address two main developmental problems:

1. Domestic urban and peri-urban consumers in Zimbabwe potentially face a health risk due to the absence of adequate quality assurance systems in smallholder production and marketing of fruit and vegetables.
2. The lack of quality assurance systems is a constraint to smallholder access to horticulture export markets.

Smallholders in peri-urban areas face major problems in resolving pollution and microbiological contamination. They lack the knowledge to fully understand the nature of the constraints and the technologies and management systems to resolve them. Increased recognition of the potential hazards arising from consumption of fresh produce contaminated with undesirable micro-organisms and environmental pollutants has led to extensive research in the field, and the development of improved quality assurance systems for fresh produce (Brackett, 1992; DeRoever, 1998; Hooda *et al*., 1997, Igwegbe *et al*., 1992., Smith, 1994; Tauxe *et al*., 1997). However, this work has focused mainly on large-scale commercial farms and processing industries in industrialised countries; very little work has been done to address the needs of smallholders in sub-Saharan Africa.

Food safety risks occur throughout the marketing chain. Produce is exposed to contamination during the handling, transportation, storage and retailing process. Consumers are vulnerable to unsafe food, which may not be apparent from the appearance of the food. This applies both to consumers in producer households and to consumers purchasing from market. Food safety is a hidden quality attribute, which is frequently ignored by local consumers, who will only pay a premium for a visible improvement in quality. However, it is self evident that in ensuring food security it is not sufficient to simply provide adequate supplies of food of good nutritional quality. If that food has been rendered unsafe by either biological or chemical contaminants it will represent a threat rather than a benefit to poor consumers who remain most at risk from foodborne illness. Some foodborne contaminants cause acute effects, but those such as the heavy metals accumulate over long periods and have chronic effects, retarding the development of young children, and increasing the risk of illness in later life.

In several sub-Saharan countries, production and marketing of fresh fruits and vegetables for domestic and export markets is an increasing and significant source of income generation and one of the largest labour employers. Rapid urbanisation, increasing wealth associated with the emergence of an urban middle class, and improved international transport and communications have created increased demands for horticultural produce. In Zimbabwe horticulture accounts for 15% of the agricultural gross domestic product, with 46% of production going for export (Mlambo, *et al*., 1992). Production for export is dominated by large-scale commercial farms. Produce for the large urban markets are mainly supplied by resource poor smallholders (communal farmers and resettlement farmers) located in peri-urban areas. Surveys have estimated that 8,500 small-scale commercial horticulturists and 950,000 communal farmers operate in peri-urban areas of Zimbabwe (Sithole and Chickwenhere, 1995). Seventy five percent of these farms are run by women. According to Orchard *et al*. (1998), the majority of peri-urban farmers belong to the poorest strata of the community who grow crops as a survival strategy to provide food and cash income for their families.

Peri-urban horticultural farmers should be well placed to take advantage of these emerging national and international market opportunities. However, they face a key constraint in their ability to provide produce that meets the increasingly demanding quality requirements of these markets and, until recently, smallholders have had a minor role in horticulture export markets. However, recent internal and external initiatives have provided the impetus for an increasing involvement of smallholders in export horticulture (Jowah and Mubvuta 1993). Hortico Produce is a major exporter of fresh produce, and has already formed links with 1700 smallholders in peri-urban areas around Harare, providing production inputs and services in return for access to the crop. Three other companies are also involved in linking smallholders to the horticulture export market. These farmers produce primarily for home consumption and the urban market with a small area of land (approximately 5-10% of production) being reserved for production of export crops (babycorn and mangetout). Hortico does not allow smallholders to grow larger areas of export crops as this would lead to reductions in quality, and increase risk to the farmer if the crop is considered unacceptable for export.

This project addresses the problem of food safety assurance within the national market chains from peri-urban production sites to urban consumers in the cities of Harare and Bulawayo. Improved levels of food safety assurance will also help smallholders to access export markets for horticultural produce. Although this project is focused on Zimbabwe, the problems addressed and solutions developed will be applicable in other sub-Saharan African countries that rely on horticultural produce to provide a significant component of the diets of urban populations.

Rapid urbanisation, increasing wealth, associated with the emergence of an urban middle class, and improved international transport and communications have created increased demands for horticultural produce. Peri-urban horticultural farmers should be well placed to take advantage of these emerging national and international market opportunities. However, they face a key constraint in their ability to provide produce that meets the increasingly demanding quality requirements of these markets.

This proposal derived from concerns raised at the WHO/UNIDO seminar on national food control systems held in Harare in May 1999 (Nyamandi, 1999). The outcomes of the seminar highlighted national concerns over the safety of foods produced in Zimbabwe, and especially weaknesses at farm level. Current legislation (Food and Food Standards Act 1996) focuses on food safety assurance in processing, storage, distribution and sale of food. Primary production is not considered and falls outside the scope of monitoring and enforcement agencies. According to Nyamandi (1999), foodborne hazards are a major public health hazard for consumers in Zimbabwe, but health authorities lack the data to enable them to assess the real level of risk, so as to focus limited resources on dealing with actual hazards rather than possible risks. Nyamandi (1999) identified the need for primary data collection, and development of appropriate systems for improving food safety assurance in Zimbabwe. Recent DFID-funded research[1] highlighted demand from smallholders and export agencies in Zimbabwe and Kenya for simple low-cost quality assurance systems to satisfy demands of safety and traceability in terms of microbiological hazards, environmental pollutants and pesticide residues. Foreign buyers are willing to source from smallholders but remain reluctant to purchase perishable horticultural produce until systems guaranteeing food safety are demonstrably in place.

In August 1999, a series of meetings was held between NRI, HRC, HPC, KRS, Hortico, the Government Analyst Laboratory (GAL), Standards Association of Zimbabwe and Agritex. These meetings revealed the potential to use investments in high value export and domestic (national tourism) markets to drive improvements in food safety assurance of produce destined for the domestic market. This concept was based on the fact that farmers involved in export markets were known to grow produce primarily for home and domestic consumption with only small areas of land set aside for export crops (5-10% of production area). Two communal farming areas around Harare were selected for work on ordinary domestic and export markets. Two additional areas were selected around Bulawayo as farms in these areas were supplying the lucrative tourist market around Victoria falls. Bulawayo was also considered to be of interest because of the more positive approach to urban production taken by the Bulawayo city authorities when compared to the negative approach taken by the authorities in Harare.

As a direct result of the meetings held in August 1999, a group consisting of NRI, HRC, HPC and KRS as formal partners with non contractual links to Hortico, Agritex (Harare & Bulawayo) and the National University of Science and Technology (Bulawayo) developed a project proposal for submission to CPHP at the end of August 1999. This proposal was approved and work commenced in March 2000 after completion of contracting formalities.

Section D Evaluating the implementation process

Project R7528 derived its organisational approach from valuable lessons learned by NRI in Ghana under projects R6504 and R7418 (expanded markets for cassava projects). It was clear to NRI that the traditional approach of having a single lead institution and project leader with collaborating institutions, with all responsibility and managerial power vested in the project leader at the lead institution was not appropriate.

In project R7528, a partnership approach was adopted so as to build an effective management team. The team comprised of four organisations (NRI, HRC, HPC & KRS). Each organisation selected a project leader to take responsibility for delivery of activities and act as point of contact within the project. Each organisation had a

[1] Project No. ZB0132: "Development of Tools for Ethical Trading of Horticultural Exports by Resource Poor Groups-Phase 1"

distinctive role, and took responsibility for developing their own work programme and budget. HRC was given the role of national co-ordinator. The national co-ordinator was required to keep the team together through liaison and mediation between partners at national level.

NRI took the role of overall project co-ordinator, acting as main contact point between the project team and the CPHP in the UK. Given the approach taken by CPHP at the time, NRI was still considered by the programme as a traditional lead institution (as described above) but this was not how things worked in practice. Although NRI took responsibility for delivery of management reports these were developed collaboratively within the team and individual partner organisations retained control over budgets and expenditure, with NRI simply acting as a means of providing advance funding.

Management decisions on direction and major changes to the project were vested with the management team, but the co-ordinating partners were charged with the role of mediation and overall leadership, and were given the power collectively to make the final decision in the event of a lack of consensus.

Management reporting was set-up along the lines required by DFID with each managing partner to provide quarterly reports to the overall co-ordinator. The overall co-ordinator then prepared composite quarter reports for submission to the CPHP.

Co-ordination meetings of the whole team were held at least twice per year with the key meeting being held in March of each year for the team to prepare the annual report of the project. Annual reports were signed off by each institution before submission to CPHP.

NRI as overall co-ordinator had the following roles and responsibilities:

- Financial control (through sub-contracts with other partners)
- Contractual responsibility (to CPHP) for delivery of the project
- Preparation and submission of project management reports on behalf of the team
- Liaison with CPHP head office in the UK
- Technical inputs on food safety management, microbiology and pesticide residue analysis

HRC as national co-ordinator had the following roles and responsibilities:

- Liaison with all partners in Zimbabwe on technical matters and management reporting to NRI.
- Liaison with CPHP regional office in Harare
- Technical inputs on horticultural practice and sharing of sampling with KRS

Horticultural Promotion Council (HPC) took responsibility for training and promotion activities and also made inputs into the socio-economic side of the project.

Kutsaga Research Station (KRS) took responsibility for analysis of microbiological and pesticide residue contamination and shared responsibility for sample collection with HRC.

The **University of Zimbabwe (UZ)** was not formally involved in the project but Mr Ben Mlambo of UZ was employed on a consultancy basis to carry out socio-economic aspects of the baseline survey of small-scale growers and consumer survey in Harare.

The non-managing/peripheral partners and linkages to the project were as follows:

Hortico – Hortico were involved in the project from an early stage as a major export company heavily involved with small-scale growers. In 1999, Hortico had over 1000 small-scale growers supplying produce for export, during the life of the project this number increased to nearly 3000 as the large-scale commercial sector collapsed.

Agritex – Agritex acted as a liaison between the project team and farmer groups, in this role they proved to be particularly effective around Chinamhora where distances between farms and Agritex houses are short. In the Murewa area most farmers had never seen their Agritex officer and did not even though the officers name. This was not the fault of the officers concerned, but rather a reflection of the economic collapse leading to shortages of funds to provide transport and fuel for field staff. In the Murewa area commercial extension agents from Hortico proved to be effective as they had transport and fuel paid for by earnings from export crops.

National University of Science and Technology (NUST) – In August/September 2000, NRI and HRC met with Dr Mwenje at NUST to discuss work around Bulawayo. Dr Mwenje was happy to become involved with the project on the analytical side, but work was never started due to the lack of fuel restricting activities to close to Harare.

Farmer groups around Chinamora and Murewa – Groups of farmers from 2 wards in Chinamora and 2 around Murewa were involved in the project from August 2000 onwards (just prior to the socio-economic survey). Contact was easily maintained with the farmers at Chinamora through direct visits by the project team and links to Agritex. However, as the project progressed contact with the farmers at Jekwa and Mashambanaika (Murewa area) became increasingly difficult and sporadic in nature due mainly to fuel shortages and political activity during the presidential election.
In September 2000, NRI and HRC made visits to irrigation schemes around Lupane (West of Bulawayo) but were unable to initiate activities due to the lack of reliable fuel supply.

Department of Housing and Community Services (Harare City Council) – The DHCS were approached for formal permission to work within Mbare Musika market. Officials of the DHCS assisted in introducing the project team to the market association but then took no further part in the project. Representatives of Harare City Council were invited to the September 2001 project workshop but were unable to attend due to other commitments.

Mbare Musika Market Traders Association – In order to operate within the market, the project team formed a link with senior members of the market association associated with the section of Mbare known as the producer market. The market association was involved in initial discussions, was kept informed of progress and was invited to the September 2001 project workshop held jointly with project R7519.

Crop Post Harvest Programme – Links were maintained with the CPHP through formal management reports, and informal meeting and discussions between the project leaders at NRI and HRC with the Regional Co-ordinator and the Programme Manager.

The approach taken by R7528 remained largely unchanged during the life of the project, but various weaknesses and limitation to the existing systems were identified, that were taken into consideration in developing the follow on project (R8271). Most notably it became clear that a more regional approach was required in order to maximise use of limited resources in the Southern African region and limit the disruption caused by the political situation in Zimbabwe that had such a damaging effect on project R7528. In addition it was felt that future initiatives should link closely with the European retailers as these organisations have a massive influence on food safety and quality standards acting as a powerful driver for adoption by farmers in developing countries wishing to access high value export markets.

The original plan of activities for project R7528 was influenced by the collapse of the economy and political instability in Zimbabwe, and also by the discovery of a related proposal to CPHP (R7519) submitted at the same time as the project memorandum that became R7528. A brief summary of these changes is given below.

Additional activities developed to minimise disruption caused by political problems in Zimbabwe

In March 2000, political violence flared in the lead up to the general election in Zimbabwe. The aftermath of the election and land resettlement campaign seriously disrupted project activities in Zimbabwe. To maintain operations NRI and HRC agreed that NRI should use funds (from the NRI budget line) to initiate some field activities in Kenya and strategic research in the UK via two students working for MSc's in Post Harvest Horticulture at NRI as part of the University of Greenwich. Initially these activities were funded exclusively by NRI, but later on the Programme Manager of the CPHP provided additional funds to help support the work in Kenya.

The strategic work at NRI in the UK, addressed an issue raised by Hortico, who expressed concerns over the validity of conventional tests for contamination with *E.coli* and potential for false positives leading to unjust condemnation of produce on safety grounds. A review of the literature showed these concerns to be well grounded. As an immediate solution commercially available chromogenic media were recommended. However, the MSc student also developed experimental techniques using calorimetry to reduce sample analysis time from 24 down to 0.5 to 5 hours depending on initial numbers of *E.coli* present. The calorimetric process showed considerable promise although further research and development work would be required in order to develop a cost effective commercial system.

In Kenya, NRI formed a partnership with Jomo Kenyatta University of Agriculture and Technology (JKUAT), Horticultural Crops Development Authority (HCDA), Indu-Farms and small-scale growers in Kirinyaga District in the Central Highlands. This partnership enabled the second MSc student to develop, implement and evaluate the effectiveness of training packages and food safety management systems for small-scale growers under field conditions over several growing seasons.

Links between projects R7528 and R7519

Near to the time of submission of project memoranda, the R7528 team became aware of a related proposal developed by a team from University of Zimbabwe, Imperial College at Wye and Agritex. This proposal was entitled "Pollution and health problems in horticultural production in Harare: The need for improved quality assurance systems". This proposal that later became project R7519 appeared at face value to be very similar to that of R7528. Indeed it would be true to say that both projects shared a common goal in aiming to improve safety of produce for marketing. However the strategies and approach of the projects were different.

Project R7528 focused on peri-urban production (outside the city limits) and the role of exporters in driving the process of development of appropriate food safety management systems. In contrast project R7519 focussed on urban production in areas of Harare such as Epworth where a high risk of domestic and industrial pollution exists. The R7519 project team were concerned mainly with perceived risks of heavy metal contamination and strategies for reducing these risks. These urban growers were operating under very different conditions to the peri-urban growers, and marketed their produce only within the Epworth area. None of this produce was going to Mbare and such growers would never become involved in export markets.

However, given the apparent similarities the two project teams agreed to work together using a common project title in Zimbabwe to emphasise unity. Many meetings were held between the two teams both in Zimbabwe and also in the UK, and joint workshops were held in March 2000 and September 2001 to disseminate project outcomes more widely. Collaboration on socio-economic aspects proved reasonably effective, but technical co-operation was more limited due to the differences in project focus, and problems encountered by the R7519 team in getting their pesticide analysis facility operational. Following the joint workshop in September 2001, the two teams focussed in on their respective areas and further collaboration was of a minimal nature.

Section E Evaluating your activities

Output 1: Quality constraints (with implications for safe food delivery) facing smallholders in peri-urban locations involved in production and marketing of fresh fruits and vegetables assessed.

Summary of achievements

In discussions with individual farmers and in focus group discussions, farmers showed that they have some awareness of food safety issues especially with regard to toxicity of crop protection chemicals. However, they were unaware of any risks associated with unclean water or poorly composted animal manure. Understanding of safe use of crop protection products was limited with most farmers being unaware of the need for pre-harvest withdrawal periods. In fact many farmers using Dithane M45 to give a shine to tomatoes and leafy vegetables just prior to marketing. Farmers felt that contamination at the production stage was likely to be a rare occurrence or non-existent and blamed poor hygiene in Mbare Musika for any outbreaks of foodborne illness associated with their produce. Poor drainage and lack of sanitation were highlighted as the worst problems at Mbare, followed by lack of solid flooring, and inadequate rubbish disposal.
In terms of food safety assurance, problems with irrigation water, poorly composted manure and inappropriate use of crop protection products, and general lack of awareness or training in good agricultural practice were found to be the most important issues for the small-scale sector.

Of the samples analysed for faecal contamination as indicated by the presence and number of *E.coli*, 92% of samples analysed were found to meet the UK, PHLS definition of satisfactory produce (max 20 CFU/g). Three percent of samples found to be borderline cases and 5% of samples were considered unacceptable under the PHLS standard (>100 - <10^4 CFU/g). Similar results were obtained in Kenya, where 90% of samples were found to be satisfactory (see output 2). These results tend to refute the assertion that small-scale growers produce represents a high risk from microbiological contamination, although it is still true that small-scale growers operating practices leave much to be desired and need improving to minimise the risk of an incident occurring.

In general lower income consumers in Harare were found to be aware of foodborne illness, with some 30% reporting illness associated with consumption of fresh produce. Consumers were mainly concerned with visibly unhygienic conditions at vending sites, but were largely unaware of potential hazards associated with inappropriate practices at farm level. Relatively few were aware of chemical contaminants mentioning pesticides and over application of fertiliser as a cause for concern, none of the consumers was aware of heavy metal poisoning as a risk associated with fresh produce. Consumers are guided by considerations of price and availability and as such there was little indication that lower income consumers would be either willing or able to pay a premium for enhanced levels of food safety assurance.

Summary of activities

Production practices and management systems of small-scale growers in Zimbabwe: Implications for food safety assurance
In October 2000, a techno-economic survey was carried out on 128 (64 per District) small-scale farms in Chinamhora and Murewa Districts. Farmers in Chinamhora grew exclusively for the local market feeding into Mbare Musika in Harare. Farmers around Murewa also grew for produce for the domestic market, but most were also growing babycorn and mangetout peas for export to Europe under contract for Hortico a major export company. Vegetable production was found to be the major source of income for 84% of households covered by the survey. Vegetable plots ranged in size from 0.01 to 0.5 of a hectare with most farms having around 0.1-0.2 hectares of productive land.

In terms of food safety the following issues were identified as being of most concern:

Pesticides
- Non-user friendly labelling and calibration
- Use of cheaper non-labelled pesticides
- Pre-Harvest Intervals (withdrawal periods) are not understood/adhered to
- Majority of farmers rely on bucket and *pfunde* broom system for applying pesticides due to lack of knapsack sprayers
- Dithane M45 used to enhance colour of leafy vegetables
- Harvest intervals for tomatoes are ignored when prices are high, providing an impetus for a quick sale
- Seasonality and market opportunities push crop production out of optimum growing time, thus requiring greater use of pesticides

Water
- Shallow wells are the main source of irrigation water
- Bucket irrigation is the most common application method- increasing risk of contamination of edible portions of the crop
- Many farmers cultivate crops on flooded vlei lands and areas along river banks

Fertiliser and manure / compost
- Most animal manure is improperly composted
- Use of broadcast techniques for application increase risk of faecal contamination
- No specific or accurate measurements for chemical fertilisers

Knowledge & training
- Extension coverage inadequate (67% of respondents at 3 sites had little or no contact with Agritex)

- Farmers lack knowledge of basic good agricultural practice, and are generally unaware of the risks associated with unclean water, poorly composted animal manure and inappropriate use of crop protection products

Consumers awareness and attitude to food safety of horticultural products in Harare, Zimbabwe

In 2001, a survey was made of consumer's awareness of and attitudes to safety of horticultural products in Harare. The survey targeted 400 lower income consumers seen purchasing fresh vegetables at markets and shopping centres at Mufakose, Glen View, Epworth, Tafara and Chitungwiza. Thirty percent of respondents had experienced illness after consuming fresh vegetables with the most common complaints being of diarrhoea (22%) and general stomach pains (6%). Around 1% of consumers had suffered from cholera that they attributed to consumption of unsafe leafy vegetables or tomatoes. Leafy vegetables were perceived as high risk by 22% of consumers as compared to just 12% for tomatoes.

Most consumers blamed unhygienic practices by retailers for any illness experienced. There was relatively little understanding of possible risks occurring during production with only 10% of consumers blaming pesticide abuse for illness and 4% citing use of dirty irrigation water as a health risk. This is perhaps unsurprising since most consumer's base their assessment of quality and safety on visual perception of the produce at the point of sale, in the absence of additional information through the media. This conclusion is supported by the observation that 42% of consumers rated street stalls as high risk outlets as compared to just 2% for permanent markets.

When consumers were asked about their reasons for choosing a particular outlet as their regular source of supply, price (40%) and convenience of location (33%) were identified as the most important factors. Quality was an issue for 17% of consumers, but food safety and hygiene were not rated at all.

Sampling and analysis of fresh vegetables for microbiological and pesticide residue contamination

At an early stage in the development of the current project it was realised that almost no data was available on the true extent of microbial or chemical contamination of fresh produce in Zimbabwe. This has important implications for both export and domestic markets. A lack of data makes it almost impossible for export companies to provide a due diligence defence under European food safety regulations. Similarly farmers and exporters have no way of proving that European perceptions of risks associated with small-scale farming operations are unfounded. On the domestic front, governments and health authorities have no way of making valued judgements with regard to food safety risks and hence cannot prioritise scarce resources effectively.

For these reasons a two year contaminant monitoring programme was undertaken to assess the level of faecal contamination and pesticide residues associated with leafy vegetables and tomatoes grown by farmers in Chinamhora and Murewa Districts. Initially it was intended that samples should be collected from both farms and Mbare Musika market. However, in practice sampling at the farms was of a sporadic nature due to fuel shortages and political instabilities, and this data was not considered sufficient to draw any conclusion. However, sampling did take place at two week intervals over a two year period.

Of the samples analysed for faecal contamination as indicated by the presence and number of *E.coli*, 92% of samples analysed were found to meet the UK, PHLS definition of satisfactory produce (max 20 CFU/g). Three percent of samples found to be borderline cases and 5% of samples were considered unacceptable under the PHLS standard (>100 - <10^4 CFU/g). Similar results were obtained in Kenya, where 90% of samples were found to be satisfactory (see output 2). These results tend to refute the assertion that small-scale growers produce represents a high risk from microbiological contamination, although it is still true that small-scale growers operating practices leave much to be desired and need improving to minimise the risk of an incident occurring.

Pesticide residue analysis proved problematical in both Zimbabwe and Kenya. Most laboratories claiming capacity in this area lack the capacity and resources to carry out reliable analyses. In Kenya, NRI visited four laboratories in Nairobi (JKUAT, KEPHIS, KARI/NARL and ICIPE. Only ICIPE and JKUAT had reasonable functional facilities. The other laboratories suffered from lack of water/water storage, lack of electricity generators and problems with consumables. However, results from Kenya were found to contain many unlikely compounds, and it was suspected that laboratory reagents and work surfaces had become contaminated leading to unreliable results. All the Kenyan samples were frozen and taken to NRI for re-analysis. Results for pesticide residues given under output 2 were derived from work carried out at NRI.

In Zimbabwe, NRI visited three laboratories in Harare (KRS, GAL and DR&SS) that claim capacity for pesticide residue analysis. It was immediately obvious that facilities at the DR&SS and GAL were in such poor condition as to preclude any chance of reliable analysis of pesticide residues. The laboratory at KRS appeared to be well equipped and staffed with every evidence of high quality analysis being done for the tobacco industry. For this reason KRS was chosen to carry out the monitoring of pesticide residues in fresh produce, and a detailed analytical protocol was agreed between NRI and KRS.

However, results from KRS appeared to indicate an almost complete lack of residues in most cases. This was considered suspicious as farmers had reported using chemicals that ought to be detected a reasonable residue laboratory. When duplicate samples were divided between KRS and NRI, marked discrepancies were found between the results from the two laboratories. Two members of NRI staff were sent to KRS to make a detailed assessment of quality of analysis at the KRS laboratory. Numerous problems were identified and a report with recommendations was prepared and circulated to the Director of KRS. However, the outcome of this was that it was considered necessary to discard all of the Zimbabwe pesticide residue data as unreliable.

Output 2: Improved quality assurance systems for smallholder production of fresh produce, and techniques for improving the safety of resource poor farmers produce developed and validated.

Summary of achievements

The main achievement of this output was the development and validation of food safety management system and guide (see annex VII) for small-scale vegetable growers in Kenya. The content of the guide for farmers, exporters and extension personnel was based on data from Zimbabwe & Kenya (see Output 1) that highlighted areas of risk in existing production and management practices in the small-scale sector. Copies of the guide were prepared in Swahili and used for farmer training sessions backed with locally available posters of good agricultural practices. Monitoring and support of farmers over three growing seasons demonstrated a significant reduction in the levels of faecal contamination on produce grown by trained farmers when compared to a control group. Levels of pesticide residue also decreased, but levels of dicofol and endosulphan remained above EU MRLs for French beans thus indicating the need for further training on correct use of chemicals.

Following on from concerns raised by the export industry in Zimbabwe regarding speed and reliability of existing methods for detecting faecal contamination, strategic research was initiated in the UK to address this problem. A review of scientific literature confirmed that the techniques used by laboratories in Zimbabwe and Kenya can give false positive readings for *E.coli* contamination on fresh produce. This is simply a reflection of the fact that these procedures were designed for use in water testing, and cannot cope with cross contaminants routinely found on fruits and vegetables.

As an immediate measure, a commercially available chromogenic medium was introduced to the laboratories and export and domestic food businesses in Zimbabwe via a seminar and practical demonstration conducted by NRI at KRS in Harare. This medium proved effective for detection of *E.coli* in fresh produce and gave a result within 24 hours (more rapid than conventional methods that require 2-3 days).

However, the export industry remained keen to obtain more rapid methods of detection, due to the high level of perishability of fresh vegetables. Ideally the industry would like a system capable of providing a reliable measurement with 3-4 hours. Strategic research carried out at NRI resulted in the development of a calorimetric system capable of detecting *E.coli* in fresh produce with 0.5-5 hours depending on initial level of contamination. This was a promising result but more research is required in order to develop a practical commercial system, as the research calorimeter used for the work would not be appropriate for routine field use.

Summary of activities

Development and validation of a food safety management guide for small-scale growers of vegetable crops

French beans are the most important export horticultural crop in Kenya both in value and volume (HCDA, 2000). In 2001, the value of fresh produce exports from Kenya was in excess of $210 Million.

In the early 80's, between 70-85% of horticultural exports came from small-scale farmers, but current estimates are down to 40% (GTZ- IPM, 1997). The reason for this decline is due to concerns from major European markets (supermarkets) on the clear lack the resources, facilities and knowledge that can enable small-scale farmers to meet European standards and demonstrate adequate and acceptable levels of food safety assurance. However, these perceptions are not backed up by data on the degree of food safety risk associated with production by small-scale farmers.

In order to find out the level of food safety awareness amongst small-scale farmers in Kenya, a study was conducted on two groups. One group was trained on food safety Good Agriculture Practices (GAP), before the commencement of the field study and throughout the production cycles (a production cycle for French beans is 45 days, and three cycles were done for this study), and another group was not given any training. This was used as a control.

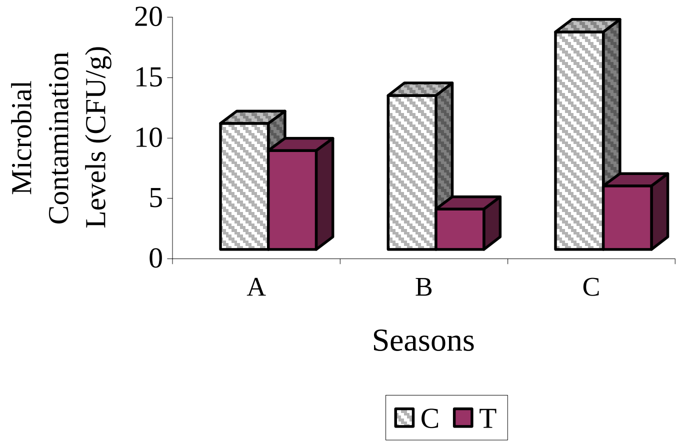
At the end of the training, laboratory analysis was done on produce from the two groups to find out the level of faecal bacteria (*Escherichia coli)* and pesticide residue levels (MRLs).

Samples from the trained group had significantly lower ($p<0.001$), *E coli* contamination of 6 cfu/g, (n=24, SD=2.52) compared to samples from the control group, with *E.coli* contamination of 14 cfu/g, *(n*=24, SD-8.76). However, only 10 % of the total farmers in the two groups had produce with contamination at the borderline (20-100cfu/g *E.coli*) given by the Public Health Laboratory Service (PHLS, UK). The rest (90%) had acceptable (0-20cfu/g *E.coli*) contamination levels in their produce.
Twenty-one pesticide compounds were analysed for MRLs, and three were detected in the samples from the two groups. Endosulphan was found to be in highest concentration in the treatment group; with average levels of 0.154 ppm (EU MRLs is 0.05 ppm). From the same treatment group, Cypermenthrin and Dicofol concentration were 0.02 ppm and 0.04 ppm respectively (EU MRLs are 0.05 ppm and 0.02 ppm respectively). From the control group Dicofol concentration was 0.03 ppm. The concentration of Dicofol and Endosulphan residues in the French bean samples from both study groups was significantly higher ($P<0.001$) than EU MRLs for French beans.

Samples from the treatment group had mean *E.coli* contamination levels of 6 cfu/g (n=24, SD=2.52), compared to samples from the control group which had mean *E.coli* contamination levels of 14 cfu/g (n=24, SD=8.76). A two-way Analysis of Variance (ANOVA) test done showed a significance difference ($P<0.001$) in contamination levels between samples from the trained group and the untrained group, (Fig 4.1).

However, training alone could not be attributed to the low level of *E.coli* contamination without appreciating other underlying factors that gave farmers in the treatment group a comparative advantage over farmers in the control group. From the baseline survey done before commencement of the study, farmers in the group chosen as the treatment group had carried out French bean farming for an average of three years. They had thorough contact with horticulture field extension workers and received information on the export market requirements. This could be seen in the well-designated grading shed that they had constructed together with pit latrine and running water for hand washing during grading. It was therefore possible to practice and implement food safety training done because basic hygiene facilities were in place. On the contrary, the control group farmers had no prior knowledge about export horticulture that could have enabled them to have in place facilities like a grading shed, toilet and running water. French bean grading in the control group farmers took place about anywhere in the field or homestead or by the roadside as they waited for willing buyers. These places could not guarantee hygiene and the produce was therefore exposed to contamination risk.

Fig 4.1- Variations in *E coli* levels on French bean samples between the trained group (T) and the untrained group (C) in three seasons



Results in Fig. 4.1 above, showed a decline in *E.coli* contamination from season A, which was the first study season, for the treatment group through to season C, the last study season.

However, the decline was not consistent as during the third season, C as *E.coli* contamination increased instead of decreasing, as farmers became more familiar with food safety principles. An increase in rainfall during the months of February/ March, when the final harvesting was taking place could probably account for the increase in *E.coli* contamination during the third season. In rainy weather, the effect of soil splashes onto produce resulted in muddy and soiled produce. To avoid export companies rejecting their produce due to soil/mud, small-scale farmers resort to field washing. However, river water used for field washing of French beans could not be guaranteed as completely safe from microbial contamination and especially during the rain seasons when there was the likelihood of floods. This together with use of dirty washing containers could have combined to increase the risk of microbial contamination during this season. However, *E.coli* contamination in the French bean samples from the two study groups was below the level given by Public Health Laboratory Services (UK), on acceptable number of *E.coli* (cfu/g) in fresh produce. Only10% French bean samples had *E.coli* contamination levels in the borderline class (20-100 cfu/g) and the rest of the samples (90%) had *E.coli* contamination below the 20 cfu/g, which is in the acceptable range. Most of the small-sale farmer's production activities needed minimal modification and if this could be carried out, then it would help to have small-scale farmers producing as per market requirements.

Pesticide Residues Analysis by GC

Organochlorine, organophosphorous and pyrethroid in French beans were analysed by gas chromatography. The GC, model 6890, Hewlett Packard, USA, equipped with an electron capture detector, ECD- Ni^{63} and a nitrogen-phosphorous detector (NPD) was used in this study. The ECD maximum temperature was 330˚ C, with a constant makeup nitrogen gas flow of 60.0 ml/min. The capillary column used was 30 m long, model number: JWS 122 - 5032, with column maximum temperature of 325˚ C. The oven initial temperature was 100□ C, which was held for 1 minute and increased by 5□ C/ min to 290□ C and then held for 3 minutes. The detector temperature was 330□ C. Operating time of the split less mode was 1.10 min and the run time was 27 minutes. The nitrogen phosphorus detector (NPD) maximum temperature was 325˚ C, with a constant make up hydrogen gas with a flow of 3.2 ml/min and airflow of 60.0 ml/min.

Capillary column used was BD-5, serial No: 8697585, model No: JWS 122 - 5032, with a column maximum temperature of 325˚C. The column length was 30.0 m, diameter of 250.0 µm and nominal film thickness of 0.25 µm. Oven temperature was 50˚ C, which was held for 10 minutes and then increased to a final temperature of 250˚ C and held for 5 minutes. The operating time of the split less mode was 1.10 minutes and the run time was 26 minutes.

Sample extraction with Ethyl Acetate

A French bean sample (30g) was chopped and put into a maceration jar. Ethyl Acetate (60 ml) was added in the presence of 5g sodium hydrogen carbonate ($NaHC0_{3-}$ Sigma, UK) and anhydrous sodium sulphate, 35g (Na_2SO_{4-} Sigma, UK), added. A high-speed macerator (H-AM Kokusan homogeniser) was used to blend for 5 minutes. Sodium sulphate was added to remove water from the sample and sodium hydrogen carbonate acted as a buffer. The temperature during extraction maintained at 27-33˚ C. The slurry was transferred to a fume hood to let the solvents separate from the solid material for 20 minutes. The mixture was separated by filtering through a cotton wool plug into a 25-ml glass-stoppered measuring cylinder. The filtrate (25 ml) was evaporated in a Rotary evaporator (Ribby, Model RE 100B, UK) to near dryness. This was rinsed with 2 ml of ethyl acetate, transferred to a test tube and re-concentrated to give a final volume of 1ml using dry nitrogen gas. It was then transferred to a 5ml vial for storage at ± 2° awaiting clean up. (USFDA, NRI, Pesticide analysis manuals

The clean up method employed in this study used florisil column. A chromatography column (0.25-mm internal diameter) was clamped vertically, rinsed with hexane and the rinse collected in a beaker. The stopcock was closed and fresh hexane poured to a height of 15cm. Approximately 20 g of florisil (BDH, UK) was poured into the column and this was allowed to settle evenly in the hexane. An even layer (1 cm thick) of sodium sulphate was added to the top of the florisil to form a protective cap and the column rinsed again with hexane. A round bottomed flask (500ml capacity) was placed under the column to collect the elute. The stopcock was opened and hexane allowed to flow at a steady rate of approximately 5ml/min (USFDA, NRI, Pesticide analysis manuals). Elution of extracts was done using hexane (5ml), which was added to the prepared extract. The column was rinsed down with two consecutive aliquots (5 ml) of hexane at different fractions. The first fraction was made up of diethyl ether, (200ml of 6% v/v) in hexane and this was added down against the walls of the column and as the solvent level drained down, the stopcock was adjusted to maintain the required flow rate.

Eluent from this column was collected in a 500 ml round bottomed flask. The second fraction, diethyl ether in hexane (200 ml of 30% v/v) was likewise added. Eluent from this second fraction was collected in a second round-bottomed flask (500ml capacity). Each eluent was evaporated with a rotary vacuum evaporator (RIBBY, model RE 100B, UK) at 40º C to near dryness. The extracts were then rinsed with hexane and transferred to a volumetric flask (5-ml) and the volume adjusted to the meniscus mark with hexane. Samples were stored frozen at ±2° prior to analysis by GLC (USFDA, NRI pesticide analysis manuals).

1 □ l of sample extract was injected (split less) into the GC column for analysis with the ECD and NPD to determine the concentration of pesticide residue levels in mg/kg (ppm). (Cox, 2001). Standard solution mixtures prepared in hexane at a concentration of 0.01 - 0.05 ppm were injected into the GC. A concentration for each was determined based on the chromatogram obtained using the Hewlett Packard workstation. Data produced on the chromatograms was analysed and identification of pesticide residues was done by comparing the sample retention times and area with those of the injected standards. The concentration of each in the sample was calculated from the reference standard chromatograms and quantification of the residues for those samples found positive, was done using the formula:

$$\frac{V1*S*V2}{V3*W}$$

V1= Volume (µl) of standard injected
V2= Final volume (ml) in which sample was reconstituted in
V3= Volume (µl) of sample injected
S= Concentration of standard (ppm)
W= Effective weight of sample (g) (USFDA, NRI, pesticide analysis manual)

Results and Discussion on Pesticide Residues

Of the 21 compounds analysed for, only 3 compounds were detected in the French bean samples from the two groups. Results in the table below 7 show the distribution (percentage) of farmers under each compound detected on French bean samples for each group. French bean samples from farmers in the treatment group had more pesticide residue contamination for the three compounds detected. From the results, 73% of the samples had Cypermethrin residues, 27% had Dicofol residues, and 20% had Endosulphan residues, as compared to samples from farmers in the control group, 60% who had Cypermethrin residues, 33 % Dicofol residues and none had Endosulphan residues.

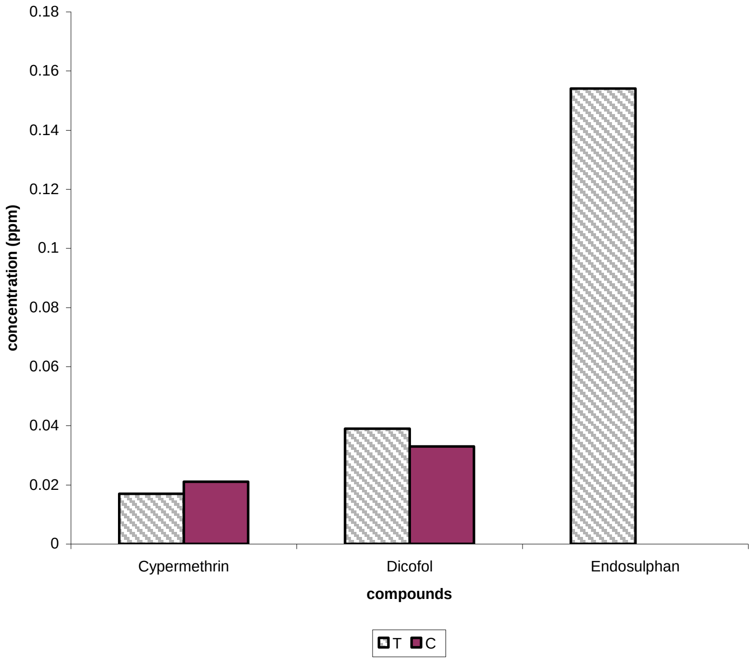
Distribution (%) of French bean samples detected with pesticide residues in the two study groups

Group	% number of samples detected with Pesticide residues		
	Cypermethrin	**Dicofol**	**Endosulphan**
T	**73%**	**27%**	**20%**
C	**60%**	**33%**	**0**

Key: T= Treatment group
C= Control group

Samples from the treatment group showed high pesticide residues, and this could have been due to the fact that farmers were in a better position to purchase chemicals since they were engaged in producing for an exporter as contract farmers and had better prices for their produce as compared with those in the control group. The farmers in the control group may not have needed to spend money on chemicals as they were not guaranteed prices that could cover for the cost of such an input.

FIG 5.1 COMPARISON OF CONCENTRATION OF PESTICIDE RESIDUES DETECTED IN FRENCH BEAN SAMPLES BETWEEN THE TRAINED GROUP (T) AND THE UNTRAINED GROUP (C) DURING THE STUDY SEASONS



They may have been forced to use chemicals meant for other farming operations e.g. tomatoes or rice farming.

The largest pesticide concentration was Endosulphan, with an average concentration of 0.154 ppm (n=15, SD=0.34), Fig 5.1, from farmers in the treatment group. The Maximum Residue Levels (MRLs) given by EEC, Directives 76/895/EEC, 86/362/EEC, 86/363/EEC & 90/642/EEC for endosulphan in French beans is 0.05 ppm. The concentration of this compound was therefore higher than EU MRLs and Analysis of variance (ANOVA) done against EU MRL showed that its concentration was significantly higher, ($P<0.001$). However, concentration of Cypermethrin (0.02 ppm) from French bean samples for both study groups was within the EU MRLs, of 0.05 ppm. The concentration of Dicofol in samples from the treatment group was 0.04 ppm and 0.03 from the control group. EU MRL for Dicofol is 0.02 ppm, showing that Dicofol was high in samples from both study groups. Analysis of Variance (ANOVA) against EU MRLs for Dicofol showed that the concentration was significantly higher at ($P<0.001$).
Both Cypermethrin and Endosulphan are pyrethroid insecticides, which are sprayed onto produce close to harvest. Their presence in the samples could have most likely be from lack of strict observance of waiting periods, although Dicofol is more persistent and should be used with caution on such a short term crop. When farmers fail to observe pre-harvest intervals as given in the pesticide labels, this introduces

possibility of residues in harvested produce, because the chemical compounds have not been allowed to undergo complete breakdown.
Keeping farm records which showed dates of chemical application and harvest due dates could have helped in knowing when to harvest. Farmers generally lacked training on record keeping.
Training on good agricultural practice emphasised the need for follow up on record keeping, pesticide chemical application methods and use of approved chemicals.
Farmers' ignorance, poverty, illiteracy, poor prices and lack of support from the industry are believed to be responsible for the farmer's choice of pesticide and method of application (HCDA, 2001). Misappropriation, more than use of inappropriate chemicals was the main problem in the field among the small-scale farmers studied in this experiment. Lack of money played a big role as it forced farmers to resort to buying chemicals they could afford without checking whether it was appropriate for French beans or not. Most export companies have realised the problem and have resorted to providing farmers with chemicals as part of the inputs, which are then deducted from the farmer's proceeds. But this method does not always work as farmers sometimes find this kind of arrangement expensive and result to buying chemicals not approved for use on French beans.
The move by some export companies to hire field agronomists to train small-scale farmers to strict adherence to pesticide application details as outlined by each company could make a difference in the pesticide problem on produce from Kenya. The big challenge that farmers and exporters are facing is on how to harmonise company requirements with what chemical manufacturers or chemical merchants are selling to the farmers to avoid contradictions. Educating farmers on the damage caused by pesticide abuse both to consumer and producer health, ecosystem and pest build up is a task that needs to be addressed by not just the export industry but by all stakeholders. This would be more effective if government intervention on issues related to pesticide policies/ regulations were more pronounced in terms of training and surveillance on products being used in the country's horticulture sector, in view of the importance of horticulture to the country's economy in terms of foreign earnings. Consultations between exporters and small-scale farmers on acceptable pesticides in the market were not up to date. There was need for this to be done on a regular basis through training and education on market requirements. The small-scale farmers need to be given training on pest and disease control through Integrated Pest Management (IPM) procedures and proper follow-up so as to realise the ultimate goal of reducing pesticides residues in fresh produce.

The results of microbial contamination on French beans showed that, small-scale farmers' microbial contamination problems are more perceived than real. Even for farmers who did not have good grading and field facilities as well as other basic infrastructure, *E. coli* contamination levels were detected in only 10% of the samples. These results were at the borderline of acceptable cfu/g as provided under the Public Health Laboratory Services (PHLS, UK) guidelines. This however, does not undermine the need to train small-scale farmers on pre and post harvest hygiene principles.
The study elucidated a clear lack of regulatory measures and mechanisms at the field level and that is the cause of problems such as the unregulated sales of pesticides. There needs to be a better structural support in matters of control of sales and utilisation of pesticide. Small-scale farmers lack support from the stakeholders in matters of training and support or implementation of improved food safety assurance. Sometimes, training is left to the relevant exporter who may not be able to carry out training due to the heavy financial commitment required to employ food safety specialists. Lack of trained field personnel in the area of pesticide use made it difficult to pass appropriate information to small-scale farmers. Due to lack of

trained personnel in agronomy and chemical use, the farmers get contradictory instructions or misleading information especially from pesticide vendors.
Lack of price controls often make farmers look for cheaper chemicals, which could be adulterated, unregistered or restricted. Implementations of good farming techniques require capital, which most small-scale farmers cannot afford. There was also a clear lack of uniform export market standards, (for example within the EU) which in most cases confused farmers on which standards to implement. Farmers would tend to go for the least strict market, as this would require least inputs, and this helped to bring about a situation that created a general breakdown of good farming practices. Lack of an active horticulture industry laboratory service provider, who could be relied on to analyse and communicate results within a good time frame, was also a limiting factor in implementing good farming practices as there were no results showing need to reform current practices. Most exporters as yet do not appreciate the importance of laboratory analysis for fresh produce, which places them at a disadvantage with the rest of the global food producers who take matters of food analysis more seriously. Due to lack of credible analytical work, there is no convincing data that can help the industry defend itself if need be.

Development of a rapid and reliable method for detection of *Escherichia coli* in fresh produce using calorimetry

Fresh produce has a maximum shelf-life of 7-10 days (depending on the type of produce); most of the conventional methods which are approved as reliable for detection of faecal contamination require a minimum of 24-72 hours (2-4 working days) to get a confirmed result. Since fresh produce (salad vegetables) are highly perishable a more rapid and reliable method of detection is needed which would give reliable results within a maximum of one working day. The potential of calorimetry for rapid detection of *Escherichia coli* was investigated using lettuce as a model system in this study.

As calorimetry is a non-specific technique, a selective medium for *E.coli* was required that would exclude other members of the *Enterobacteriaceae.* A chemically defined selective medium for optimal growth of *E.coli* was developed by varying pH, incubation temperature, and concentration of NaCl, D-glucose (carbon) and ammonium sulphate (nitrogen) using base E (Owens and Keddie, 1969) as a basal medium. In order to create a selective environment for *E.coli* a combination of bile salts and β-D-glucuronic acid were introduced along with an elevated incubation temperature (44.5°C).

A new selective medium was developed (MMBE + Bile) which is composed of D-glucose (15g), Ammonium sulphate (1g), and Bile salts (20g) for 1000ml of base E solution with final pH (7.2 $\pm$ 0.5). The MMBE + bile medium was found to restrict the growth of other background flora present on lettuce leaves and support vigorous growth of *E.coli* at 44.5°C. The growth rate or doubling time of *E.coli* was found to be for every 28 minutes ($\pm$1.414). Using the MMBE+ bile medium the potential of the microcalorimeter was investigated for detection of *E.coli*. Results indicated that *E.coli* (pure culture) with an initial concentration of 10^3CFU/ml was detected within 300 minutes (5 hours) or less through calorimetry. The results of this study indicate that calorimetry could provide a promising rapid detection system for determining the presence of unsatisfactory or satisfactory levels (PHLS standard) of *E.coli* in fresh produce within 0.5-7 hours depending on number of *E.coli* present.

This study showed that *E.coli* could be detected within one working day by calorimetry using a selective medium (MMBE + bile medium) at an incubation temperature of 44.5°C. Microcalorimetry could constitute a rapid and simple detection procedure for faecal contamination in fresh produce.

The selectivity of the growth medium was of primary importance in the current work as calorimetry is a non-specific technique. The modified mineral base E medium (MMBE)+ bile salts (20g/l) developed in the current work provides a selective environment for *E.coli* that restricts the growth of the background microflora of lettuce leaves at an incubation temperature of 44.5°C. The MMBE + bile medium at 44.5°C provides 5-6 log cycles of growth within 24 hours whereas in the presence of *E.coli* the background flora is reduced to a very low level at the end of 24 hours of incubation. But in the absence of *E.coli* the medium supports the growth of background organisms at 40°C, whereas at 44.5°C in absence of any *E.coli* the count of the background organism remains static (the normal count of the background microflora is about 10^5 CFU/ml). As there is no growth at this temperature, the background flora will not increase the heat output of the sample, and thus will not contribute towards any thermal response detected by the TAM.

The growth characteristics of *E.coli* determined using conventional non-calorimetric techniques are comparable with the results obtained from the calorimetric response data. This shows the potential of calorimetry for detailed studies of the physiology of microorganisms under controlled conditions.

The predicted minimum response time for detection (taken from conventional studies of growth kinetics) and actual response time for the microcalorimeter showed some variation. This could be attributed to the differences in conditions between the two methods. In the conventional method the culture was better aerated with constant agitation to provide a homogeneous environment. In the microcalorimeter, there was no aeration or agitation. The conditions found in the calorimeter vial would have restricted growth to some extent when compared to conditions found in a flask culture.

Reproducibility of detection time for a given set of conditions varies and need more experiments to take these variations into consideration. The changing of pH during the growth may also affect the growth which might have an effect on outputs. Further experiments in more buffered environment are recommended for further studies.

Output 3: Potential for production of safer fruits and vegetables by smallholders in peri-urban areas, and importance of food safety promoted to agricultural policy makers, rural and urban planners, horticultural exporters and NGOs that can facilitate uptake of methods for delivery of safe food.

Summary of achievements

Meetings organised for stakeholders in Zimbabwe had the effect of raising the profile of food safety as an issue of concern for production and marketing of vegetables by small-scale farmers. Participants commented that they had not really taken food safety into account and were largely unaware of the risks associated with existing production and marketing practices. It also became clear that there was a general lack of information available, especially in Bulawayo, even though this city contained extensive evidence of use of sewage effluent for irrigation due to seasonal water shortages.

Although participants were concerned over the issues raised, it was clear that even in 2000 economic constraints would hamper most attempts to improve conditions in the domestic markets. For example participants at the meetings in Harare considered poor hygiene conditions at Mbare Musika to represent the greatest risk to health. However, the city authorities admitted that insufficient funds were available to enable any upgrading of the market to take place. Since the time of the meetings conditions have deteriorated further with severe limitations on the ability of the city health authorities to deliver the necessary services. In addition food safety has ceased to be an immediate priority for consumers as food shortages have forced consumers to adopt the survival strategy of trying to get sufficient food to survive regardless of quality and safety. High inflation and unemployment mean that few consumers are in a position to pay a premium for improved levels of food safety assurance.

Summary of activities
Three project specific workshops (two in Harare and one in Bulawayo) were held in Zimbabwe during the life of the project. These meetings were attended by representatives of local NGO's involved with small-scale farmers, city authorities, and consumer organisations. The national workshop held in Harare in September 2001 was also attended by 4 small-scale vegetable growers from the Chinamhora communal farming area covered by the project.

Further meetings did not take place due to the gradual break-up of the original project team and difficulty of implementing field activities in Zimbabwe due to the fuel crisis and political disruption.

Section F Evaluating Project effectiveness

The Purpose
Project R7528 was badly affected by the collapse of the economy and continuing political instability in Zimbabwe.
However, thanks to the efforts of the team in Zimbabwe, diversification of work into Kenya and development of strategic activities in the UK the following outcomes were still achieved:

- An improved understanding of producer practice and risks associated with small-scale vegetable production in Zimbabwe and Kenya, and methods for minimising these risks;
- A validated food safety management system for small-scale French bean farmers;
- An improved understanding of the viewpoints and motivations of consumers in low income groups in Harare with regard to food safety of vegetables;
- An improved understanding of the shortcomings of many laboratories in developing countries, especially with regard to complex chemical analyses;
- An experimental system for detection of *E.coli* in fresh produce within 0.5-5 hours using calorimetry.

At the end of project R7528, the level of impact of outputs on the purpose was necessarily limited due to the project having to focus mainly on strategic and adaptive research issues. This was necessary partly to understand the existing systems through techno-economic surveys and contaminant monitoring, and also to develop appropriate measures for minimising risk.

The current project gave emphasis to improving food safety assurance of fresh produce entering domestic markets, using the requirements of export production and tourism as a financial impetus. This concept proved impractical in Zimbabwe, partly due to the collapse of the tourist industry and shift in consumer demand away from quality towards surviving food shortages and economic hardship. However, it became clear that even if Zimbabwe's future had remained bright only communities linked to exporters would have benefited from this approach. Farmers around Chinamhora have no interest in export markets because of the close proximity of Mbare Musika. Likewise no exporter would start operations in Chinamhora because of the risk of export produce and inputs being diverted toward the domestic market.

However, the outcomes from the work in Zimbabwe and Kenya, demonstrated the importance of the export industry for many thousands of households in those countries. European perceptions of the food safety hazards associated with fresh produce grown by small-scale farmers were shown to be largely unfounded, but farmers still faced exclusion from export markets due to risks associated with poor agricultural and management practices on farm.

For the new project (R8271) the focus has shifted away from domestic markets and much greater emphasis has been placed on dissemination and uptake as shown below.

Emphasis of work (%)	**R7528**	**R8271**
Strategic research	30%	0
Adaptive research	55%	30%
Awareness dissemination	10%	30%
Uptake by beneficiaries	5%	40%

The Outputs
The degree of achievement for each output has been summarised in the table below. Recommendation and plans for further work to complete studies initiated under R7528 are given in annex 4.

	Signature	Date
Natural Resources Institute (NRI)	……………………………..	……..
Project leader	……………………………..	……..

Summary of achievements at output level for the project on Improving quality assurance systems for fresh fruits and vegetables produced by peri-urban resource poor farmers in Zimbabwe (R7528).

Output	Objectively Verifiable Indicator (OVI)	Comment	Rating
1. Quality constraints (with implications for safe food delivery) facing smallholders in peri-urban locations involved in production of and marketing of fresh fruits and vegetables assessed.	Assessment of quality constraints and key problems identified by September 2001.	Work on this output was largely successful with detailed information being obtained on current production and management practices. The contaminant monitoring programme suffered badly from the economic collapse in Zimbabwe and much of the pesticide data had to be discarded due to quality control problems at the laboratory. Pesticide analysis for the Kenyan work was repeated at NRI and gave good results.	2
2. Improved quality assurance systems for smallholder production, and techniques for improving the safety of resource poor farmers produce developed and validated.	Improved quality assurance systems for production of safer fresh produce by smallholders developed and validated by November 2002.	An improved food safety management system for small-scale growers was developed and validated in Kenya. Microbiological quality of produce improved dramatically over 3 growing seasons amongst trained farmers, as compared to those that did not receive training.	2
3. Potential for production of safer fresh fruits and vegetables by smallholders in peri-urban areas, and importance of food safety promoted to agricultural policy makers, rural and urban planners, horticultural exporters and NGO's that can facilitate uptake of methods for delivery of safer food.	Brochures produced and at least two workshops or field days organised for key players in the local and export market systems, with all activities complete by April 2003.	Workshops for relevant Zimbabwean stakeholders were held in March 2000, December 2000 and September 2001. In Kenya awareness, field training and follow up sessions were held for export vegetable growers over 3 growing seasons in 2000-2001. A food safety manual was produced for growers in Kenya.	3

Annex I. Project Logical Framework

Logical framework for the project entitled "Improving quality assurance systems for fresh fruits and vegetables produced by peri-urban resource poor farmers in Zimbabwe (R7528)", as revised in March 2001.

Narrative Summary	Objectively Verifiable Indicators	Means of Verification	Important Assumptions
Goal			
Poor people benefit from new knowledge applied to food commodity systems in peri-urban interface areas.	By 2002, increased number of poor households, in two target countries, who use improved storage and agro-processing techniques in a sustained manner. By 2002, increased numbers of poor households, in two countries, benefit from improved marketing and credit systems. By 2002, increased contribution to nutrition of poor households from own produced food. By 2002, increase in income from the sale of fresh and processed crops by poor households, two countries.	National and local adoption rate surveys. National food security data.	Poor people invest benefits to improve choices and options for livelihood strategies.
Purpose			
Improved quality assurance systems validated and promoted for fresh produce important to the poor.	1.1 By 2005, improved quality assurance systems validated for fresh produce important to the poor. 1.1 By 2003, new knowledge adopted by target institutions. 1.1 By 2004, end users in target countries aware of knowledge programme outputs.	Annual Research programme reports. External refereeing. External O/P reviews. Target institutions reports.	Resources managers, producers and processors are able to adopt new knowledge. Enabling environment exists for widespread adoption of new knowledge. Capabilities of target institutions maintained at least at current levels. Food production constant or increasing.

Outputs			
1. Quality constraints (with implications for safe food delivery) facing smallholders in peri-urban locations involved in production of and marketing of fresh fruits and vegetables assessed. 2. Improved quality assurance systems for smallholder production of fresh produce, and techniques for improving the safety of resource poor farmers produce developed and validated.	1. Assessment of quality constraints and key problems identified by September 2001. 2. Improved quality assurance systems for production of safer fresh produce by smallholders developed and validated by November 2002.	1. Project reports available. 2. Project reports available.	1. and 2. (a). Stakeholders are willing to collaborate to achieve research outputs. (b). Policy makers and urban planners are willing and able to implement recommendations for improving quality and safety of fresh produced and marketed in peri-urban and urban locations. (c). Smallholders in urban and peri-urban areas will be willing and able to co-operate in uptake of better methods for quality assurance. (d). Smallholders producing for export and local markets will apply the same production standards to all of their produce. (e). Foreign buyers of fresh produce will accept that smallholders can deliver fresh produce that meets specifications set under European food safety regulations.
3. Potential for production of safer fresh fruits and vegetables by smallholders in peri-urban areas, and importance of food safety promoted to agricultural policy makers, rural and urban planners, horticultural exporters and NGOs that can facilitate uptake of methods for delivery of safer food.	3. Brochures produced and at least two workshops or field days organised for key players in the local and export market systems, with all activities complete by April 2003.	3. Dissemination materials, and reports of workshops and field days available. Deadlines to be determined by progress made with outputs 1 and 2.	3. (a). All stakeholders are willing to participate in workshops and field days. (b). Output two is successful and provides material for dissemination. (c). Export agencies (such as Hortico) will be willing to invest in uptake of improved quality assurance systems by smallholders who produce fresh fruits and vegetables for local and export markets.

Activities	**Inputs**	**Means of Verification**	**Important Assumptions**
	Total cost: £241,550	Quarterly and annual reports	
1.1. To make a preliminary survey of quality constraints faced by smallholders, and those marketing fresh produce in peri-urban areas of Zimbabwe (Harare and Bulawayo).	1.1. Preliminary economic and technical assessment of quality constraints involved in production and marketing of fresh produce in peri-urban areas of Harare and Bulawayo completed by October 2000.	1.1. Economic and technical report available by October 2000.	1.1. Smallholders, exporters, wholesalers and retailers of fresh produce in urban markets and representatives of local government are willing to co-operate with survey personnel.
1.2. To carry out detailed assessments (at four sites identified in 1.1) of quality at all stages in the market system from the production site through to the final point of sale or export from Zimbabwe.	1.2. Detailed technical and economic assessment of factors that influence quality at all stages in the market system (2 sites near Bulawayo and 2 sites near Harare) completed by February 2002.	1.2. Economic and technical report available by March 2002.	1.2. Selected smallholders and stakeholders in the market chain will co-operate with research personnel.
1.3. To prioritise quality constraints in terms of level of risk and potential benefits, and to identify key problems for local and export markets with potential for development of technical and economically viable solutions in phase II of the project.	1.3. Key quality problems for local and export markets identified, and work programme developed for Phase II of the project, completed by August 2001.	1.3. Report on key quality problems, and Phase II work programme available by August 2001.	1.3. Activities 1.1 and 1.2 are completed on schedule.
2.1. To assess problems of development of undesirable microflora at different points in the market chain and develop strategies for limiting risk of undesirable microbiological contamination.	2.1. Studies of microbiological problems associated with fresh produce complete and strategies developed for limiting risks by November 2002.	2.1and 2.2. Final report on microbiological problems, and pesticide residues with economically viable strategies for limiting risks available by November 2002 (interim reports to become available at intervals between December 2001 and September 2002).	2.1 and 2.2. Stakeholders, representatives of local government, and NGOs active in the fields of water and sanitation are willing to co-operate with research personnel. That economic and socially acceptable strategies for minimising food safety risks arising from biological and chemical sources can be developed.
2.2. To develop appropriate strategies for limiting the risk of contamination of produce with unacceptable levels of pesticide residues.	2.2. Strategies for limiting risks from pesticide residues developed for limiting risks by November 2002.		
2.3. In collaboration with local farmers associations, HPC, SAZ and Hortico to develop a system for quality assurance that is appropriate for smallholders, and meets the requirements of both national and export markets in terms of produce quality and traceability.	2.3. Appropriate quality assurance systems for smallholders developed by December 2002.	2.3. Document giving details of quality assurance systems for smallholders and suggested uptake pathways available by December 2002.	2.3. Stakeholders are willing and able to cooperate in development of appropriate quality assurance systems for smallholders.
2.4. In collaboration with urban policy makers, and other appropriate organisations to investigate the best approach for taking forward recommendations for ways of improving the safety of vegetable production and marketing in peri-urban and urban areas.	2.4. Strategies for improved food safety assurance for production and marketing of fresh produce in urban environments developed by December 2002.	2.4. Document describing strategies for improved food safety assurance for production and marketing of fresh produce in urban environments with suggested uptake pathways available by December 2002.	2.4. Stakeholders involved with production and marketing of fresh produce in urban environments are willing to cooperate. That political sensitivities relating to food safety and the urban environment can be overcome.

3.1. To raise awareness of the issue of food safety, and promote uptake of simple and low cost strategies for improving quality and safety of fresh produce production and marketing. 3.2. To promote the uptake of improved methods for quality assurance that will enable smallholders to deliver food that meets specifications established under European food safety legislation.	3.1. Awareness and discussion seminars held September 2001 and December 2002. 3.2. Dissemination materials prepared by January 2003, and at least eight field days for smallholders, and those in involved in marketing of fresh produce for local and export markets held in areas of Bulawayo and Harare between February and May 2003.	3.1. Reports of awareness seminars with recommendations available in October 2001 and January 2003. 3.2. Copies of dissemination materials available by January 2003 and report on field days available in May 2003.	3.1 and 3.2. All stakeholders are willing to participate in seminars and field days. That outputs one and two are successful and thus provide material for dissemination.

Note: Outputs should be numbered 1, 2, 3, *etc.* Activities should relate to these outputs and be numbered 1.1, 1.2, ...2.1, 2.2, ...*etc.*

Revised:
15th March 2001

Annex II.

Results of end of project workshop

Problems were encountered with the inability of the Horticultural Research Centre and Horticultural Promotion Council to continue to participate in project activities due to loss of key staff, and losses of staff from KRS. Field activities were reduced due to problems with fuel, and much of the pesticide residue data was found to be unreliable due to attempts by KRS to reduce analytical costs by simplifying the agreed protocol.

For these reasons it was felt to be inappropriate to hold an end of project workshop. However, the surviving partners recognised the importance of the export horticulture industry as a market for small-scale growers, and identified food safety assurance as the key issue likely to impact on ability of small-scale growers to continue to access high value markets. For these reasons proposals were developed to take forward useful outcomes from the work in Zimbabwe and Kenya, and overcome shortcomings identified during implementation of R7528 (see annex III).

Annex III.

Target Institution's workplan for adopting project outputs

In May 2003, the R7528 project team met to consider ways of maximising the outcomes from project R7528 and deal with identified shortcomings. The team concluded that future work should focus exclusively on export markets, as it was apparent that domestic markets in Zimbabwe lacked scope for improved food safety management due to the harsh economic environment and lack of supporting infrastructure. In contrast export markets continued to provide a valuable source of income for ~3,500 small-scale growers in the communal areas around Harare with scope for an increase in the number of farms to meet the shortfall created by the demise of much of the commercial farming sector. The work in Kenya demonstrated that a combination of training and support for growers, coupled to effective contaminant monitoring could lead to significant improvements in microbiological safety of produce within 1-2 growing seasons.

It was also clear from project R7528, that future work should take a regional approach, and form strong links with European retailers, intermediate buyers and representatives of commercial standards so as to ensure support for uptake of project outputs within the supply chain. The idea of taking a regional approach was to build partnerships to share common resources and expertise between countries so as to improve capacity at minimum cost. In the case of Zimbabwe there were clear advantages in forming stronger links with the Zambian export industry. Zambia is a relative newcomer but has good capacity in the area of farm based training via a training trust formed through a public / private sector initiative. In contrast Zimbabwe has a wealth of experience that could benefit the Zambian industry.

The new expanded regionally based project team agreed to develop proposals to assist small-scale growers to cope with the implications of the European Retailers Protocol for Good Agricultural Practice (EUREPGAP). EUREPGAP was created by a group of 26 retailers in the EU as a due diligence defence against existing and proposed food safety regulations within Europe. EUREPGAP has become the most important farm gate standard, controlled and driven by the private sector. Any grower wishing to supply a EUREPGAP member must demonstrate compliance with EUREPGAP to continue to access the market.

A pre-concept note was submitted in May 2002, this was followed by a full concept note in September 2002, which lead to submission of a full project memorandum in November 2002. The new project (R8271) received approval and commenced activity in January 2003.

A Copy of the pre-concept note for the new project is given below:

PRE-CONCEPT NOTE

Project Title: Promoting improved food safety management for small-scale farmers involved in horticultural exports

Project Partners & their Full Contact Details:
Following detailed discussions with stakeholders in Zambia and Zimbabwe, a list of skill areas required for the project was prepared and stakeholders approached to assess interest in becoming a partner in a regional team.

List of partners by country in alphabetical order:
Zambia
Food and Drug Control Laboratories (FDCL), Ministry of Health, Lusaka, Zambia (contact via NISIR see below)
Contact: Mrs Margaret Mazhamo
FDCL will provide the bulk of analytical services in Zambia, dealing with microbiology, mycotoxins and heavy metals. Pesticide residues can also be handled if the filters on the nitrogen generator can be replaced.

National Institute for Scientific & Industrial Research (NISIR), International Airport Road, PO Box 310158, Chelston, 15302, Lusaka, Zambia, Tel: 00 260 1 28 24 88, Fax: 00 260 1 28 10 84, e-mail: nisiris@zamnet.zm
Contact: Dr Rodah M. Zulu e-mail: mzimba@unicef.org (preferred contact)
NISIR will provide additional analytical support to FDCL in microbiology and specialist knowledge of food safety.

NRDC/ZEGA Training Trust (NZTT), NRDC Business Centre, Great East Road, Chelston, PO Box 310241, Lusaka, Zambia, Tel/Fax: 00 260 1 283324, e-mail: nztt@zamnet.zm
Contact: Dr Glenn Humphries
NZTT will take the lead in developing and delivering a training package to disseminate the research outcomes of project R7528 in Zambia and Zimbabwe.

Zimbabwe
Agricultural Ethics Assurance Association of Zimbabwe (AEAAZ), PO Box WGT 290, Westgate, Harare, Zimbabwe, Tel: 00 263 4 309800, Fax: 00 263 4 309866, e-mail: hpcproject@cfu.co.zw
Contact: Mr Kennedy Chakanyuka
AEAAZ will work with NZTT to transfer training activities developed in Zambia to Zimbabwe.

Government Analyst Laboratory (GAL), PO Box CY231, Causeway, Harare, Zimbabwe, Tel: 00 263 4 792026/7, Fax: 00 263 4 708527, e-mail: theod@africaonline.co.zw
Contact: Mrs Theodora Nyamandi
The GAL will provide analytical services for microbiology, heavy metals, mycotoxins and pesticide residues, and staff with specialist knowledge of food safety issues.

Kutsaga Research Station (KRS), PO Box 1909, Harare, Zimbabwe, Tel: 00 263 4 575289, Fax: 00 263 4 575288, e-mail: naume_mandizha@kutsaga.co.zw
Contact: Mrs Naume Mandizha
KRS will co-operate with GAL to handle some of the pesticide residue and microbiological analysis, having two laboratories involved will reduce the risk of down time through equipment failure and allow for comparative analysis to ensure quality assurance.

United Kingdom
Natural Resources Institute (NRI), University of Greenwich, Central Avenue, Chatham Maritime, Kent, ME4 4TB, United Kingdom, Tel: 00 44 1634 883239, Fax: 00 44 1634 883714, e-mail: a.j.graffham@gre.ac.uk
Contact: Dr Andrew Graffham

NRI will be involved in provision of specialist knowledge of food safety including microbiology, pesticides, heavy metals, mycotoxins, and food safety hazards associated with horticulture NRI is co-ordinating the development of this proposal.

Duration and Location of Project: 2 years. Harare, Zimbabwe and Lusaka, Zambia

Date Of Submission: 25th May 2002

Background:
Horticultural exports to Europe have proved a growth area for countries such as Kenya, Zimbabwe and Zambia, with opportunities for small-scale growers to derive an additional source of income by accessing the export market via an export company. Traditionally small-scale growers were favoured by exporters because of the labour intensive approach taken by small-scale farmers that encourage attention to detail and delivery of a high quality crop. Although outbreaks of serious food/water borne diseases such as cholera had occurred in production areas, there is little evidence of any foodborne disease reaching European consumers via fresh produce grown in either East or Southern Africa thus strengthening the argument that small-scale farmers are a safe source of fresh produce.

However, the creation of the Sanitary and Phyto-Sanitary (SPS) agreement administered by the WTO with its incorporation of the Codex Alimentarius guidelines on food hygiene has raised the stakes by obliging countries to demonstrate equivalence of risk outcome as a prerequisite for participation in international trade. The move towards compliance with SPS and the introduction of strict codes of practice such as the EUREP-GAP code introduced by a consortium of European supermarkets represents a serious threat to the continued participation of small-scale farmers in export horticulture. Small-scale farmers are generally perceived as high risk in terms of potential for food safety hazards and lack of traceability. And in Kenya, the major export companies have already begun to shift away from small-scale farmers as a source of produce. In theory small-scale farmers only need to demonstrate that their produce is safe (demonstrate equivalence of risk outcome in terms of SPS), but in practice this is impossible as there is a complete absence of baseline data on the safety of fresh produce grown by small-scale farmers, and the farmers typically use production and handling practices that are not approved by European inspired codes of practice.

An existing CPHP funded project on food safety management for small-scale farmers (**R7528**) in Zimbabwe and Kenya has investigated practices used by small-scale farmers, collected baseline data on pesticide residues and faecal contamination, and tested improved practices under field conditions (in Kenya). The findings of this project demonstrated that the widely held perception of small-scale farmers produce as inherently unsafe due to pesticide residues and microbial contamination was incorrect. Farmer's produce was generally of high quality, although some production practices were undesirable and would not be accepted under the stringent conditions set by the various codes of practice.

The current project has focused mainly on obtaining baseline data, testing improved management systems on a small-scale, and providing awareness and training sessions to small groups of farmers from within the project. It is clear that dissemination of the outcomes of this work should be disseminated more widely via an uptake pathway that will be sustainable beyond the life of a CPHP project.

Project Purpose or Objective:
The present proposal seeks to promote the research findings from R7528 more widely, by taking a regional approach and forming a partnership with NRDC/ZEGA training trust (NZTT) in Zambia. NZTT is a permanent trust formed through a partnership between government and the private sector in Zambia. Over a 5 year period NZTT has successfully provided training in all aspects of horticulture and food hygiene for small-scale farmers wishing to enter the export market. It is anticipated that NZTT will develop a more regional role over the next few years.

Project Activities:
Output 1:
1.1 Training package of improved food safety management measures developed for small-scale farmers developed and integrated in to the existing programme of NZTT.

1.2 Validation of effectiveness of training by technical monitoring of selected farmers over a 12 month period to see if adoption of training outcomes leads to sustained improvement in level of food safety assurance associated with the farmers produce.

Output 2:
2.1 Promotion of greater awareness of food safety, personal and community hygiene issues to communities involved in export horticulture via local drama productions, video presentations and leaflets distributed as an aide memoire.

Project Outputs:
Output 1: Training package of improved food safety management developed for small-scale farmers developed and validated.
Output 2: Greater awareness of food safety, personal and community hygiene issues promoted to target communities involved in export horticulture.

Contribution of Project Outputs:
Successful promotion of improved food safety management systems for small-scale farmers would help to ensure that farmers already involved in export horticulture could continue to generate income from this opportunity, and allow many others to enter the market.

In addition the promotion of wider awareness of food safety and issues of personal and community hygiene has potential to reduce the risk of foodborne disease in peri-urban communities involved in horticultural production.

How will the outputs be delivered to the intended beneficiaries?
The intention is to develop and validate a training package for small-scale farmers, working closely with professional educators at NZTT. The course materials will be designed to maximise visual content and meet the needs of the target audience both in terms of language requirements and educational background. As part of raising awareness of food safety issues in the production communities, drama will and video presentations will be developed as ways of putting over concepts in a graphic and easily appreciated form.

Beneficiaries:
The primary beneficiary of this project would be the small-scale resource poor farmer, who would benefit from continued access to an important income generating opportunity, and greater guarantee that this opportunity will continue to be available in the future.

Risks and Assumptions:
The major risks and assumptions for this project are:
- Political environment in the partner countries remains stable
- Professional staff remain in post at partner organisations
- Developments in SPS, EUREP-GAP and EU legislation do not exclude small-scale farmers from export markets.

Budget Estimate: The consortium partners require more time in which to develop programmes of activities and budgets, it was therefore not considered appropriate to provide a figure at this stage.

Annex IV.

Feedback on the process from collaborating institution(s) and farmers (where appropriate)

The PER report is being circulated in draft form to surviving partner organisations (namely AEAAZ & KRS) with the request that they provide feedback on their experience of project R7528. In all other cases the persons involved in the work have either left Zimbabwe or simply ceased to be employed in the organisations involved in the project. Even in the case of KRS none of the original team is still employed at KRS, the current partner Mr Mharapara was not involved with work on R7528.

Annex V.

List of publications

Publications:

NYAGA, R. (2001). Improving food safety assurance of French bean production by small-scale farmers in Kenya. MSc thesis, University of Greenwich, UK. 107pp.

VENKATARAGHURAMAN, S., GRAFFHAM, A. and BEEZER, A. (2001). Development of a rapid and reliable method for detection of *E.coli* in fresh produce by calorimetry. PROCEEEDINGS OF THE Post-Harvest Postgraduate Conference on current research in post-harvest biology and technology. Cranfield University, Silsoe, UK. 31 may – 1 June 2001. (Poster presentation)

VENKATARAGHURAMAN, S., (2001). Development of a rapid and reliable method for detection of *E.coli* in fresh produce by calorimetry. MSc thesis, University of Greenwich, UK. 121pp.

Internal Reports:

COX, J. R. and KING, W. J. (2002). Report of a visit to Kutsaga Research Station to assess pesticide residue analytical quality, 18 January 2002 – 3 February 2002, Natural Resources Institute, UK. 15pp.

COX, J. R. and KING, W. J. (2002). Multi-residue analysis of tomato and kale samples. Laboratory Analytical Report No: 01BR-BS, Natural Resources Institute, UK. 7pp.

COX, J. R. and KING, W. J. (2002). Multi-residue analysis of tomato and kale samples. Laboratory Analytical Report No: 01BP-BQ, Natural Resources Institute, UK. 17pp.

COX, J. R. (2000). Protocol for the selection, collection, transportation and preservation of samples for pesticide residue analysis. Joint report of the Natural Resources Institute, Horticultural Research Centre, Kutsaga Research Station and Horticultural Promotion Council. pp26.

GRAFFHAM, A., (2000). Protocol for sampling of fresh produce, manure/compost and water for microbiological analysis and determination of *E.coli* in fresh produce, water and manures/composts. Joint report of the Natural Resources Institute, Horticultural Research Centre, Kutsaga Research Station and Horticultural Promotion Council. pp9.

HANYANI-MLAMBO, B. and GOODLAND, A. (2000). Report of a techno-economic survey of food safety assurance among communal farmers in Chinamhora and Murewa. Joint report of the Natural Resources Institute, Horticultural Research Centre, Kutsaga Research Station and Horticultural Promotion Council. pp53.

MBULAWA, R. E. and MANDIZHA, N. T. (2002). Laboratory Analytical Report No 201195. Kutsaga Research Station, Zimbabwe. 7pp.

MBULAWA, R. E. and MANDIZHA, N. T. (2002). Pesticide residue analyses and microbiological tests on peri-urban grown vegetables (kale & tomato). Laboratory Analytical Report No 270302. Kutsaga Research Station, Zimbabwe. 6pp.

NYAGA, R. (2002). Effect of training Kenyan small-scale French bean farmers on modern food safety management systems. Natural Resources Institute, UK. 20pp.

Other Dissemination of Results:

ANON. (2000). Food safety in horticultural markets. Joint report of Agritex, University of Zimbabwe, HPC, KRS, NRI and Imperial College at Wye. Pp18.

GRAFFHAM, A., NENGUWO, N, MBULAWA, R. E. COX, J. R., KING, W. J., GOODLAND, A., COOTE, C., and CHAKANYUKA, K (2001). Food safety in horticultural markets in Zimbabwe. Presented at the CPHP Workshop on Food Safety in Crop Post Harvest Systems, Harare, Zimbabwe. 20-21 September 2001.

GRAFFHAM, A., NENGUWO, N, MANWAYANA, E. and CADISCH, G. (2001). National workshop on improving food safety assurance of fresh produce in Zimbabwe, New Ambassador Hotel, Harare, Zimbabwe. 17-18 September 2001.

GRAFFHAM, A., GOODLAND, A., KING, W. J., NENGUWO, N. and MBULAWA, R. E. (2000). Improving food safety assurance for fresh vegetables produced by communal farmers in Zimbabwe: project Inception Workshop. Bulawayo, Zimbabwe, 8th December 2000. pp29.

GRAFFHAM, A., (2000). Chromogenic assay for rapid detection and enumeration of *E.coli* in fresh produce as an indicator of faecal contamination. Paper presented at a practical seminar held at Kutsaga Research Station for representatives of food and horticultural companies working with communal farmers. Joint seminar of NRI, HRC, KRS & HPC. pp4.

Annex VI.

A catalogue of data sets and their location

Sets of original data are held at the partner institutions responsible for the major share of the work in Zimbabwe & Kenya. The Natural Resources Institute in the United Kingdom holds master sets of data for the project. The individual holdings of data sets are as follows:

Natural Resources Institute

- Master set of data for the project
- MSc data for Miss Ruth Nyaga
- MSc data for Mr S. Venkataraghuraman

Kutsaga Research Station

- Master set of microbiological & pesticide data for Zimbabwe

Jomo Kenyatta University of Agriculture & Technology

- Master set of microbiological & pesticide data for Kenya
- Copy of MSc thesis of Ruth Nyaga

Annex VII.

Food safety management guide for small-scale farmers
(English language text of guide used in Kenya)

FOOD SAFETY MANAGEMENT GUIDE FOR SMALL-SCALE FARMERS IN KENYA

Contents

I. Introduction

Food safety has become a global concern due to rise in food-borne diseases (WHO, 1997) mainly brought by an increase in the emergence of food-borne pathogens, e.g. *Salmonella* spp, *Campylobacter* spp, *Listeria monocytogenes* and others. This has made the food industry, which includes the fresh produce sector to come increasingly under surveillance from consumers, mainly in Europe where most of the fresh produce from developing countries is marketed. Ehiri, (1995) reports that, annually between 200-500 deaths occur in the USA alone from food poisoning related to fresh produce and evidence from Venezuela show that food poisoning incidents all related to fresh produce have increased about five fold between 1976 and 1996.

In terms of economic losses, in the late 1980s one country turned back some 18,000 food shipments valued at US$ 1100 million in a single year, as a result of failure by the exporting country to follow Codex procedures on food safety (Oniang'o and Allotey, 1999). Currently the European Union has threatened to impose a ban on the multi-billion shilling fresh produce exports from Kenya (last year the sector earned Sh14 billion in foreign currency) due to high pesticide residue levels, microbial and physical contamination's (Nation Newspaper, August 2000). Similar problems associated with hygiene and safety have caused the recent ban of fish from the Kenya to the European Union, with loss of trade amounting to millions of Ksh shillings in recent months. This shows that unless measures are put in place to avoid the socio-economic problems associated with food safety, African countries, the majority of whom depend on agriculture for domestic and export need, stand to lose, if they do not address the crucial aspects of food safety.

To prevent food-borne disease problems associated with fresh produce, it is necessary to reduce initial contamination, and prevent growth of pathogens. This means that practices and procedures that will ensure that produce is safe and free from microbial, chemical and physical hazards must be put in place at the very cradle of production- the farm, since this is where most food-borne hazards associated with fresh produce can be minimised or eliminated.
Knowing that most vegetables grow in non-sterile environments where growers have little control over conditions in the field, it is important that production practices like field hygiene, manure, water application methods, pest and disease control, harvesting and sorting procedures are given appropriate concern. This is because these are operations that are critical to product safety and if measures are provided on appropriate and available control measures then its possible to minimise risks.

Some of the contamination in fresh produce include, environmental pathogens like, *Listeria monocytogenes*, *Clostridium botulinum* and *Bacillus cereus,* pathogens in raw manure, irrigation and surface water e.g. *Shigella* spp, *Salmonella* spp, *Campylobacter* spp and *Escherichia coli,* chemical toxins, physical contamination i.e. stones, mud/ soil, leaves, bird droppings and others.

The task ahead of the fresh produce industry in Kenya, therefore is to increase the assurance that it can deliver to the consumer food that is safe by making sure that growers take a proactive role in minimising potential food safety hazards associated with the production environment.
This will enable exporters to vouch for the products they sell within the wider global markets and hence ensure continuity of trade, secure jobs and hence reduce poverty and in this sustain horticulture as a main foreign currency earner.

II General Principles

This guide is based upon certain food safety principles and practices associated with minimising food safety hazards at each production stage up until field harvesting and grading. By identifying the potential sources of microbial, chemical and physical hazards within the area of growing and harvesting, users of this guide will be better prepared to recognise and address the principal elements known to cause food safety concerns. The food safety measures provided in this guide are adopted from proposals and guidelines provided by various food safety groups, i.e., the Food and Drug Administration (FDA, 1998), Campden & Chorleywood Food Research Association Group, Ministry of Agriculture and Fisheries U.K (MAFF), Fresh Produce exporters Association of Kenya (FPEAK) and the Kenya Flower Council (KFC) codes of practice.

FDA principles of GAP and GHP

Principle 1. Whenever water comes in contact with produce, its source and quality dictates the potential for contamination. To minimise the potential of contamination, water whose source is not certified as potable should not come into contact with the edible parts of produce.

Principle 2. Prevention of contamination of fresh produce is favoured over reliance on corrective actions once contamination has occurred.

Principle 3. Fresh produce can become contaminated at any point along the farm-to-table food chain. The major sources of contamination are associated with human or animal faeces for microbial contamination and abuse of chemicals in the case of chemical contamination.

Principle 4. Practices using animal manure should be managed closely to minimise the potential for microbial contamination of fresh produce.

Principle 5. Workers hygiene and sanitation practices during production, harvesting, sorting, and packing play a critical role in minimising the potential for microbial contamination of fresh produce.

Principle 6. Follow all applicable local and national laws and regulations for good agricultural and hygiene practices.

Principle 7. Accountability at all levels of the production environment for a successful food safety programme is important. Qualified personnel to effectively monitor and ensure that all elements of the programme function correctly and to help trace the origin of produce back to the producer are a necessity.

III Use of guide

This document has been prepared to be used for training by horticultural produce exporters to address the various areas of concern at growing, harvesting and sorting of French beans. Hazards will be assessed and identified along the food chain and pre-requisite food safety management systems (Good Agricultural Practices and Good hygiene Practices) will be proposed as control measures at each target area.

In using this guide it is hoped that the horticulture industry in Kenya can stem the current trend in thinking among UK supermarkets, which associates the small-scale producer with unsafe produce, in favour of the large-scale producers.

The ultimate aim of the guide is to prepare for future implementation of the Hazard Analysis Critical Control Point (HACCP) food safety standards, at the small-scale farmer level. This will be achieved by the implementation of prerequisites food safety management systems including GAP and GHP.

HACCP has emerged as a key component of food safety assurance in the international trade. An HACCP-based approach is recommended by both Codex Alimentarius Commission (CAC) and the World Trade Organisation Sanitary and Phytosanitary Agreement (WTO SPS) as important in reducing food-borne diseases. Most European countries have gone further and developed regulatory strategies for implementing HACCP at all levels in the production chain.

Several important considerations to remember when using this guide are:

1) It can be used by the horticultural export companies as a checklist to assess the level of adoption of food safety procedures by the small-scale producers as advocated herein.
2) It can be used as a basis for training and education programmes by export companies for the small-scale producers through company's technical personnel.
3) It presents broad, scientific based principles developed from current knowledge of food safety practices of HACCP published by, CODEX, FDA, CCFRA, FRESH PRODUCE CONSORTIUM and others, which can be used to help assess the hazards at each specific practice as it applies to the production of French beans.
4) It can be used to support the design and implementation of appropriate food safety management systems.

5) As new information and technological advances expand the understanding of factors associated with identifying and reducing food safety hazards, revisions to update the recommendations and information contained here will be provided.

Section 2

IV FIELD SANITATION

Horticultural food crops should not be grown or harvested where the presence of potentially harmful pathogens would lead to unacceptable levels of such substances in the food. Prevention of food-borne illness begins on the farm.

a. Hazards present in the field

Field hygiene if not properly observed can be a source of contamination, when appropriate procedures that concern the environment where crops are grown are not observed. The growing area can provide a suitable environment for pathogen growth or transfer as either microbial, chemical or physical contamination to produce. Chemical hazards can result from improper disposal of chemical containers and chemical products, or mulch (green manure) from other crops recently sprayed. Examples of microbial contamination that can result from poor field hygiene are, poor methods of domestic waste disposal, presence of livestock in the fields, fields adjacent to animal feed lots and lack of field facilities e.g. latrines which may promote defecating in the field. Physical contamination can be brought about by lack of good waste disposal systems, presence of animals in the field where they leave hairs and droppings.

b Control of potential hazards

i) Waste disposal management

Crops should not be in an area contaminated by domestic/ animal or organic waste.

Waste of any nature should be composted and not spread on crops to reduce risks of microbial contamination. Domestic waste for example should be composted and whatever cannot be, should then be burnt. Chemical product wastes and containers should be disposed of in a manner that does not pose harm to the environment, water, people, animals and crops, either by incineration on puncturing or returning the containers to the manufacturers if such an arrangement is can be made.

ii) Field facilities

Provision of field toilets and hand washing facilities is important in order to reduce risks from microbial contamination.

These should be conveniently located but not adjacent to the crop area, with the hand washing facility where workers must pass on their way back to the fields or packing sheds. Provision and of soap and clean water must be emphasised in order to prevent pathogen contamination.

iii) Harvest containers' management

Harvest containers whether plastic crates or fibreboard boxes should be stored away from any source of contamination. Use of containers like polyethylene bags used for other purposes should be discouraged as well as personal bags, sacks, cloths etc. Harvest containers should not be stored together with food stuffs or chemicals.

iv) Storage facilities

A farm storage place should be provided for chemicals and harvesting containers. The farm store should not be used for storing foodstuff and neither should they be stored where people sleep or eat. The storage place can be a simple well-ventilated store and should be able to keep water and any source of moisture out. It should be easy to clean to reduce risk of contamination from dust and should be kept free from pests and rodents.

Where a farm store is not possible the export company should provide the farmer with specific amount of chemicals and harvest containers due for use each time there is need.

v) Animals should not graze in the fields and feed lots should not be near the field.

Due to risk of microbial contamination from animal droppings all livestock and pets should be kept away from areas where crops are growing. At the same time crops should not be grown adjacent to animal feed lots for the same reason. Leachate from animal sheds should not be directed to where crops are growing so as to minimise risk of microbial contamination. Animals should not graze on grading sites as well so as to avoid physical contamination from their hair or wool.

V MANURE APPLICATION

Farming practices that emphasise the use of animal manure and animal based compost play an important role in the recycling of organic nutrients and developing a rich soil structure. However, the use of improperly composted manure is likely to contain pathogens of public health significance that can contaminate produce. Crops in or near the soil are most vulnerable to pathogens in manure mainly, where the edible portion of the crop is in contact with the soil.

a. Potential hazards found in animal manure

Animal manure and faecal matter represent a significant source of human pathogens. Some particularly dangerous pathogens e.g., *Escherichia coli* O157:H7, *Salmonella* and *Crytopsporidium* are well known to originate primarily from ruminants such as cattle and sheep, whereas *Salmonella* has been known to originate mainly from chicken manure. The use of manure must therefore be closely managed to limit the potential of pathogen contamination.

b. Control of potential hazards

Good agricultural practices for the use of animal manure include proper composting to reduce pathogens, proper application methods and maximising the time between application to production areas and harvest of the crop. This is because, animal faeces is a known source of pathogens that can cause food-borne illness.

i) Good agricultural practices for manure management

Growers should follow good agricultural practices for handling manure to reduce the introduction of microbial contamination to produce.

These practices include, composting manure and minimising direct or indirect contact between raw manure and the edible part of produce.

ii) Types of treatments that reduces pathogen levels

Manure treatment will depend on needs and resources of an individual farmer. Two types of treatments that can easily be used by the small-scale farmers are:

- **Passive treatments**

  These rely primarily on the passage of time, in conjunction with environmental factors, such as temperature and moisture fluctuations and ultraviolet irradiation, to reduce pathogens. To minimise microbial hazards, growers relying on this method should ensure that manure is well aged and decomposed before applying it to the field.

  These will all depend on seasonal climatic factors both of rain and sunshine as well as the source of manure.

- **Active treatments**

  Active treatments generally involve a greater level of management. The most common method is composting. This is used to reduce the microbial hazards of raw manure.

  It is a controlled and managed process in which organic materials are digested, aerobically or anaerobically, by microbial action. When this is carefully controlled and managed, and the appropriate conditions are achieved, the high temperature generated can kill most pathogens in a number of days. This therefore reduces the risk of microbial contamination compared to untreated manure.

iii) Handling and application methods

- Good agricultural practices to minimise the time between manure application, harvest and contaminating the crop are important, since the shorter the time between application of raw manure to a crop and harvest, the greater the risk of pathogens being present in manure and hence contamination of the crop.

Its important to avoid manure top dressing to reduce the risks of contamination while making use of this important source of nutrient.

The use of "side-dressing" or "banding" is an important step that can reduce pathogen contamination during production. Use of raw/fresh manure or slurries from feed lots should be avoided as much as possible since this increases the risk of microbial contamination.

vi) **Composting procedures**

Proper composting can reduce *E.coli, salmonella*, and other pathogens found in manure. Compost should be maintained at temperatures of 55-60 degrees C for a period of several days- if possible up to two weeks. As pointed out previously, composting reduces pathogens in several different ways.

One way is by generating temperatures unfavourable to the undesirable organisms. Temperature increases during composting are the result of microbial metabolism. The temperatures generated have the benefit of reducing population of many pathogenic organisms.

VI PEST AND DISEASE CONTROL

Control measures involving treatment with chemicals should only be undertaken under direct supervision of personnel who have an understanding of potential risk to health.

a. Chemical hazards

Pesticides are a group of chemicals designed to control weeds, insects, fungi or other pests on crops, or animals. The most commonly used pesticides are insecticides, and fungicides and prudent use of these have played a vital role in feeding the world's growing population by dramatically increasing crop yield through pest and disease control. However, when improperly used or stored, pesticides can potentially be harmful to humans, wildlife and the environment.

When pesticides are used according to label directions, the remaining pesticide residues do not pose an unacceptable health risk to consumers.

Internationally, the Codex Alimentarius Commission (CAC) has stipulated maximum residue levels (MRLs) for specific pesticides permitted on specific crops. MRLs are not safety limits, but rather they represent the maximum amount of a pesticide, which is expected in a product if a pesticide has been applied correctly to a crop. National regulations in Kenya on the other hand, give guidelines on handling and use of pesticides.

c. **Control of potential hazards**

The decision to use pesticides needs to be made carefully. The first step is to correctly identify the specific pest or pests affecting the crop. The mere presence of a pest or disease in a crop does not necessarily require action against it.

It is rather more important to consider whether the potential economic loss to the crop is outweighed by the cost of applying the pesticide. Some of the methods that can be used to keep pest/disease levels below economically damaging thresholds include a combination of biological, cultural, mechanical and chemical methods.

The above methods should be based on, source of seed (whether certified or not), crop susceptibility to pests and diseases, weather, regular scouting of the field (by a trained company agronomist/ technical staff) and nature and state of adjacent fields. The above principles of pesticide minimisation do not prevent farmers from using pesticides where incidence of pest and disease in the interest of the maintaining efficient agricultural production are justifiable. However, pesticides should only be used when the agro-economic need has been established, provided that a responsible and appropriate approach has been taken, so as to minimise undue risk to human health, livestock and the environment. This should be done in consultation with qualified personnel.

i) **Approved chemicals**

Under no circumstance should products banned in Kenya be used on any crop. All products in use should be registered by the Pest Control Board (PCPB) and should have clear labels and manufacturers instruction.

The application rate of pesticides per given area and the dilution rates must comply with recommendations on the product label and guidance should be sought from company field personnel.

Where a choice exist, products, which are safer to handle and have less environmental impact, should be chosen with advice from company technical personnel.

ii) **Use of spray schedules, record keeping and chemical label guidelines.**

Exporting company should provide farmers with spray schedules as per crop requirements, with manufacturer's information clearly written on container labels, and provide proper supervision, and training farmers on the dangers of abuse of agro-chemicals so as to assist the farmers to use pesticides safely and effectively.

Records should be kept to monitor problems that can arise through abuse, whether on the crop or to the consumer. These should have the time and date of application, amount and type of pesticide, the area under treatment, reason for application and the name of sprayer. Agro-chemical labels should give information on maximum dosage for the crop in question, number of safe treatments, latest timing of application, repeat application, re-entry periods, pre-harvest interval, restriction and precautions, and safe disposal of product and container.

iii) **Sprayer calibration.**

Procedures for preparing application equipment for workers, calibration and proper operation methods with minimum risk to workers should be given through field training and demonstrations.

Faulty, cracked containers are not only a risk to the crop in that it is likely to leak onto the crops and hence increasing residue contamination, but also to the worker's health. Farmers and any of their farm helpers who are involved in spraying and chemical handling should be trained on proper use of equipment and this should be repeated as often as possible.

iv) **Training**

Training of farmers on safe use of pesticide cannot be overemphasised. Most of the problems that are attributed to abuse of chemicals arise from ignorance and lack of knowledge on what chemicals to apply when and what procedures to follow.

Farmers or field sprayers should be trained on proper storage, handling, mixing, and disposal of empty containers, other contaminated materials and surplus pesticide whether dilute or concentrated. Training should be an ongoing requirement with strict update of new chemicals and market requirements so that farmer is able to appreciate the exporter's concern on pesticide use.

v) **Safe disposal of pesticide residues and containers**

If possible a method of safe disposal of chemical containers should be developed between the exporter and the farmer. This could be done within the spray record form and a column developed where containers supplied are recorded as well as their return.

- A monetary incentive, which provides more than what farmers can get by selling these containers at the markets (and these containers being abused in return), should be explored. Any unused chemicals should be buried and never emptied in rivers and ponds. Farmers should know the dangers both to crops and human of keeping chemicals in other containers e.g. beverage bottles.
- Alternatively each farmer can select a small place away from crops, and use this to burn empty containers only after **puncturing** in case of ***metals and drums*** **BUT** not ***aerosol*** cans**.** ***Plastics*** should be rinsed (but not in rivers, ponds or streams), punctured and burned and ***cardboard*** should be burnt.

VII WATER

Wherever water comes into contact with fresh produce, its quality dictates the potential for pathogen contamination.

Water used in crop production involves numerous field operations including irrigation and application of pesticides and fertilisers.

Water of inadequate quality has the potential to be a direct source of contamination and if pathogens survive on the produce, they may cause food-borne illness.

a. Water hazards

Water can be a carrier of many microorganisms including pathogenic strains of E.coli, *Salmonella* spp, *Vibrio cholerae, Shigella* spp, *Cryptosporidium parvum, Giardia lamblia, Cyclospora cayetanensis, Toxiplasma gondii,* and the Norwalk and hepatitis A viruses. Even small levels of contamination with some of these organisms can result in food borne illness. Use of contaminated water for irrigation has been shown to increase the frequency of pathogen isolation from harvested produce.

Disposal of hazardous materials, like, pesticide/ chemical containers and products in rivers and open water sources for irrigation purposes can be a source of chemical contamination on fresh produce.

b. Control of potential hazards

The quality of water, how and when it is used, and the characteristics of the crop influence the potential for water to contaminate produce.

The quality of water in direct contact with the edible portion of produce may need to be better quality compared to uses where there is minimal contact.

Surface water close to untreated sewage or open latrine or a livestock operation should not be used in overhead irrigation in order to minimise risk of contamination. Disposing chemical wastes in irrigation water must be avoided.

Use of simple drips, furrows or basin methods of irrigation should be considered practices.

i) Irrigation methods

In order to minimise microbial food safety risks, irrigation practices that expose the edible portion of plants to direct contact with contaminated water should not be used. Use of alternative irrigation methods that direct water to the ground surface such as furrow, basin and drip irrigation should be considered in place of overhead wherever possible.

ii) Water source

- There should be communal efforts by water users within a common water source at each 500m to where irrigation is being done to avoid disposal of hazardous wastes like chemical containers.

Latrine or open sewage within the same distance and as much as possible livestock operations should be limited to minimise animal access to water source mostly when irrigation operations are being carried out. Latrine should not be located near open water source used in irrigation or in a location that would subject it to potential runoff in the event of heavy rains. Runoff from improperly constructed and located toilet facilities has the potential to contaminate soil water source produce animals and workers. Chemical containers and waste products should never be disposed off in water.

VIII WORKER HYGIENE

Existing state and national regulations regarding standards for worker health, hygiene and sanitation practices during growing, and harvesting should be followed to minimise the risk of contamination or transmitting of food-borne pathogens.

a) Hazards associated with field workers

The importance of field workers understanding and practising proper hygiene cannot be overemphasised. Workers can unintentionally contaminate fresh produce, water supplies, and other workers, and transmit food-borne illness if they do not follow basic hygiene principles. Some of the pathogens that can be transmitted by workers include Salmonella spp, Shigella spp, E.coli O157: H7, and hepatitis A viruses.

b) Control of potential hazards

Train all workers to follow good hygiene practices.

- All workers should have a good working knowledge of basic sanitation and hygiene principles. If formalised training is not possible or practical, verbal instructions and demonstrations on proper health and hygiene practices, such as hand washing practices should be done. These should be explained in relation to their importance on food safety and should include, use of clean water and soap on use of toilet and before commencing work with produce. Employees with open sores, boils or infected wounds located on parts of the body that might have contact with produce during harvesting, sorting, or packing, should not take part in these activities so as to minimise the risk of contaminating fresh produce.

All workers should understand that good hygiene not only protects the workers from illness but it reduces the potential for contaminating fresh produce which if consumed by the public could cause both economic and social problems.

i) Field facilities-toilets and hand-washing

Toilets should be accessible for use. The more accessible the toilet the greater the likelihood that they will be used. Workers should always have the opportunity to use the facilities when they need to and not only when they are on break. This will reduce the incidence of workers relieving themselves elsewhere in the field and thus increasing the risk of faecal contamination.

IX TRACEABILITY AND DUE DILIGENCE

Due diligence means, having all the precautions of a safe food product in place. The ability to identify the source of a product can serve as an important complement to good agricultural and hygiene practices intended to minimise liability and prevent the occurrence of food safety problems. Traceability is the ability to track food items, including fresh produce, back to their source (growers, packers etc.)

A system to identify the source of fresh produce cannot prevent the occurrence of a food-borne hazard that may lead to an initial outbreak of food-borne disease. However, the ability to identify the source of a product through traceback can serve as an important complement to good agricultural and hygiene practices intended to prevent the occurrence of food safety problems. Information gained from traceback investigation may also be useful in identifying and eliminating a hazardous pathway.

a. Record keeping- types of records

- All farm operation records should be kept as evidence to show that all steps that are necessary to produce safety have been taken to eliminate, control or minimise hazards.

- There should be records to show that manure application has been done as proposed so as to minimise contact between the edible parts of the crop and the manure and in this way control or minimise microbial contamination and documented evidence showing that proposed irrigation methods are practised.

- There should be documented records on user training on all the aspects of chemical handling procedures, so as to provide information that all necessary steps and corrective actions have been taken to avoid and minimise chemical residue hazards. Records should show that the chemicals are registered for use on the particular crops and that they have all the necessary information on the labels. Records on each chemical application for each crop should be maintained showing the date, chemical name, dosage, pre-harvest interval and expected harvest.

Training of the farmers and field workers should be done at the local level and even if done verbally it should be documented. Training of supervisors should be done by an approved pesticide officer and should be documented.

b. **Monitoring of production practices**.

Records on the various aspects of production that are critical to produce contamination should be able to demonstrate the monitoring procedures that are applied.

As outlined in the guide, the major production areas of concern are **WATER QUALITY, MANURE, WORKER HYGIENE, FIELD HYGIENE/ FACILITIES, AND PEST AND DISEASE CONTROL.**

Growers should be trained to consider all the areas of potential source of contamination associated with each farm operation and take suggested precautions as control measures. Regular monitoring should be done by trained supervisors to make sure that good agricultural and hygiene practices are followed to ensure that all attempts are put in place to minimise food safety hazards in vegetable production.

X APPENDIX

DEFINITIONS
The following definitions apply to this guide as provided by Codex Alimentarius.

Good Hygiene Practices refers to all measures necessary to ensure the safety, soundness and wholeness of food at all stages from its growing, production and processing environment.

Good Agricultural Practices refers to general practices to reduce food safety hazards in the growing, harvesting, sorting and packing of produce.

Hazards mean a biological, chemical or physical agent in, or condition of, food with the potential to cause an adverse health effect.

Pathogen means a microorganism capable of causing disease or injury.

Microorganisms include yeasts, molds, bacteria, protozoa, worms, and viruses.

Composting refers to a managed process in which organic materials, including animal manure and other wastes, are digested aerobically or anaerobically by microbial action.

Control measures means any action or activity that can be used to prevent, reduce, or eliminate a food safety hazard or reduce it to an acceptable level.

Critical control Point (CCP) means a step at which control can be applied and is essential to prevent or eliminate a food safety hazard or reduce it to an acceptable level.

Monitoring means the act of conducting a planned sequence of observations or measurements of control parameters to assess whether a CCP is under control.

Equipment and containers means containers used for harvesting of Fresh produce.

Pest and disease control means control measures involving treatment with chemical methods.

HACCP means a system, which identifies, evaluates, and controls hazards, which are significant for food safety.

Control means to take all necessary actions to ensure and maintain compliance with criteria established in the HACCP plan.

Corrective action means any action to be taken when the results on monitoring at the CCP indicate a loss of control.

Contaminant - any biological or chemical agent, foreign matter, or other substances not intentionally added to food which may comprise food safety or suitability.

Contamination- the introduction or occurrence of a contaminant in food or food environment.

Food hygiene-all conditions and measures necessary to ensure the safety and suitability of food at all stages of the food chain.