GLOBAL HORTICULTURE ASSESSMENT

June 30, 2005

USAID
FROM THE AMERICAN PEOPLE

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AVRDC
The World Vegetable Center

MICHIGAN STATE UNIVERSITY

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List of Acronyms

AERI - Agricultural Exports and Rural Incomes
ANE - Asia/Near East region
APAARI - Asia-Pacific Association of Agricultural Research Institutions
ART - Anti-Retroviral Therapy
ASNAPP - Agribusiness of Sustainable Natural African Plant Products
AVRDC – The World Vegetable Center
BRC – British Retail Consortium
CAADP – Comprehensive African Agriculture Development Programme
CBD – Convention on Biological Diversity
CGIAR – Consultative Group of International Agricultural Research
CIDA – Canadian International Development Agency
CIMMYT – International Maize and Wheat Improvement Center
CRSP – Collaborative Research Support Program
DFID – Department For International Development
EIARD – European Initiative for Agriculture Research for Development
EU – European Union
EU-ACP – European Union and African, Caribbean, and Pacific treaty
EUREGAP – European Retail Good Agricultural Practices
FAO – Food and Agriculture Organization
FARA – Forum for Agricultural Research in Africa
FAS- Food and Agriculture Service
GAP – Good Agricultural Practice
GDP – Gross Domestic Product
GHP – Good Handling Practices
GMP – Good Manufacturing Practices
HACCP – Hazard Analysis Critical Control Points
HIV/AIDS – Human Immunodeficiency Virus/Acquired Immunodeficiency Syndrome
IAC – InterAcademy Council
IARC – International Agency for Research on Cancer
ICARDA – International Center for Agricultural Research in the Dry Areas
ICM – Integrated Crop Management
ICRISAT– International Crops Research Institute for the Semi-Arid Tropics
IFPRI – International Food Policy Research Institute
INIBAP – International Network for the Improvement of Banana and Plantain
IPM – Integrated Pest Management
IPR – Intellectual Property Rights
IR4 - Interregional Research Project #4
IRRI – International Rice Research Institute
ISHS – The International Society for Horticultural Science

IWMI – International Water Management Institute
LAC – Latin America and Caribbean region
NAFTA – North American Free Trade Agreement
NARES – National Agricultural Research and Extension Systems
NEPAD – New Partnership for Africa's Development
NGO – Non-Governmental Organization
PNUCID – United Nations Programme for Control of International Illicit Drugs
PROTA – not an acronym – EU NGO affiliated with the University of Wageningen; works to catalogue useful African plants
PVP – Plant Variety Protection
SPAAR – Special Programme for African Agriculture Research
SPS – Sanitary and Phytosanitary measures
SSA – Sub-Saharan African region
TRIPS – Trade-Related Intellectual Property Rights
UN – United Nations
USAID – U.S. Agency for International Development
USAID-WARP – USAID West Africa Regional Program
USDA – U.S. Department of Agriculture
USFDA – U.S. Food and Drug Administration
VAD – Vitamin A Deficiency
WARDA – Africa Rice Center
WHO – World Health Organization

EXECUTIVE SUMMARY

Introduction

Growth potential is strong for the production of horticultural commodities in underdeveloped and emerging-economy countries of the world. Development of horticultural crop production promises to provide these countries with the ability to meet domestic food needs and diversify income sources. In addition, horticulture affords excellent opportunities for improvement of human health, and farmer household economic and social advancement. Horticulture commodities are ideally suited to accomplish these objectives because of their high economic and nutritive value, and because they can often serve as an engine for agricultural and economic diversification.

While growth in the horticultural sector presents many opportunities for growing rural economies and improving the livelihoods of many of the world's poor, the rapidly changing dynamics of horticultural markets often act as barriers to participation in the value chain for small farms and firms. Because horticultural development and marketing are strongly dependent upon knowledge, human capital and technical inputs must be provided if interventions and growth are to be sustainable. Small producers and processing firms are frequently eliminated from markets for failure to understand market dynamics or, because of their inability to meet new production, sanitary and quality standards. A dedicated emphasis on research and development initiatives focused on integrating producers and firms into the growing horticultural marketplace will contribute to alleviating poverty, growing economies, and enhancing the quality of life for a significant portion of the world's population.

Successful investments in programs aimed to enhance horticultural production in the developing world should be based upon a strategic assessment of the primary constraints faced by farmers. The awareness of these constraints must be coupled with an analysis of the local challenges for human health, as well as the demands of economic and ecosystem sustainability. In contrast to other areas of agriculture, horticulture has not received significant attention from the development community.

In September 2004, the University of California, Davis, AVRDC-The World Vegetable Center, Michigan State University, Purdue University and University of Hawaii, Manoa, initiated an in-depth, highly collaborative analysis of the opportunities and challenges for global horticultural development, the first study of its kind. As a result of this assessment, we are proposing activities that can form a priority listing for a horticultural research and capacity building agenda. We believe that such an agenda can provide the basis for USAID's portfolio in global horticultural development.

Assessment Methodology

The Global Horticulture Assessment was designed to be highly responsive and heavily reliant on participatory methods, using the following three-phase process:

I. A synthesis workshop to define U.S. stakeholder needs and inputs, and determine global priorities.
II. A series of three regional workshops and an independent survey to determine stakeholder priorities, constraints and opportunities.
III. The analysis, integration and publication of results to guide future collaborative research and development activities in global horticultural development.

Results

More than 750 participants from 60 countries provided direct input to this assessment, either through participation at one of the four workshops or through completion of the survey. This process resulted in the identification of eight significant issues, or primary issues, that either constrain the growth of horticultural development or represent core social considerations across all regions. The term *primary issue* refers to an encompassing issue of core importance to horticultural development that is highly relevant to a diversity of stakeholders across all scales of activity.

While priorities and constraints vary within and across regions, the following eight primary issues, shared throughout the regions, emerged from the assessment:

- Market systems
- Postharvest systems and food safety
- Genetic resources conservation and development
- Sustainable production systems and natural resources management
- Capacity building
- Enabling environment
- Gender equity
- Nutrition and human health

A description of these eight primary issues is provided below and is followed by an analysis of regional differences, a summary table of proposed research and development activities, and a description of the recommended implementation process designed to address these issues.

1. Market systems

The production and trade of agricultural commodities, particularly highly perishable horticultural products, requires that producers have a working knowledge of local, regional and export markets and the ability to readily access those markets and the essential market information. The modern market for horticulture is changing rapidly and new procurement strategies, fueled in part by the growth of supermarkets around the world, increasingly requires producers to meet stringent quality, consistency and quantity standards. In the developing world, local and regional market outlets are undeveloped, and accessing markets is often impossible for lack of adequate inputs and infrastructure. This is a special challenge for small producers because they have neither the resources nor the skills to access and interpret market information, nor adequate financial, human or social capital to develop the linkages needed to succeed in the market. Coordination and information exchange between all elements of the value chain (producers, marketers, exporters, etc.), the creation of stronger producer organizations, targeted investment in market infrastructure, and a combination of carefully focused and well integrated research and development activities will be required to help producers gain access to markets more effectively.

2. Postharvest systems and food safety

Poor postharvest management and lack of knowledge about required technologies, quality standards and food safety protocols severely limit many producers' access to markets. Improper harvest and postharvest procedures in developing countries result in losses that amount to more than 50 percent for perishable horticultural crops. Quality deterioration due to improper harvest and postharvest operations causes short shelf life, rejection by consumers, and contamination risks. While vertical integration has meant that larger producers and wholesalers in the horticultural industry do most of their postharvest management "in-house," smaller producers and firms often lack access to critical postharvest knowledge, technology and infrastructure. Research and development of appropriate postharvest technologies for small and medium-sized producers, value-added processing techniques, food safety protocols and quality standards for horticultural commodities can help to reduce postharvest losses, improve food safety, and contribute to increased producer incomes and the subsequent development of rural economies.

3. Genetic resources conservation and development

Quality seed and planting stock represent a package of genetic technology that is the foundation of a sound horticulture supply chain. Currently, inadequate effort is expended in research and development of appropriate, locally-adapted modern and traditional varieties of horticultural crops, resulting in decreased productivity. The development of high-quality seed and planting stock programs, focused on locally-adapted and market-demanded varieties, will lead to greater yields and higher market values. Because many developing regions are rich in endemic horticultural diversity, they could take advantage of the growing demand for indigenous and traditional crops in local, regional and export markets. In order for regions to exploit the richness of their endemic horticultural diversity, traditional knowledge and native horticultural varieties

must be identified, characterized and conserved. Small local producers have neither the knowledge nor the skills to accomplish these major research and development projects.

4. Sustainable production systems and natural resources management

Compared to cereal crops, most horticultural crops demand high levels of inputs, water and agrochemicals. Negative environmental impacts are inevitable from misuse or mismanagement of chemical inputs. Producers in developing regions often lack access to appropriate inputs and the necessary technical production skills due to inadequate input and credit markets as well as weak extension systems. Research and development of locally-adapted, integrated crop management strategies to address production demands of small producers is critical to ensure sustainable production systems that will meet market demands in the future. Improving access to appropriate inputs and information resources, especially in rural areas, can help farmers raise productivity and contribute to sound natural resource management.

5. Capacity building

Horticulture is perhaps the most knowledge intensive and dynamic agricultural system. Short-term growth and long-term viability are critically dependent on access to technical knowledge, the ability to adapt that knowledge to local conditions and the flexibility to develop new production systems as market conditions change. Capacity building is an integral component of each identified primary issue. Lack of human, institutional, and research capacity inhibits innovation, technology adoption, and the development of solutions to address key constraints in the horticultural industry. The development of effective education and extension networks, involving public, private, and civic sector collaborations, will strengthen the technical capacity of horticultural producers and improve the efficiency of current production and marketing systems. Training horticultural experts in participatory research methodologies will build local research capacity and develop relevant solutions to horticultural constraints. Enhancement of capacity at all levels and along all stages in the value chain, from production to postharvest and marketing, is critical to the creation of a dynamic and sustainable horticultural industry.

6. Enabling environment

An enabling environment can be defined as the set of interrelated economic, social, and political elements necessary for development. A structured, reliable enabling environment plays an especially critical role in determining success in modern horticulture. Horticulture requires a sound legislative and policy framework, adequate local and regional infrastructure, and institutions with a focus on capacity building, management instruments, and monitoring and evaluation. Social and political stability are also necessary components of a secure enabling environment. Examples of important policy considerations include regulatory systems for horticultural standards; clarification and application of intellectual property rights agreements; secure land tenure and credit markets for small producers and agribusinesses; water use systems; and postharvest and food safety protocols. Significant research will be required to determine the effects of intellectual property rights on production choices; the consequences of trade liberalization and market aggregation for small producers and households; credit markets; and operation of up-to-date phytosanitary monitoring systems.

7. Gender equity

In today's horticultural industries, women play significant roles as farmers, agricultural business laborers, entrepreneurs, and consumers. Women face unique constraints in horticultural production systems including inadequate or unequal access to land, credit, technology, information, and working conditions. Nevertheless, women have much to gain by investment in the horticultural industry, including increased opportunities for employment and income generation. Gender-based research has informed development agencies of the critical importance of the specific roles and needs of women to ensure a project's success. The knowledge intensive nature of horticulture will require that women have access to educational opportunities and that technical information is delivered in a gender sensitive manner. Future horticultural development must consider women's roles and needs in culturally-specific food systems, emphasize research on women's participation in small-scale production for export; include comparative research on gendered dimensions of horticultural production across regions and market levels; and document women's particular constraints and opportunities in the horticultural sector.

8. Nutrition and human health

Horticultural crops play a valuable role in food systems by diversifying diets and increasing dietary consumption of micronutrients and other plant products known to benefit human health (fiber, antioxidants, etc.). Supplements and fortified foods can effectively address micronutrient deficiencies in the short-term, but food-based solutions, such

as increasing the consumption of vegetables, legumes, and fruits represent the most sustainable method of reducing and controlling micronutrient deficiencies in resource-poor communities. Analysis of the nutritional properties of select indigenous and traditional crops and varieties, and the bioavailability of specific nutrients from enhanced mineral rich foods and food mixtures can help to determine which crops should be promoted and marketed for their health benefits. Research into how processing affects the bioavailability of certain nutrients and the limitations for utilizing crops as supplements for high-risk groups will permit the design of effective food-based nutrition interventions. Cropping systems research, including the effects of soil quality and fertilizers on the mineral content of food, as well as manipulation of the cropping mix to foster dietary diversity, optimization of irrigation and fertilization regimes, postharvest handling and storage and control of pests and diseases can all contribute to the density of nutrients in a diet.

Regionally-Specific Context and Focus

In addition to the eight primary issues that are equally relevant to all regions, regionally-specific priorities were also identified by stakeholders.

Sub-Saharan Africa

Although horticultural production has risen steadily in most regions of the world over the past few decades, the average annual growth in per capita supply of horticultural produce was negative in sub-Saharan Africa between 1971 and 2000 (Weinberger and Lumpkin 2004). Stakeholders in sub-Saharan Africa highlighted the need to develop local and regional markets because inadequate transportation infrastructure and inability to comply with EUREPGAP standards limits their participation in export markets throughout the region. Many producers lack access to even their local and regional markets making the development of cold-chain, transportation, and communications infrastructure critical to linking producers with these markets. Stakeholders throughout the region emphasized the importance of accessing and promoting the untapped wealth of indigenous crops and genetic resources for improving nutrition and incomes. Capacity building for horticultural business management, as well as training for scientific capacity and research, were also identified as priorities. Horticultural crops represent an opportunity for enhancing the diets of people living with HIV/AIDS, as well as for increasing the incomes of women, the traditional producers and marketers of horticultural crops throughout the region.

Latin America and the Caribbean

Latin America and the Caribbean currently export a high percentage of their horticultural products, especially to the United States; Mexico supplies the majority of the fresh vegetables consumed in the U.S. Despite some notable successes involving small producers, however, the majority of LAC smallholders remain disenfranchised from the thriving export market. Stakeholders in Latin America and the Caribbean stressed the necessity to create opportunities for smallholders to access niche export markets for high-value and brand-marketed products such as Fair Trade and certified organic products. The ability to meet strict phytosanitary standards of export markets will be accomplished only with increased extension assistance and with local adoption of Good Agricultural Practices (GAP) and Good Handling Practices (GHP). LAC stakeholders emphasized the need for research, conservation and increased commercialization of indigenous fruits. Research and extension for management of natural resources and cultivation on hillsides and other marginal land, as well as appropriate crop selection, testing, certification and quality assurance programs are of critical importance to all producers, large and small and is essential to reverse widespread environmental degradation. Despite their prominence in export horticulture, most Latin American countries consume inadequate amounts of fruits and vegetables as a result of limited access, poor quality and inadequate safety of the available produce. While there is significant potential for expansion of local production and consumption, product quality and reliability must be enhanced and there must be a coordinated public education campaign to emphasize the benefits of fruits and vegetables before this potential can be realized. Programs aimed at children are especially important if the dramatic increase in child health problems of malnutrition and obesity are to be reversed.

Asia and the Near East

The Asia and the Near East region is a remarkably heterogenous area characterized by a great diversity of agroclimatic zones, allowing for the production of almost any crop species and supporting a considerable richness in dietary diversity and indigenous species of regional interest. Most of the region suffers from poor market distribution, lack of adequate water (except in the humid tropics), a low level of market development, and generally poor infrastructure and

human capital development. Stakeholders in ANE stressed the importance of protecting intellectual property rights and conducting research to characterize and commercialize promising indigenous herbs and medicinals. Participants and respondents emphasized the need for varieties adapted to the diverse agroecological zones throughout the region, especially cultivars adapted to the climatic extremes of drought and high humidity, and the expansion of protected cultivation techniques to reduce seasonality. Appropriate water management was a priority throughout the region; research and development of strategies to maximize water use for smallholders will be important to ensuring the growth of the industry.

Research And Development Priorities

Table 1 provides a summary of the primary issues and sub-issues that constrain horticultural development, and the principal global and regional research and development activities needed to address these issues. Horticulture is a knowledge-dependent and highly integrated activity; the success of any individual research and development activity is intimately dependent on the efficient operation of each stage in the production chain. Capacity building and knowledge generation is of core importance to all aspects of horticultural development.

Conclusions and Recommendations

The potential benefits of horticulture for the developing world are numerous. Economic growth in horticultural products has far exceeded the growth of other agricultural commodities, and the demand for horticultural produce continues to accelerate in both domestic and international markets. This growth is fueled by affluent urban consumers in developing countries, as well as by consumers in developed countries whose diets are increasingly incorporating greater amounts of horticultural products. Simultaneous with this growth in demand is an increasing relocation of production from the developed world to the developing world. Many parts of the developing world have a relative advantage in the production of horticultural crops by virtue of the relatively high labor-to-land ratio. Small growers can usually earn much higher farm incomes cultivating horticultural products compared to cereal crops, and horticultural production results in rural economic growth and the creation of off-farm jobs through value-added industries and the local marketing of these goods. Horticultural crops also have the potential for benefiting human health by increasing dietary diversity and alleviating micronutrient deficiencies. Crop diversification and proper management of horticultural crops can lead to significant benefits to the environment as well. Women, the traditional producers and marketers of horticultural crops throughout the world, stand to benefit greatly from investment and research in this sector.

The benefits of horticulture have not favored the average small grower. While growth and development in the horticultural sector may present many opportunities for small farmers and rural economies, the rapidly changing dynamics of the global horticultural market often act as barriers to their participation in the value chain. Exporters and supermarket chains require increasingly stringent food safety, quality and reliability standards that small producers and businesses are often unable to meet. Horticultural production is knowledge intensive, highly integrated, dynamic and highly site and market specific. This represents a particular challenge for the rural poor who tend to lack education and resources. Despite its obvious importance, there has been very little adaptive horticultural research and essentially no research on non-commercialized indigenous species in the developing world.

Addressing the challenges and realizing the opportunities of horticulture for development will require significant and well-coordinated investment in research, human capacity development, technical support and enabling environments. To succeed, each activity must be conducted with keen awareness of the complexity and interrelatedness of the horticultural production chain.

There are a number of mechanisms that could be proposed to address the issues and realize the opportunities of horticultural development. Whatever mechanism is developed must recognize the relative advantage of the U.S. universities, must be responsive to USAID-Washington and USAID Missions, and should play a role as an integrator of horticultural development knowledge and as a key partner in program development in the horticultural sector.

Given the dependence of horticulture on knowledge generation, human capacity building and integration across scale and discipline, it would be inefficient to fund isolated, targeted or site-specific activities in the absence of a core integrating program. The development of a core program in horticulture would provide for a degree of program integration, synergy and efficiency that is currently lacking. Short and mid-

term targeted activities will continue to play an important role in horticultural development, but their benefit will be greatly enhanced through coordination and integration.

A successful horticultural development activity must have the following characteristics:

1. Horticulture is a highly technical, knowledge dependent and dynamic industry. To sustain growth in horticulture there is a fundamental need for investment in human capacity building and knowledge generation. The development of a local capacity for independent and creative knowledge generation is essential.
2. The production and marketing of horticultural products is a vertically integrated and strongly interdependent activity. All activities and interventions must reflect this context.
3. A diversity of scales and modes of interventions will be required. Thus activities may address local and/or global scales and may include the continuum of activities from short-term infrastructure investment and technology transfer to long-term research and capacity building.
4. Creative mechanisms for program coordination, knowledge sharing and adaptive research must be emphasized so that coordination of projects is maximized and lessons learned in one activity can inform and improve activities elsewhere.
5. Public-private partnerships will be critical to the equitable development of horticultural enterprises. The private industry has a unique role and interest in the provision of inputs and service for horticulture. Public agencies have an obligation and an opportunity to ensure these inputs are made available to the poor and to ensure the use of inputs is environmentally appropriate.
6. Activities must strive to reduce poverty, stimulate economic growth, improve the environment and support gender and social equity.

Any horticultural investment must develop a cadre of people and a pool of knowledge that can adapt to changing production constraints and market demands. A successful horticultural enterprise is characterized by its ability to adapt, innovate and compromise.

A Collaborative Research Support Program in Horticulture is proposed. This CRSP would be designed to provide the research, capacity building and knowledge extension support essential for the development of the global horticulture sector. The new Horticulture CRSP will partner closely with the World Vegetable Center and its CGIAR partners in the newly developed Global Horticulture Initiative. This partnership ensures synergy and efficiency of programs and directly enhances the capacity to identify and implement key development programs in horticulture.

In addition to its role as a center for knowledge generation, capacity building and integration, the Horticulture CRSP would also partner with individual, regional and global consortia of Missions, and private and public partners to design and implement specific targeted short and mid-term projects that address the core challenges in horticulture identified in this analysis. These projects would be selected on the basis of their regional or global relevance and would be implemented with a goal to develop a product that can be adapted for use by missions globally. The following projects are provided as illustrative examples of high priority projects:

1. Development of Phytosanitary and Postharvest Protocols for the Small Producer.

2. Development of Small Scale Agrochemical and Seed Supply Micro-enterprises

3. Establishment of a Global Horticulture Knowledge Bank and Extension System

The initiative would strengthen the ability of USAID-Washington and the Missions to develop and implement effective programming in the horticulture sector; would strengthen existing USAID funded programs that have a horticulture component and would serve a coordinating and integrating role. The initiative would also partner with existing CRSPs to strengthen their ability to achieve their development goals. A core principle of this initiative is to support USAID and missions by providing program design and implementation advice, technical expertise and coordinated knowledge generation and extension programs.

Table 1. Summary of primary and sub-issues that constrain horticultural development

Subissue	Highlighted Research and Development Priorities	Regional foci
MARKET SYSTEMS		
Increase access to market information	• Analyze constraints to developing market intelligence at the local, national and global levels. • Identify quality, pricing, demand and other relevant conditions for major and promising horticultural products in local, domestic, and international markets. • Develop systems to collect, analyze, and deliver real-time market information to producers and marketers. • Increase partnerships between producers, public institutions, and industry to facilitate market information exchange and develop capacity.	**SSA:** Improve market access and infrastructure; develop local and regional markets. **LAC:** Enhance market linkages and subsequent postharvest and production demands in order to gain access to high price export and tourism markets. **ANE:** Establish regional market standards to differentiate product qualities.
Strengthen producer and marketing organizations	• Analyze the impact of producer organizations on expanding smallholders' access to markets. • Identify and adapt successful models of producer organizations to specific regional and cultural contexts. • Enhance capacity and competitiveness of farmer organizations through targeted training of skill sets and increased linkages with external sources of information and the private sector.	
Impact of changing market systems	• Analyze the costs and benefits explicit and implicit to small farmers and processing firms to produce for and sell to the modern food industry segments compared to traditional market channels. • Determine where modern food industry segments and companies are successfully sourcing from small farms and firms and the conditions for success.	
Investment in marketing infrastructure	• Assess market infrastructure to determine priorities for investment. • Develop appropriate low cost technologies and infrastructure investments to promote efficiency in communications and input access. • Partner with agrochemical and seed distributors to enhance access to inputs by developing small-scale local supply systems.	

Table 1. **Primary issues and highlighted research and development activities.**This table outlines the primary and sub-issues identified during the assessment and several research and development activities recommended for each issue. These activities represent a sample of the activities recommended in the results section of the document; they are not listed in order of priority.

POSTHARVEST SYSTEMS AND FOOD SAFETY		
Develop and disseminate appropriate postharvest technologies for small, medium, and large-scale producers	• Examine the production - market supply chain on a commodity basis and determine points of greatest product loss where cost effective interventions are possible. • Identify, develop, and/or adapt appropriate harvest, storage, transport, processing, and packaging technologies for targeted small and medium producers using locally available materials. • Develop and institute short-term training of individuals involved in postharvest handling, logistics, storage, and safety, in accordance with Good Handling Practices (GHP) and Good Manufacturing Practices (GMP). • Develop basic postharvest data on indigenous vegetables, fruits and ornamental crops with market potential.	**SSA:** Integrate appropriate postharvest infrastructure (cold-chain) for destined market. **LAC:** Enable certification and compliance with food safety protocols for export and regional markets. **ANE:** Enhance infrastructural needs including cold-storage and processing to aid large rural agrarian populations.
Enhancement of value-added processing techniques and opportunities	• Assess viable value-added markets, favorable production areas, and suitable processes; facilitate market linkages. • Develop appropriate value-added processing techniques for small-scale producers, particularly those of low cost, adapted to local resources. • Identify and encourage public/private market linkages to promote the development of agro-processing micro-enterprises for local and regional markets. • Provide necessary credit infrastructure for small farmers to invest in appropriate technology for value-added production.	
Development and extension of food safety protocols and quality standards for horticultural commodities	• Study the levels of pesticide exposure, agrochemical residues and sanitary and phytosanitary conditions of marketed produce, along with related management practices, on a regional basis to determine areas of high risk and potential intervention. • Develop participatory training programs to enable farmer groups to implement Good Agricultural Practice (GAP) and Good Handling Practice (GHP) to meet the standards required for domestic marketing as well as for supermarkets and export markets. • Develop simple low cost rapid assays and monitoring methods for pesticide levels and microbial contamination at the wholesale level.	
GENETIC RESOURCES CONSERVATION AND DEVELOPMENT		
Development of high-quality seed and planting stock programs	• Acquire, develop and evaluate cultivars for target horticultural crops and varied production systems. • Develop seed certification and distribution programs at the regional and/or national levels. • Promote the use and development of local varieties adapted to environmental conditions and pests. • Establish nursery systems for the distribution of quality planting stock to address commercial demand.	**SSA:** Increase quality seed availability; conservation and utilization of indigenous vegetables. **LAC:** Utilization of indigenous genetic material for crop improvement and new crop development. **ANE:** Develop systems to protect intellectual property rights.
Exploration, collection, conservation and utilization of indigenous genetic germplasm and knowledge systems	• Document and inventory indigenous horticultural crops (fruits, vegetables, and medicinals) and knowledge about their use and cultivation at the regional or national level. • Develop replicable propagation systems for select indigenous crops. • Develop participatory *in-situ* conservation strategies for landraces of commercially important horticultural crops.	

SUSTAINABLE PRODUCTION SYSTEMS AND NATURAL RESOURCES MANAGEMENT		
Development of integrated crop managemetn strategies to address horticulural production demands	• Evaluate the effectiveness of ICM techniques at improving soil fertility, water efficiency, pest and disease control, and the production of horticultural crops • Establish and optimize best management practices for new production techniques including covered production (greenhouse and plastic houses), shade production and hydroponic cultivation. • Collaboratively research and develop locally and regionally appropriate IPM practices for crops of horticultural importance. • Document and evaluate the effectiveness of indigenous cropping systems and pest and disease control measures to increase crop productivity.	**SSA:** Development and dissemination of technologies and information on appropriate water application and scheduling. **LAC:** Minimize impact on natural resource base through development and dissemination of information on appropriate usage of inputs. **ANE:** Development of water saving technologies, maximizing efficiency of application.
Access to appropriate inputs and resources	• Identify gaps in input and credit markets on a national and regional basis; develop innovative ways to provide credit to small producers to purchase essential inputs. • Assist in the development of a private agribusiness enterprises to provide seed and agrochemical inputs to small and mid size horticultural producers. • Provide producers with access to information and training about Good Agricultural Practices (GAP) standards and the safe and appropriate use of agrochemicals.	
CAPACITY BUILDING		
Information management and knowledge sharing systems for the horticultural supply chain	• Design an information database to provide technical production and marketing information to all levels of production. • Develop networking and information exchange 'best practices' for retailers, wholesalers, growers and other participants in the production chain. • Develop low-cost and innovative methods of information sharing including: cell phones, radios, and computer technology.	**SSA:** Management skills training for entrepreneurial development and research training and education. **LAC:** Increase partnerships between the private sector and research institutions for certification and information sharing. **ANE:** Assess needs on a country by country basis. Develop networks for information sharing across.
Strengthen human capacity through the development of effective extension and education networks	• Develop North-South and South-South partnerships between research institutes, universities, and extension agents to enhance learning and build research capacity. • Ensure educators are well informed about appropriate information and technologies and the most effective means of delivering information to stakeholders. • Strengthen local extension networks through partnerships with the private sector.	
Strengthen local research capacity with a focus on participatory methodologies	• Provide training in critical production management strategies; design innovative mechanisms to encourage farmer participation and innovation. • Foster innovative partnerships between the public sector, private industry and producers to provide effective training.	
Develop local capacity to conduct advanced research, development and training	• Develop creative, cost effective and relevant long-term training programs to develop local human capacity to ensure long term viability of the industry. • Create public-private partnerships to ensure long-term viability of local research and training facilities.	

ENABLING ENVIRONMENT
• Identify public policies and options needed for the development of efficient and competitive agricultural markets, and to improve the access of small farmers, women and traders to these markets. • Identify and analyze constraints to the rural horticultural industry including food safety regulation, credit, infrastructure, product certification for improved policy development. • Critically evaluate the impacts associated with subsidies, tariffs, quotas, and trade agreements for both developed and developing nations. • Develop and implement appropriate IPR frameworks that protect a nation's rights to equitable profits from utilization of their genetic resources, while encouraging research and development of those resources.
GENDER
• Actively recruit female farmers, scientists and engineers for participatory research. • Emphasize research on women's participation in small-scale production for export. • Prioritize comparative research on gendered dimensions of horticultural production for export and for domestic production and marketing in all regions. • Document region to region variations of women's constraints and opportunities in the horticultural sector.
NUTRITION AND HUMAN HEALTH
• Evaluate select indigenous horticultural crops and cultivars for their nutritional properties. • Analyze the bioavailability of specific nutrients from enhanced mineral rich foods and food mixtures, examine the effects of food processing and postharvest techniques and the effects of soil/fertilizers on mineral content of foods. • Conduct integrated cropping systems research with the explicit goal of enhancing dietary nutrient consumption. Manipulation of the cropping mix, optimization of irrigation and fertilization regimes, postharvest handling and storage and control of pests and diseases can all contribute to the density of nutrients in a diet. • Examine ways to enhance the bioavailability of certain crops through processing to reduce volume and fit within cultural norms. • Involve women and families in the establishment of home gardens coupled with nutrition education to promote the health of families and increase incomes from the sale of surplus produce.

INTRODUCTION

Making the Case for Investment in Horticulture

Development experts and donors agree that research and development investment in agriculture is essential for economic growth in the developing world and to meet the U.N. Millennium Development Goals (Rubin *et al*. 2005, EIARD 2004). The new USAID Agricultural Strategy concludes that "in many developing countries, the agricultural sector's performance determines overall economic growth, trade expansion and increased income-earning opportunities" (USAID 2004). Amongst all agricultural sectors, the production of horticultural crops - fruits, nuts, vegetables, herbs, medicinal plants and ornamentals - represents a particularly promising opportunity for income generation and food production in developing and emerging economies. Horticultural crops are an invaluable instrument for agricultural development because of their high economic and nutritive value, and their latent ability to serve as an engine for agricultural and economic diversification, especially for smallholders who can gear production to specific local, regional or export markets. Horticulture, however, is a highly technical and knowledge dependent process and success is contingent upon the adoption of appropriate cultivars and management technologies, knowledge of market requirements and practices, and appropriate investment in inputs and infrastructure. Unless and until farmers in developing countries can access reliable information and possess the technical skills to apply it, they will be shut out of the boom in horticultural production.

Current and Growing Horticultural Market Opportunities

During the last decades, economic growth in horticulture has far exceeded that in most agricultural commodities. Since the 1970s, annual growth rates for vegetable supplies have surpassed cereals by 200 percent to 800 percent, with much of this acceleration occurring in the 1990s (Table 2). The increasing world consumption of horticultural products is driven by rising incomes, urbanization, awareness of health, and changing labor practices (Rubin *et al.* 2005; EIARD 2004). Developments in production practices, postharvest technology, shipping and storage allow for sourcing of materials throughout the world, providing year-round product availability, and increased market opportunities. Urbanization and changes in

Table 2. Average annual growth rates (%) in fruit and vegetable and cereal supply (per capita)

	Fruits and Vegetables			Fruits and Vegs	Cereals
	1971-1980	1981-1990	1991-2000	1971-2000	1971-2000
China	1.5	7.5	9	6.2	0.8
South Asia	0.7	0.8	2.5	1.2	0.5
East and Southeast Asia	3.4	0.5	1.1	1.2	0.5
Latin America and Caribbean	0.2	1.6	1.4	0.9	0.2
Sub-Saharan Africa	-0.6	-0.4	-0.1	-0.3	0.4
World	0.9	1.6	3	1.6	0.4

Source: Weinberger and Lumpkin 2005.

the labor market, including the expanded presence of women in the workforce, amplify the demand for convenience foods (prepared salads, fresh-cut fruits, restaurant food, etc.) as well as novel and exotic horticultural products that will play a significant role in future demands of high-value products.

Accelerated global vegetable and fruit production since 1960 has resulted in an approximate doubling of per capita supply in developed countries and much of the developing world, with the notable exception of Africa (Figure 1). The vast majority of expansion in horticultural production has occurred through increases in land areas devoted to these crops and greater investment in inputs (irrigation and fertilization), but there has still been only marginal improvement in yields for most species (Weinberger and Lumpkin 2005). In comparison to the significant yield increases in cereal production, the slow and low growth in horticultural yields mirrors the lower levels of research investment in these crops and implies a tremendous unrealized potential for yield improvements.

The United States and the European Union, followed by Japan, are the world's three largest importers of fruits and vegetables. Most horticultural crops imported by these markets are grown in Latin America and the Caribbean (LAC), and Africa, respectively. The strong growth in global markets for horticultural products in both the developed and developing world over the past 30 years has occurred during a period of rising labor costs, escalating environmental constraints and competition for land from urban expansion in the developed world. Elevated costs and scarcity of farm labor have significantly impacted profitability of crops in much of the developed world (white asparagus in Germany, stone fruit in South-East Australia, fresh tomato and citrus in the U.S., etc.) The consequence of these pressures has been the transfer of much horticultural production from the developed world to the developing world, resulting in a ten-fold net increase in imports of horticultural products into the developed world's markets (Table 3; FAOSTAT Data 2004).

Major world markets are subject to considerable competition and price protection. Though export markets are potentially very lucrative, high transaction costs and the lack of necessary technological sophistication limits the participation of many small and medium-sized producers and firms. For much of the developing world, the greatest economic opportunity for horticultural products is in expanding local and regional markets. An estimated 95 percent or more of the world's horticulture produce and market activity is local (Reardon 2003). Even in Mexico, which emphasizes horticultural production for export with over 3 billion U.S. dollars in fruits and vegetables exported to the U.S. in 2003, more than 65 percent of all horticultural trade occurs locally (USDA 2004). Local and regional markets for horticultural products in the developing world can be expected to increase for many of the same reasons that they have burgeoned in the developed world, namely, education and recognition of health benefits, increased urbanization, improved production technologies and market capacity, and more sophisticated retailing. Perhaps a more telling indicator of the potential of local and regional markets in the developing world is population growth, particularly in urban areas, coupled with low current levels of horticultural consumption. The combination of increasing local and global demand for horticultural products, the declining ability of developed countries to meet their own consumption demand, and the relative advantages of land and labor offered by developing countries, represents a very significant opportunity for horticultural growth and economic expansion in developing countries.

Market trends indicate continued growth in horticultural production and trade. Horticulture promises substantial economic, social, health and environmental benefits to smallholders, the rural poor (especially women) and the agro-ecosystems of developing countries. The degree of economic and social benefits actually derived from the transition to and diversification of horticultural production will depend on many factors, including local agro-ecological and environmental suitability, level of technical skill and/or support services and access to a viable market.

Horticulture for economic development and poverty alleviation

In the developing regions of the world, an estimated three billion people exist on less than two U.S. dollars per day (AVRDC 2004a). For the vast majority of small land-holders a focus on the production of staple crops provides very limited prospects for generation of higher incomes. Transition to and/or diversification of horticultural crops can help to revitalize rural economies and alleviate poverty through increased farm profits, employment generation and economic diversification.

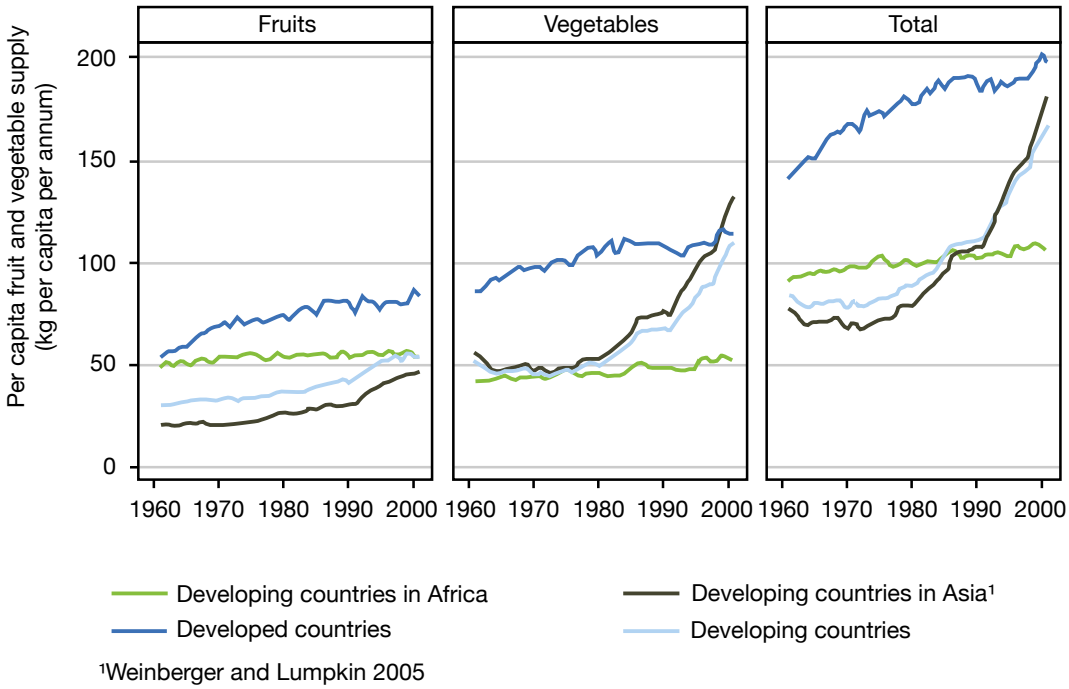
Farmers engaged in high-value horticultural crop production can earn higher net farm incomes than those growing staple

crops (Table 4). Fruit and vegetable producers in India generate five to eight times more in profits than cereal farmers (Subramanian *et al*. 2000). In Kenya, farmers producing fruit, vegetables or flowers for export can earn six to twenty times more than maize growers (Gabre-Mahdin and Hagglade 2003; Minot and Ngigi 2003). The greatest benefits accrued to Kenyan producers of green beans for the European export market, who benefit from a favorable confluence of ideal growing conditions, technically supported growers, excellent infrastructure and strong export market demand.

In addition to the economic benefits of horticulture for the producer, the high labor demands of horticultural production and related processing industries have the added benefit of local employment generation. Per hectare, the production of horticultural crops creates more than twice the number of jobs that cereal production generates (Ali *et al.* 2002). In regions where labor is abundant, horticulture represents a valuable employment opportunity, both for family members during crop growth periods, and hired labor during planting and harvest. A thriving horticulture industry also provides landless laborers and smallholders the opportunity to earn extra income on large farms or in related agro-processing firms (McCulloch and Ota 2002; Weinberger and MSuya 2005).

Horticulture generates economic benefit beyond the farm through associated services and industries. Such farm-related business could include provision of seeds; agrochemicals and infrastructure (irrigation, sheds, etc.); the development of value-added industries such as jams, pickles, dried product, packaging, storing; and transportation of products. Women could potentially benefit most from horticultural employment opportunities because they comprise a majority (50 to 91 percent) of the horticultural labor supply in most developing countries (Barrientos 1999; Hamilton et al. 2001; Korovkin 2003; Dolan 2004). In Mexico, 80 to 90 percent of all individuals involved in packaging are women; evidence from Africa illustrates a similar pattern (Dolan and Sorby 2003; AVRDC 2004a). Additional opportunities for income generation and production diversification may decreases risks for smallholders and ultimately increase food security.

Figure 1. Per capita fruit and vegetable supply



¹Weinberger and Lumpkin 2005

Table 3. Net trade in fruit and vegetable and food products (billion US$)

Year	China	South Asia	East and SE Asia	Latin Amer. And Caribbean	Sub-Saharan Africa	Developed Countries
Fruits and vegetables						
1970	0.38	0.04	0.1	0.51	0.05	-2.54
1980	1.04	0.2	1.04	1.82	0.07	-8.19
1990	1.97	0.05	1.6	5.68	-0.01	-18.67
2000	2.56	-0.03	1.24	8.3	0.32	-20.04
All food products						
1970	0.52	0.03	-0.49	4.27	1.52	-7.65
1980	-1.07	1.35	-0.24	15.26	1.96	-16.26
1990	1.84	0.92	0.58	15.27	0.76	-24.38
2000	3.11	1.93	-3.21	16.08	-0.44	-12.85

Source: Weinberger and Lumpkin 2005

Horticulture for improved health

The increased demand for horticultural products in the developed world is driven by the recognized health benefits of a diet sufficient in fruits, vegetables (including vegetable based oils) and nuts. Many vegetables and fruits are rich in beneficial phytonutrients including lycopene, beta-carotene and other antioxidant compounds that can reduce the risk of chronic disease by protecting against free-radical mediated damage (Southon, 2000). Obesity, epidemic in the developed world and rapidly gaining in the developing world, is best combated by shifting consumption from processed, starch-based foods towards consumption of fresh horticultural crops (U.S. Dept. of HHS 2005). The new USDA dietary guidelines call for the consumption of five to ten servings of fruits, nuts and vegetables each day. These recommendations correspond to a combined consumption of 700 to 1200 grams per day, an increase of more than a 200 percent over current U.S. per capita consumption (U.S. Dept. of HHS 2005). The recognition that greater consumption of fruits and vegetables has beneficial health outcomes is becoming increasingly widespread in the developed world and underscores the likelihood of increased demand.

In many parts of Asia, Africa and Latin America the consumption of fruits and vegetables is inadequate for health. Diets low in fruits and vegetables are typically deficient in a range of nutrients, vitamins and phytonutrients essential for human health. Micronutrient deficiencies, which affect more than two billion people worldwide, increase disease susceptibility in all populations and compromise the development of cognitive capacity in children. The impacts on human development, as well as clinical symptoms resulting from micronutrient deficiencies, disproportionately affect women and children in the developing world, thereby exacerbating the cycle of poverty (Demment *et al.* 2003). Economic losses resulting from decreased human capacity and productivity as a result of micronutrient deficiencies are so substantial that economists at the Copenhagen Consensus agreed that alleviating this concern should be one of the highest priorities among world development initiatives, second only to relieving the HIV/AIDS crisis (Economist 2004).

Increasing consumption of fruits, vegetables and nuts is the most sustainable strategy for mitigating micronutrient deficiencies. Biofortification of staple products and development of genetically modified cereal grains, while potentially effective, does not offer the suite of health benefits that are attained by an increase in consumption of fruits, nuts and vegetable. Increased production of horticultural crops can facilitate access to a range of nutrients, vitamins and phytonutrients essential for human health while improving smallholder incomes.

Paradoxically, obesity is becoming an increasing problem in many developing countries and is particularly worrying in transitional countries. In 2000, 115 million of the estimated 300 million obese individuals resided in developing and transitional countries; in Thailand the prevalence of childhood obesity rose from 12% of the population to 16% in just 2 years (WHO 2000). From 30-40% of all adults are overweight in the developing and

Table 4. Net farm income per family member of horicultural versus non-horticulutral smallholder farms.

Country	Difference in farm income (%)
Kenya	497
Bangladesh	29
Cambodia	117
Lao PDR	380
Vietnam (northern)	20
Vietnam (southern)	189

Source: Weinberger and Lumpkin 2005.

transitional nations, including Chile, Mexico, Peru, Colombia (FAO 2005). Increased consumption of fruits, vegetable and nuts is recognized as an important component of a leaner, healthier diet.

Horticulture for an improved environment

Horticultural production is invariably more intensive and input dependent than staple or broad acre crop production, and consequently, can increase risk of environmental degradation if managed improperly. However, appropriate horticultural management can yield significant environmental advantages. Crop diversification, planting of nitrogen-fixing species and species that enhance carbon sequestration and increase soil organic matter, and those that reduce soil erosion, all benefit the environment. Horticultural cropping systems have the potential to provide great flexibility in planting decisions, allow for almost continuous year-round ground cover and contribute to greater degrees of biodiversity than mono-cropped cereal production. In Asia, the AVRDC-The World Vegetable center has introduced the cropping of mung bean during the short fallow season after harvesting wheat and before planting rice to alleviate many of the problems associated with intensive cereal production. Mung beans also enhance the diets of farming communities as they are rich in iron and other micronutrients necessary for human development and health. In the Indo-Gangetic plains of India, economic studies indicate that farmers practicing mung bean rotation have increased their incomes up to 27 percent, due in part to the increased rice yields associated with the nitrogen-fixing benefits of mung bean rotation (AVRDC 2004b). In the Sudano-Sahel, ICRISAT is collaborating with local researchers on projects to introduce perennial horticultural species into annual cereal rotations to improve soil health, arrest desertification, contribute to biodiversity, and raise producer incomes (See Case Study 6: New Cropping Systems for the Sahel).

The benefits of investment in research and human capacity building

Horticulture has the proven potential to stimulate economic growth, reduce poverty, and address issues of inequity and environmental degradation in developing countries. While there is significant potential for horticulture to contribute to a variety of development goals, the conditions for success and sustainable growth are complex and not well articulated, underscoring the need for research investment. Production systems for horticultural crops in much of the developing world have not been adequately researched and most growers lack a sufficient technical knowledge base. Furthermore, the complexities of marketing perishable produce, minimizing storage and transport losses and complying with strict sanitary and phytosanitary standards are beyond the capacity of most smallholders. The nature of the modern horticultural production and market system demands that producers, shippers and marketers of horticultural products be technically competent, and able to respond quickly to market opportunities and coordinate information transfers throughout the value chain.

Technical knowledge and the ability to adapt to changing market circumstances are paramount to the success of horticultural industries and only very few low and middle-income countries have managed to sustain long-term growth in horticulture. The nations that have been able to maintain growth and profitability have done so by developing the research, training, infrastructure and technologies critical to sustaining this success, notably Chile, Mexico, Kenya, and Egypt. One striking aspect of the Chilean horticultural industry since 2000 has been the marked increase in non-governmental extension services and industry-supported research programs. This outcome, was only possible as a result of public sector investment in universities and governmental coordination and oversight of research programs. Countries that failed to invest in research and human capacity building have experienced short-term growth or growth in a limited number of highly targeted crops, but have not achieved sustained growth and development in this sector.

Because of the technical, knowledge dependent and dynamic nature of horticulture, growth cannot be sustained without a

well trained workforce and a local capacity to conduct both original and adaptive research in all aspects of production, handling and marketing.

Despite the clear benefits of horticultural crop production for developing nations, horticulture has received vastly less development and research investment than cereal grains. Between 1968 and 1996, USAID was one of the largest donors to international research centers focused on cereal crops such as rice, wheat and maize (IRRI, WARDA, CIMMYT). During this same period, USAID provided centers focusing on tropical fruits and vegetables, such as INIBAP and AVRDC, with less than one-tenth the amount invested in the staple crop centers (Weinberger and Lumpkin 2005). Although the Consultative Group on International Agricultural Research (CGIAR) has recently expressed interest in high-value horticultural crops, investment in the sector is still inadequate. In 2003, the CGIAR invested 118 million U.S. dollars in research for cereals compared with only 15.7 million U.S. dollars for fruit and vegetable research (Weinberger and Lumpkin 2005). Nevertheless, growth percentages for horticulture currently exceed all other major commodities, and on a global level the value of all fruits and vegetables traded is more than double the value of all cereals traded (Diop and Jaffee 2005; Weinberger and Lumpkin 2005). The potential of the horticultural sector to stimulate economic growth of developing economies and reduce poverty has only recently been recognized. Consequently, horticulture has become an explicit priority in the recent development agendas of most donors, research and implementing agencies (Rubin *et al*. 2005). Many of the priority issues in horticultural development identified by this assessment link to the strategic themes outlined in USAID's New Agricultural Strategy (see Table 5).

Summary

Irrespective of the scale of production or target market (local, regional, international), the Global Horticulture Assessment revealed significant opportunity for the expansion of horticulture in developing countries. In order for this expansion to succeed, and more importantly, for that expansion to benefit the rural poor in those countries, many challenges must be addressed through a combination of targeted research, human capacity enhancement and integrated development activities. Given the complexity and interrelatedness of all aspects of horticultural production, the efficiency and effectiveness of development interventions will depend not only on how well they are designed and implemented, but on how well they are integrated from research to field application and from farm to fork. Though research is often viewed as an expendable and non-essential component of the development process, it is in fact critical to the most efficient use of development dollars. Investment in research is an investment in project design, implementation and integration. Relevant new information, obtained through targeted research, is essential to understanding the context in which interventions will be implemented. The average rate of return to public agricultural research and extension is 81.3 percent (Alston *et al.* 2000).

Given the technical nature of horticulture, investment in research, extension and human capacity building is of paramount importance. Only from this base can economic growth in horticulture be sustained.

Table 5. Linkages to the *USAID New Agricultural Strategy*. Demonstrates the linkages between the primary and sub-issues identified during the course of the assessment and USAID's Agricultural Strategic Themes. The sub-issues within each primary issue are not ranked against one another; specific research and development activities for each sub-issue are detailed in the results section (III).

Global Research and Development Priorities	USAID Ag. Strategic Theme(s)
MARKET SYSTEMS	
Increase access to market information	1, 3, 4
Strengthen producer and marketing organizations	1, 2, 4
Impact of changing market systems	1, 2
Investment in marketing infrastructure	1, 4
POSTHARVEST SYSTEMS AND FOOD SAFETY	
Develop and disseminate appropriate postharvest technologies for small, medium, and large-scale producers	1, 2, 3, 4
Enhancement of value-added processing techniques and opportunities	1, 3
Development and extension of food safety protocols and quality standards for horticultural commodities	1, 3
GENETIC RESOURCES CONSERVATION AND DEVELOPMENT	
Development of high quality seed and planting stock programs	2, 3
Exploration, collection, conservation and utilization of indigenous genetic germplasm and knowledge systems	2, 4
SUSTAINABLE PRODUCTION SYSTEMS AND NATURAL RESOURCES MANAGEMENT	
Development of integrated crop management strategies to address horticultural production demands	2, 3, 4
Access to appropriate inputs and resources	1, 2, 4
CAPACITY BUILDING	
Information management and knowledge sharing systems for the horticultural value chain	3, 4
Strengthening human capacity through the development of effective extension and education networks	3, 4
Rebuild local scientific and technological capacity through innovative degree and non-degree programs	1, 2, 3, 4
Strengthen local research capacity with a focus on participatory methodologies	3, 4
ENABLING ENVIRONMENT	
Critical evaluation of macroeconomic policies (tariffs, subsidies, trade agreements) that affect the horticultural industry	1, 2
Institution of effective IPR frameworks to protect national rights to genetic resources	1, 2, 3
Regulatory mechanisms for protecting natural resources, worker and consumer safety, and rights of small producers/firms	1, 2
GENDER EQUITY	
Actively recruit female farmers, scientists and engineers for participatory research	3, 4
Research on gendered dimensions of horticultural production across and within regions	2
NUTRITION AND HUMAN HEALTH	
Evaluation of select horticultural crops for their nutritional properties and bioavailability	2, 3
Development of appropriate food-based solutions to alleviate micronutrient deficiencies and other health concerns	2, 3

Key: USAID Agricultural Strategic Themes: **1**) Expanding Trade Opportunities and Improving Trade Capacity of Producers and Rural Industries, **2**) Improving the Social, Economic and Environmental Sustainability of Agriculture, **3**) Mobilizing Science and Technology and Fostering Capacity for Innovation, **4**) Strengthening Agricultural Training and Education, Outreach and Adaptive Research

II. METHODOLOGY

Introduction

The Global Horticulture Assessment was designed to be highly responsive and focused on priorities determined by stakeholders. Specific development, capacity building and research recommendations have been proposed. The resulting research and development project suggestions are problem-oriented models built on a foundation of true collaboration. The following principles, developed from previous experience in similar activities, guided the assessment methodology:

- A combination of ***top-down and bottom-up input*** is key to identifying globally relevant themes and locally adapted priorities.
- ***Regional participation*** is an essential component of the process in order to develop a portfolio of challenges and opportunities that are current and pertinent.
- ***Recommendations should be collaborative, efficient and sustainable.***
- Researchable issues should be developed into ***problem models*** that comprehensively define the challenging problem to be addressed and aim to provide practical solutions.

These principles, also employed in the Global Livestock Collaborative Research Support Program (CRSP) portfolio and endorsed by the CRSP Administrative Management Review Team (USAID 1997), place considerable importance on stakeholder input, team building and planning.

Stakeholder Input

The horticulture assessment was guided by input from three sets of stakeholders. The first level consisted of the USAID Washington, U.S. Universities, Congress and the domestic horticulture industry. The national research institutes in developing countries, the National Agriculture Research and Extension Systems (NARES), governmental agencies, national universities, and USAID Missions comprised the second level. The third level of stakeholders included the users of research products in the field, including farmers, households, consumers, private sector stakeholders including but not limited to packers, traders, supermarkets, processors and suppliers of ancillary goods and services (certifications, irrigation, cooling, etc.). The Global Horticulture Assessment sought input at all three levels through a highly participatory process involving workshops, surveys, and integration of outside documentation reports and reviews.

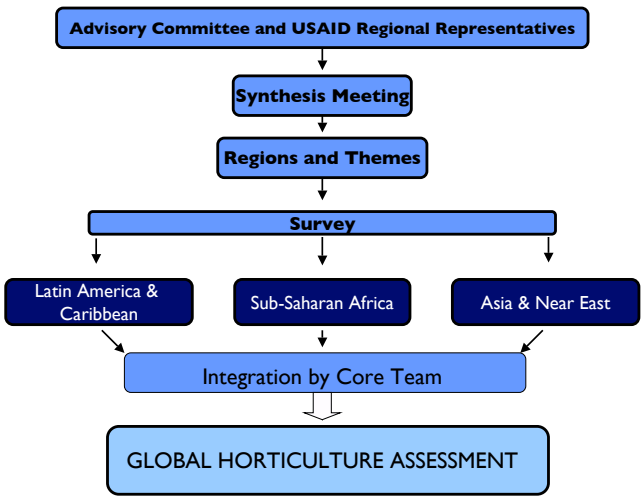


Figure 2. This diagram is an outline of the assessment process utilized for the Global Horticulture Assessment.

Partnership

The Advisory Committee (Planning and Coordinating Committee) consisted of representatives from University of California, Davis; AVRDC-The World Vegetable Center; University of Hawaii at Manoa; University of Michigan; and Purdue University, as well as USAID delegates and other experts in the field of horticulture and development. (See Appendix VIII for list of committee members.) This Advisory Committee planned, coordinated and carried out the nine-month assessment. UC Davis accepted primary responsibility for the structural development and facilitation of the regional workshops, organization and implementation of the Synthesis Workshop and publication of its results, plus preparation of the final assessment document. AVRDC-The World Vegetable Center organized the regional meetings in partnership with assistance from the AVRDC-Africa regional office in Arusha, Tanzania, Zamorano University, in Honduras, and ICARDA in Cairo, Egypt.

Process

A three-phase sequence was designed to gather and analyze stakeholder input (Figure 2). The phases included:

I. A synthesis workshop to define U.S. stakeholder needs and inputs and determine global priorities.

II. A series of three regional workshops and an independent survey to determine stakeholder, priorities, constraints and opportunities.

III. Analysis, integration and publication of results to guide future collaborative research and development activities in global horticulture.

Phase I: Synthesis Workshop on Global Horticulture Challenges and Opportunities

October 18-19, 2004 – University of California, Davis

The objective of the workshop was to identify the primary challenges and opportunities for global development in horticulture in order to alleviate poverty, meet domestic human nutritional needs and stimulate economic growth in emerging economies. Leading experts and professionals in various aspects of horticulture and development participated in the synthesis workshop, including: USAID-Washington, USDA, university horticultural scientists, horticultural industry private sector representatives, NGO's and donor agencies (see Appendix II for a list of participants). Participants provided input on global themes and geographic emphases and helped to set the broad agenda for the program that would satisfy the interests and needs of USAID, Congress and the domestic private sector.

Synthesis Workshop Structure

The workshop included invited presentations as well as discussion groups arranged by theme and region. (See Appendix I for the workshop prospectus.) Presentations highlighted such major issues in horticultural production as supermarkets, food safety, sustainable production, and gender.

Participants then joined discussion groups based on the following themes:
(1) Biodiversity and Biotechnology
(2) Marketing and Global Standards
(3) Human Nutrition, Food-Safety, and Postharvest Chains
(4) Sustainable Production, Abiotic and Biotic Stresses

Group members identified the opportunities and challenges within each of the thematic areas and discussed strategies for addressing priority issues. Presentations to the plenary session encouraged dialogue and information sharing between groups. During the second day of the workshop, small groups discussed opportunities and challenges for horticulture development in each of three regions: Latin America and the Caribbean, Asia and the Near East, and sub-Saharan Africa. Participants also suggested ways to broaden the scope of stakeholder input at each of the three subsequent regional workshops. General consensus among participants led to the development of the survey, discussed in Phase II.

The information gathered at this workshop set the stage for the regional workshops and the development of global priorities for research and development.

Phase II : Regional Workshops and Survey

February 14-16, 2005, Arusha, Tanzania
March 24-26, 2005, Zamorano, Honduras
April 12-14, 2005, Cairo, Egypt

The regional meetings gathered diverse groups of stakeholders including scientists, development specialists, government ministry representatives, NARES, IARCs and CGIAR, Non-

governmental Organizations (NGOs), USAID Missions, host country universities, private sector, and producer organizations. (See Appendix II for lists of participants from all meetings.) Advisory committee members, USAID missions, and national governments nominated invitees. Program sponsorship, through travel support and/or waived registration was provided for approximately 35 participants at each workshop; registration fees for the remaining participants were minimal. Workshop locations were chosen on the basis of available USAID Mission support, as well as by the existence of local organizing institutions such as the AVRDC - Regional Center in Arusha, Zamorano University in Honduras, and ICARDA in Cairo, Egypt.

Primary regional workshop objectives were to identify and describe the priority research and development issues facing horticultural development in the region. Results are presented in Section III of this document.

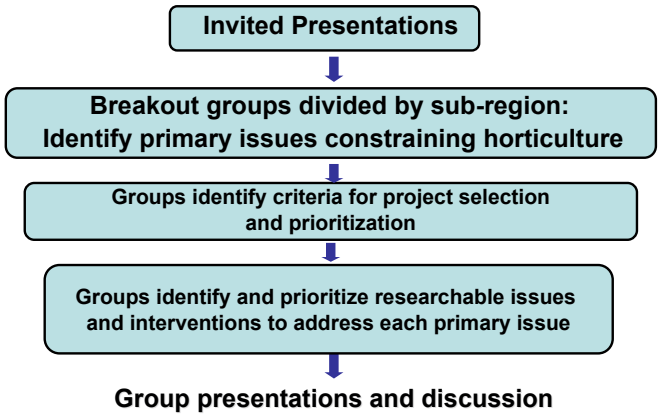


Figure 3. Diagram of the regional workshop structure. The process enabled full participation from workshop attendees and allowed the assessment team to capture the input.

Regional Workshop Structure

The workshops were designed to elicit equitable and active participation from all attendees. A clearly defined process replicated at each of the three meetings ensured continuity of results across the regions. Introductory presentations set the context for the workshop and highlighted emerging regional trends in the horticulture sector. Small groups divided by geographical sub-region then participated in a facilitated series of exercises for the purpose of identifying the primary issues that constrained the development of horticulture in their region. For the purposes of this assessment, the term "primary issue" refers to an encompassing issue of core importance to horticultural development, that is highly relevant to a diversity of stakeholders across all scales of activity. Subregional groups then developed and ranked research and development priorities for their regions based on the following the following criteria (in no particular order):

- Probability of success
- Returns on investment
- Targeted sectors
- Gender
- Poverty alleviation
- Nutrition
- Scale

Each group modified the criteria listed above to include factors such as sustainability, replicability, the environment, and originality, among others. The regional sub-groups presented their results to the plenary session on the final day to stimulate debate and discussion. A field trip to several nearby horticultural operations closed each of the three-day workshops.

Regional Workshop Details

Sub-Saharan Africa

The sub-Saharan Africa (SSA) regional workshop, held in Arusha, Tanzania, February 14-16, 2005, brought together 72 leading experts and key stakeholders from 21 countries.

To facilitate the process, participants were divided into five subregions based on geopolitical and linguistic considerations. The subregional groups and countries represented are as follows:

- Francophone/West Africa - Rwanda, Mali, Senegal, Nigeria, Cameroon, Benin, Niger, Cote d'Ivoire, Burkina Faso
- East Africa A - Kenya, Tanzania
- East Africa B - Kenya, Tanzania
- East Africa C - Ethiopia, Uganda, Eritrea
- Southern Africa - Tanzania, Mozambique, South Africa, Malawi, D. R. Congo, Zimbabwe

Simultaneous translation for all plenary sessions ensured effective communication and participation between French and English speakers (Figure 4).

Table 6. Number of regional workshop participants and number of survey recipients and respondents

	SSA	LAC	ANE
Participants from Region @ Workshop	73	85	67
Regional Countries Represented @ Workshop	19	18	18
Survey Recipients	386	447	373
Survey Respondents	122	97	84
Countries Represented in Survey	32	23	23

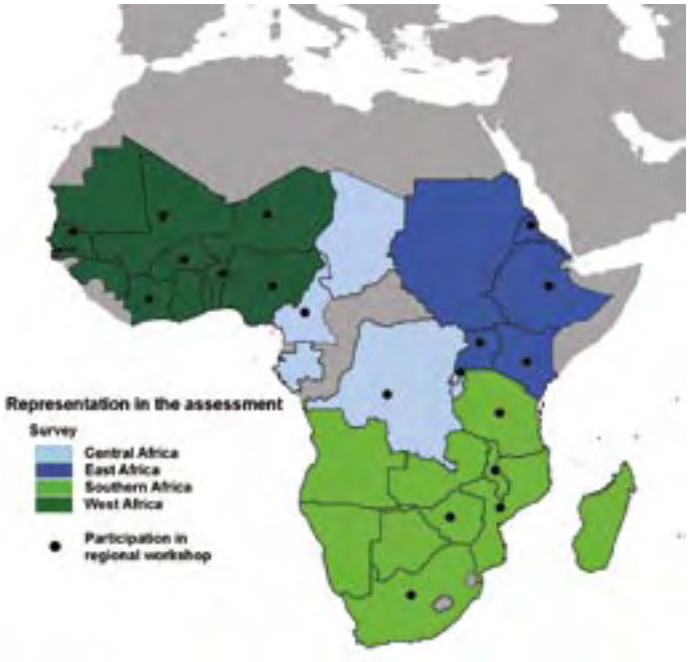


Figure 4. Map of Africa showing the representation of individual countries in the assessment. Survey responses were received from countries with subregional shading. A dot within a country indicates that the country was represented at the regional workshop.

Latin America and the Caribbean

The Latin America and Caribbean Regional Workshop took place in Zamorano (Escuela Agricola Panamericana), Honduras, during March 29-31, 2005. Over ninety participants, representing seventeen different Latin American and Caribbean nations contributed to the numerous discussions and outcomes during the course of the three day workshop. During the workshop, the participants were divided geographically into five different working groups, each consisting of 12-18 people:

- Central America 1 - Nicaragua, Costa Rica, Honduras, El Salvador, Guatemala, Mexico
- Central America 2 - Nicaragua, Costa Rica, Honduras, El Salvador, Guatemala, Mexico
- Central America 3 - Nicaragua, Costa Rica, Honduras, El Salvador, Guatemala, Mexico
- Caribbean - Jamaica, Trinidad and Tobago, Belize, Haiti, Guyana, St. Vincent and the Grenadines
- Andean - Columbia, Peru, Ecuador, Bolivia, Paraguay

By virtue of the workshop location, a large proportion of participants were from Central America. Each Central American group contained a representative sample of all of the Central American nations represented (Figure 5).

Asia and the Near East

The ANE workshop was held in Cairo, Egypt, April 12 to 14, 2005. Attendees at the ANE regional workshop were subdivided into four subregions: North Africa, Near East, South Asia, and South East Asia. Biophysical and cultural conditions determined these subregional designations. USAID's existing subregion 'Near East' is divided into North Africa and Near East due to the large representation from this area (Figure 6).

The subregions and countries represented were:

- North Africa – Tunisia, Egypt
- Near East – Iraq, Jordan, Lebanon, Oman, Palestine, Syria, U.A.E., Yemen
- South Asia – India, Sri Lanka, Bangladesh, Pakistan
- Southeast Asia – Philippines, Indonesia, New Zealand, Cambodia

Survey

During the synthesis meeting held at UC Davis, stakeholders expressed concern that three regional workshops would not generate a wide enough variety of stakeholder input. Various participants suggested that a survey, distributed to stakeholders in each of the three regions, would help to reach a larger number and variety of people and institutions than would be able to attend the regional workshops, and the Advisory Committee concurred.

Beginning in January of 2005, the survey, developed by the UC Davis team, (see Appendix III) was distributed via email to more

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Figure 5. Map of Latin America and the Caribbean (LAC) showing the representation of individual countries in the assessment. Survey responses were received from countries with subregional shading. A dot within a country indicates that the country was represented at the regional workshop.

than 2500 individuals and institutions in sub-Saharan Africa, Latin America and the Caribbean, and the Asia/Near East regions. The International Society for Horticultural Science (ISHS), Advisory Committee members, and participants in the Synthesis Workshop helped to identify survey recipients. Subsequently, survey recipients forwarded and distributed the survey to colleagues and recommended invitees for the regional workshops. The response rate was approximately twenty percent.

In addition to substantially enlarging the breadth of stakeholder input, the survey data represents a level of crop-specific detail not reached at the regional workshops. Due to the broad geographic areas covered at the regional workshops, participants were often hesitant to make recommendations or prioritize crop-specific constraints such as pests and diseases, as these tend to vary widely across agro-ecological regions. In contrast, survey respondents generally represented just one country and elaborated on the crop-specific constraints in detail. A database has been created to house the extensive survey information about institutions, horticulture research and development projects, important and underutilized crops, as well as general and crop-specific constraints to horticulture development. Survey data, including the most important and highest potential crops, as well as the most severe constraints to horticultural production, were presented at the regional workshops to help ensure that a broad range of input was included in the final recommendations drafted by workshop attendees. Survey data has been integrated into the recommended research and development priorities described in section III of this document. Analysis of regional survey data can be found in Appendices IV, V and VI.

Phase III: Analysis, Integration and Publication of Results

The structure of the final document and the recommendations herein were defined by the outcome of the workshops and surveys, and from key literature. The bottom-up primary issues identified at the regional workshops and in surveys are integrated with the top-down analysis from the synthesis workshop in order to create the primary issue problem models described in Section III of this document.

A problem model[1] is a detailed description of a development issue that defines the problem, as well as the underlying processes that produced that problem. The problem-model focus ensures that the research and development activities recommended are geared toward addressing priority issues identified by stakeholders. As the primary issues and recommended activities were consistent across regions, the problem models represent a synthesis of input gathered at all workshops. Distinct regional priorities and recommended activities are highlighted at the end of each primary issue section and survey results in Appendicies IV-VII supplement the regional analyses. The Recommendations and Conclusions, Section IV suggests a framework within which stakeholders can collaborate through research and development activities to address the constraints identified during the Global Horticulture Assessment.

[1] The problem model framework, developed by the GL-CRSP, consists of: (1) a problem definition; (2) a hypothesis about how to address the problem; (3) research and development activities needed to resolve the problem.

6

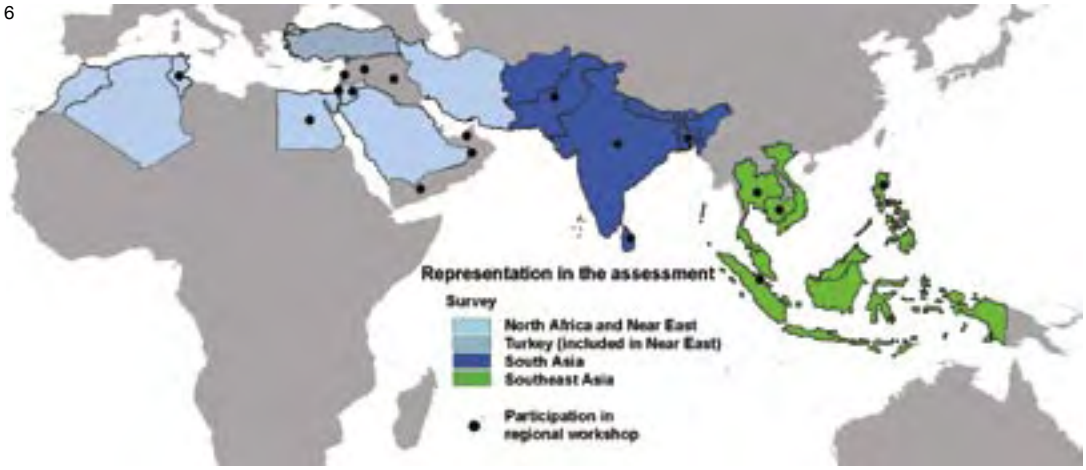

Figure 6. Map of Asia and the Near East (ANE) showing the representation of individual countries in the assessment. Survey responses were received from countries with subregional shading. A dot within a country indicates that the country was represented at the regional workshop.

Conclusion

The methodology used for the Global Horticulture Assessment stressed participation and involvement of a wide variety of stakeholders. Phase I of the Assessment elicited top-down input from international experts in the field of horticulture, development, and marketing as well as representatives from industry and NGOs. Phase II gathered bottom-up input from stakeholders based in developing countries, whose perspectives, expertise and involvement are critical to developing applicable research projects as well as sustainable and appropriate development initiatives. Workshop participants and survey respondents have expressed interest in continuing the dialogue begun with this assessment. Individuals and institutions working in the field of horticulture have much to learn from one another; shared successes and challenges can help to drive innovation and inspire change.

III. RESULTS

Introduction

As noted earlier, more than 750 participants from over 60 countries provided direct input to this assessment, via participation at the workshops or through completion of the survey. This process resulted in the identification of eight significant issues, or ***primary issues,*** that either constrain the growth of horticultural development or represent core social considerations across all regions. These primary issues are:

- Market systems
- Postharvest systems and food safety
- Genetic resources conservation and development
- Sustainable production systems and natural resources management
- Capacity building
- Enabling environment
- Gender equity
- Nutrition and human health

Each primary issue is comprised of a number of sub-issues and constraints of varying importance among the three regions. In the following pages, each of the eight primary issues (and sub-issues) is articulated and its impact on horticultural development is discussed. A problem model format, consisting of a hypothesis statement and key research activities is presented to help frame the issue and identify the key activities required to address the issue. Each primary issue analysis and problem model articulation is followed by an analysis of the region-specific context, including consideration of the importance of particular activities within the region and the identification of additional region-specific activities.[1]

I. Market systems

Successful production and trade of horticultural crops requires an understanding of the fundamentals of market structure and function. Knowledge of buyer demands, producer supplies, consumer preferences, and international and domestic standards are critical to success in highly competitive markets. The need for market information and effective market linkage is essential for profitability of growers, both large and small. The challenge for small producers is particularly acute because they have neither the resources nor the skills to access and interpret this market information, nor adequate financial, human or social capital to develop the linkages needed to succeed in the market. Due to the rapid and dynamic nature of the modern market for horticultural goods, smaller farmers will need new and innovative technologies for accessing market information. Success, for growers large and small, will depend on their ability to access diverse markets and to respond promptly to changes in market conditions.

Much of the world's poor live in the developing regions of Africa, Asia and Latin America, areas that are experiencing rapid transformations in their agri-food systems. Primary causes for these changes are: (1) increasing urbanization, (2) growth of supermarkets, and (3) increase in export market opportunities. One well-documented shift in market function is the rapid expansion of supermarket chains (Reardon *et al*. 2003). The growth of the supermarket has had repercussions

[1] 'Enabling environment', 'Gender equity' and 'Nutrition and human health' do not include an analysis of the region-specific context as these issues were not discussed in detail at the stakeholder meetings.

throughout the agri-food system, both directly through its effect on traditional markets and all aspects of the food production system, and indirectly by altering consumer expectations for quality, safety and presentation. Analysis of the supermarket phenomenon provides useful insights into changes throughout the food supply chain and their impact on the rural poor.

The proliferation of supermarkets in developing countries creates both challenges and opportunities for rural producers. Supermarkets may contribute to higher demand for horticultural products, while simultaneously excluding small producers from participating in supermarket procurements and contracts. Latin America has led the way among developing regions in the growth of the supermarket sector (Reardon 2003), rising from 10 to 20 percent of national retail food sales in the 1980s to 50 to 60 percent in 2000 and in some urban areas are approaching the 70 to 80 percent share common to the United States and France. In Southeast Asian countries, including Indonesia, Malaysia, and Thailand, supermarkets account for 33 percent of the market, while the figure is closer to 63 percent in the East Asian countries of Republic of Korea, Taiwan, and Philippines. In South Africa, supermarket sales account for roughly 55 percent of overall food sales (Reardon 2003). Whereas it took fifty years for supermarkets to achieve dominance in the US market, the changes observed in the developing world have occurred in just the past two decades.

The procurement practices of supermarkets significantly affect rural agricultural development and pose new challenges, particularly for small, undercapitalized growers. Reardon describes "four pillars of supermarket procurement system change," which are used as competitive tools in the retail sector and as a means to coordinate quality and consistency, and reduce costs in the supply chain.

1. Shift from local, decentralized procurement to centralization and regionalization of procurement
2. Shift from the use of traditional wholesalers to specialized/ dedicated wholesalers as agents of procurement for the supermarket
3. Shift from the use of spot markets to use of preferred supplier systems
4. Shift from informal standards or lack of public standards to the establishment of private standards of quality and food safety

Empirical data and emerging trends illustrate that these buying practices and procurement systems have significant consequences for farmers and suppliers. First, the centralization and regionalization of procurement puts local producers in direct competition with other producers across their own country and region. To stay in the system, the producer must be competitive at the national and regional level, rather than just at the local level. Second, the shift to specialized, dedicated wholesalers may result in the development of a relationship with the buyer that is formalized and potentially more secure. These buyers may also provide technical assistance, sometimes credit, and often transport. Buyers, however, will demand compliance with product quality and phytosanitary standards, will monitor volume and consistency standards, and may cancel purchase contracts if these conditions are not met. Third, the shift to preferred supplier systems means that producers are either represented on the supermarkets' procurement lists, or they are not—in which case they are excluded from the market. As supermarkets supersede urban markets, access becomes increasingly determined by a producer's ability to meet transactional and technological requirements specified by the large retailers' requirements.

The predominant procurement practices of the supermarket sector, and the even more tightly constrained practices in the export sector, represent a profound challenge to the small grower who is unlikely to have adequate knowledge, technical skills or capital to understand or meet these terms of trade. In the absence of a pool of qualified and responsive small growers, supermarkets, export companies and wholesalers often deal exclusively with wealthier large-landowners who have the capacity to meet quality standards and contractual infrastructure requirements demanded by the market.

While these changes in the marketing chain due to the rise of supermarkets present an enormous challenge, the strong growth in horticultural demand, both regionally and worldwide also provides great opportunity for producers. "A central issue for donors is to identify what appropriate research and intervention strategies can support small holders in their greater integration into this segment of the … market" (Rubin *et al.* 2005). Though supermarkets control large segments of the entire food chain, more than 75 percent of fresh fruits and vegetables are still sold in traditional open-air markets and small, independent stores (Reardon and Berdegué 2002). These markets are much more than physical locations to sell

Case Study 1. Producers' incomes increased by organizing for market integration in Egypt

Lack of current market information and poor logistical coordination can limit smallholders' access to markets. USAID's Agricultural Exports and Rural Income (AERI) – El Shams program in Egypt is overcoming these hurdles by organizing producers into farmer associations (FAs) that link them with markets. In nine governates in Upper Egypt, El Shams has effectively aggregated growers to enhance market power and facilitate capacity building. An FA serves as a center for training, as well as providing a mechanism to market product as a community. Producers receive market information, and technical training in sustainable production and postharvest quality methodologies. As a group, Egyptian FAs link with domestic and export contracts for their produce. Products include fresh cut green beans, melons, tomatoes, onions, and garlic.

As of March 2005, 79 FAs have been formed in Egypt, affording 2,400 growers direct training during cross-visits, and impacting an additional 1,200 farmers through diffusion of methodologies. El-Shams has also facilitated linkages with 31 exporters and/or buyers handling commodities produced by smallholders. To date, more than 100 high-value contracts have been signed. Horticultural sales have increased by 16.575 million Egyptian pounds and production has increased by 13,142metric tons. The average FA member's income has improved by 226 percent to 7,251 Egyptian pounds per year. The horticultural sector has created 2,972 new jobs on farm and 5,994 jobs off farm.

horticultural products; in many locations they are integral parts of the community and the society. How can these traditional markets compete with the supermarkets and their regional distribution systems? How will further globalization of the horticultural sector impact the poor, and what can be done to make traditional markets both competitive with the supermarket and profitable for smaller producers? Future studies and development must take these questions into consideration so that smaller producers are included rather than excluded in the new, complex marketplaces.

Priority research and development activities

1. Increase access to market information

Small and medium-sized farmers often lack access to information regarding product demand, existing supply, standards and prices that is available to larger, wealthier producers. Such information is essential to making informed decisions regarding production and marketing. Inadequate and asymmetric market information simultaneously limits the ability of smaller producers to compete in sophisticated markets and diminishes their ability respond to dynamic market fluctuations.

Hypothesis: The development and delivery of market information and interpretation systems will allow producers to plan their horticultural production cycle to meet specific market demands.

Activities

- Analyze existing market policies, intelligence, and information delivery systems to develop market intelligence at the local, national and global levels.
- Identify quality, pricing, demand and other relevant conditions for major and promising horticultural products in local, domestic and international markets.
- Develop systems to collect, analyze, and deliver real-time market information to specific target audiences (producers, processors, researchers, developers, policy makers) through appropriate media such as cell phones, text messaging, faxes or the internet.
- Increase partnerships between producers, public institutions, and industry to facilitate market information exchange and develop capacity.
- Promote communication and exchange of information throughout the marketing chain by developing partnerships between producers, public institutions, NGO's and private industry.
- Monitor and evaluate the utilization and impact of market information on production, research and extension programs, and income generation.

2. Strengthen producer and marketing organizations

Strict safety regulations, quality standards, and market demands for specific quantities and delivery dates restrict small producers' access to potentially profitable export and regional markets. Additionally, many certification processes (e.g., Fair Trade), which open opportunities in niche markets, require strong farmer organizations. By aggregating production and consolidating marketing through farmer organizations, smallholders may be able to overcome these constraints. Farmer organizations could also benefit members by addressing issues such as collective bargaining, contract farming, and advocacy for policy improvements.

Hypothesis: The strengthening of farmers' organizations will increase the participation of small-farm-holders in the dynamic horticulture market by increasing market competitiveness, facilitating transfer of market information, and advocating for favorable smallholder governmental policies.

Activities

- Analyze the impact of producer organizations on expanding smallholder's access to markets.
- Identify and adapt successful models of producer organizations to specific regional and cultural contexts.
- Enhance capacity and competitiveness of farmer organizations through targeted training of skill sets, including business management and accounting, and increased linkages with external sources of information and the private sector.

3. Impact of changing market systems on small producers and firms

While increasing access to market information and strengthening producer organizations may help small holders and firms to participate more effectively in the modern marketplace, the full impact of changing market systems on

Case Study 2. Agribusiness partnerships for unique plant species

Given the growing global demand for natural and organic products, and Africa's vast botanical heritage, there is great potential for business development in this sector. Historically, exports of natural plant products from Africa have been raw, with little added value and limited to just a few crops, such as rooibos (an herbal tea) and proteas (ornamental flowers). A handful of large enterprises have dominated the natural plants sector, leaving the majority of producers in rural communities without access to potential markets.

Agribusiness in Sustainable Natural African Plant Products (ASNAPP), a non-profit organization formed in 1999 with funding from USAID, is helping to create and develop successful, sustainable African agribusinesses in the natural plant products sector. ASNAPP focuses on high-value natural plant products that enable African agribusinesses to compete in local, regional and international markets. These products include herbal teas, culinary herbs and spices, and essential and pressed oils, as well as medicinal plants.

ASNAPP is unique in that it combines science-based research services with technology interventions throughout the supply chain. ASNAPP helps to develop local value-addition industries and links rural entrepreneurs of natural plant products to markets by connecting producers and suppliers to buyers, establishing quality control standards, and disseminating applied research, as well as through technology transfer and capacity building. The ASNAPP team operates in five countries, namely South Africa, Ghana, Rwanda, Senegal and Zambia, working with 25 agri-enterprises that represent more than 2,000 small-scale natural plant suppliers. The social and economic impact of these activities is significant, considering that the average producer supports a family of six.

The ASNAPP project hopes to serve as model for sustainable development and successful rural entrepreneurship – not only across Africa but also in the rest of the developing world, where agriculture is so closely linked to food security and poverty alleviation.

www.asnapp.org/

small producers, firms, and traditional market avenues is not well understood.

Hypothesis: Researching the impact of changing agri-food systems and markets on small producers and firms will lead to effective policies and programs that facilitate and ensure their continued participation in a variety of market avenues.

Activities

- Analyze the costs and benefits explicit and implicit to small farmers and processing firms to produce for and sell to the modern food industry segments (supermarkets, export distributors) compared to traditional market channels.
- Examine the types of competitive pressures from the modern food industry that might lead to local farmer loss of market share or constitute a barrier to local farmer entry in retail markets.
- Determine where modern food industry segments and companies are successfully sourcing from small farms and firms and the conditions for this success. Determine the avenues for accessing small farms and firms: directly; via associations or groups; packer-shippers; specialize/ dedicated wholesalers.
- Develop alternative market avenues for small producers and firms by improving and modernizing traditional markets.

4. Investment in marketing infrastructure

Insufficient infrastructure (deficient roads, inadequate distribution channels and cold storage chains, and lack of communication infrastructure) prevents producers from receiving essential information and critical inputs, and limits their ability to deliver products to market in a timely manner.

Hypothesis: Targeted investments in critical infrastructure will reduce costs for critical inputs (fertilizers, seed) and increase the quality and quantity of marketable crop.

Activities

- Assess market infrastructure to determine priorities for investment.
- Develop appropriate low-cost technologies and infrastructure investments to promote efficiency in communications and facilitate input access.
- Partner with agrochemical and seed distributors to enhance access to inputs by developing small-scale local supply systems.

Market systems -- Region Specific Context and Focus

The preceding issues and activities, important to all areas, are supplemented by the following regionally important issues.

Sub-Saharan Africa (SSA)

Of all the regions examined, SSA presents the greatest challenge in linking producers to information and markets. Inadequate infrastructure severely limits the competitiveness of local production and hinders producers' ability to compete in the export market. SSA's capacity for generating power is less than half that of Asia or Latin America on a per capita basis and the cold-storage chain is virtually non-existent in many regions. One-fifth of its population is landlocked, meaning that producers in Africa face great transport distances to the nearest large markets and road conditions throughout the region are deteriorating. SSA's rail freight is under 2 percent of the world's total, air freight less than 1 percent, and marine freight capacity is 11 percent (mostly foreign owned) (NEPAD 2003). Given these constraints to market infrastructure, it is not surprising that only a few sub-Saharan African countries have been successful in the highly competitive export horticultural market, which demands rigorous quality standards that many SSA producers are unable to meet.

Kenya has achieved considerable success in the exporting to the EU, with fruit and vegetable exports to Europe increasing fourfold since 1974. However, while 70 percent of rural households in Kenya sell some horticultural produce, only 2 percent market for export, and by farm-gate value, domestic sales are at least four to five times greater than exports (Tschirley *et al*. 2004). Domestic and local markets, which have great potential for benefiting smallholders and poor consumers, have been neglected by governments and private investors. Intra-regional markets have tremendous potential for growth in sub-Saharan agricultural products, but these market linkages remain largely untapped. Inadequate infrastructure (substandard rural roads, market facilities and communication networks) increases transaction costs and prevents many producers and consumers from accessing local and regional markets effectively. Ultimately, increased investment and productivity in the local and regional market sectors may generate funds that can be used to enhance production efficiency and improve market infrastructure to enable export markets in the future.

Traditional market in Asia.

Activities

- Improve traditional wholesale and retail markets in the areas of security, efficiency, hygiene, grades and standards, and price information by grade.
- Develop and support contract partnership programs that link smallholders with regional processing industries and supermarkets.
- Assess the ability of cities to meet the produce needs of growing urban populations; improve linkages and develop sustainable systems to help cities supply urban markets with perishable horticultural crops.
- Identify comparative advantage and market demand of crops within regions and promote intra-regional trade of horticulture crops in sub-Saharan Africa.
- Promote domestic consumption of underutilized horticultural crops (papaya, avocado, indigenous vegetables, etc.) through educational programs focusing on the nutritional importance of diversifying the diet with fruits and vegetables.

Latin America and the Caribbean (LAC)

Latin America and the Caribbean combine to make up the largest horticultural trade partner of the US, and as such, they face unique market systems challenges. Export markets, with their stringent quality and phytosanitary requirements, demand producer contracts that regulate all aspects of production, from exacting growing conditions, variety and quality standards, to specific dates and quantities of product delivery. Such stringent market conditions presuppose an established market infrastructure, and require the producer to gain a considerable level of market knowledge. Within a single production area, it is essential that every individual grower adhere to the standard protocols of the market to which the product is being exported. Even a single case of non-compliance (especially if it results in human illness) can result in the closure of the entire export market for that crop, with devastating consequences for all market participants. To maintain this degree of compliance requires high levels of producer understanding, technical knowledge, testing, monitoring, and oversight.

One consequence of the export market domination of LAC production has been the growth of large-scale contract production and the subsequent displacement of small and mid-size producers from the market. This phenomenon, which has resulted in escalating inequity, was identified by workshop participants and survey respondents as a high priority constraint to horticultural systems development in LAC.

Other regions besides LAC are beginning to market to the US, resulting in downward price pressures and increasing demands for quality and diversity in products. To sustain their prosperity, LAC producers must continue to innovate, offer a product of consistently higher quality, and develop production systems that are exceedingly responsive to changing consumer

Bean packaging In Egypt for export markets.

demands. They should also be able to take advantage of opportunities to increase sales locally and regionally, where fruit and vegetable consumption is amongst the lowest in the world, but is currently on the rise. Another potential market opportunity for growers in LAC is supplying indigenous and traditional crops to the growing immigrant population in North America.

Because tourism is the major industry in the Caribbean, the supply of produce to hotels and cruise lines represents a significant potential market for Caribbean produce. Currently, most major hotels or cruise lines source their produce from the US (which may include LAC produce) citing limitations of safety, quality and quantity as the primary reason for this decision. To enter this market, Caribbean producers would need to make very substantial investments in marketing systems and food safety compliance systems. The potential for growth in regional production of high quality produce for market to the tourist trade is substantial.

For the small producer in LAC, access to high-value markets (export, supermarket, tourism, organic, Fair Trade) and production of unique or regionally-favored products represents significant potential for rural economic development, but quality, consistent packaging, compliance with standards and reliable delivery are essential. Participation in these markets will require creative market development as well as the development of new technologies, specialized postharvest practices, packaging and labeling, and capable personnel within the production system.

Activities

- Identify high-value and niche markets accessible to small producers.
- Promote North-South partnerships between the “ends” of the production chain, linking importers and distributors with farmers and farmer organizations.
- Provide training and access to information and technology to successfully exploit higher value markets and meet buyer and consumer demands.
- Develop policies to encourage the tourism industries to source local products, provided standards and quantity constraints can be satisfied.

Asia and the Near East

ANE has the capacity to serve as both the source and the sink for many of the horticultural products grown in the region. Demand is growing because increasing incomes allow the population to indulge in the historically high dietary intake of fruit, nuts, and vegetables. China dominates the regional

horticultural industry with 20 percent of its arable land dedicated to horticultural crop production, supporting 47 percent of the world's vegetable production. East and Southeast Asia increased their net trade of horticultural commodities by 1.2 billion US dollars in 2002, while South Asia has become a net importer of fruits and vegetable (Weinberger and Lumpkin 2005).

While acknowledging that the primary obstacles to ANE market linkages are inadequacies in organization of producers, market intelligence, and value-added processing, it must be noted that the lack of market standards in the region impedes trade due to widely varying product quality. ANE suffers for lack of universally recognized marketing standards to gauge and judge product grades. Because standards differentiate commodities and reward producers of high-quality products, they provide incentives for improvements in quality and help to ensure marketable produce.

Activities

- Set up a multi-disciplinary team consisting of marketers, postharvest physiologists, and production experts to establish regional quality standards for horticultural commodities.
- Train producers, extension agents, processors, and marketers regarding quality defects and methodologies to avoid them.
- Create public/private partnerships to link producers to high-value markets, including export and high-end local outlets such as tourist hotels.
- Develop maturity indices to ensure highest quality at time of marketing.

II. Postharvest systems and food safety

Postharvest

Postharvest technology is traditionally defined as all processes, procedures and operations that take place between harvest and consumption of a horticultural commodity. It includes harvesting and handling techniques, maturity and quality standards, cleaning, sorting, grading, packing and packaging, storage, treatments for disease control, ripening, insect disinfestation, transportation and supply logistics, and display conditions in stores. In recent years, this definition has been expanded to incorporate value-added processing as well.

From field-to-fork, a large proportion of horticultural produce is lost. In developing countries, estimates are that 50 percent or more of fruits and vegetables are lost during postharvest (FAO 1981; National Academy of Sciences 1978). In addition to discarded product, deterioration of quality (appearance, texture, flavor and nutritive value) and subsequent decreases in market value are significant factors. Quantitative and qualitative postharvest losses can be reduced through the adoption of appropriate management practices, both before and after harvest. Any reduction in postharvest losses serves to increase food availability to burgeoning human populations while decreasing the total land area needed for production, thereby conserving natural resources (Kader 2003).

Postharvest handling practices are crucial to maintaining quality during all stages of the value chain. Providing optimal ranges of temperature and relative humidity is the most important element for maintaining commodity quality and safety, thereby minimizing respiration and water loss (Cantwell and Reid 1993; Gross *et al.* 2002; Kader 2002; Nell and Reid 2000; Thompson *et al.* 1998). In addition, many fresh market horticultural commodities are highly susceptible to mechanical injury commonly inflicted during packing, shipping and handling, and resulting in bruising, cuts, or opportunities for infection. Although weight loss and mechanical injury diminish product, many postharvest quality and handling characteristics are determined by preharvest conditions. Strategies for loss prevention include the use of genotypes that have a longer postharvest life, adequate fertilization and irrigation regimens, effective insect and disease control, uniform harvest dates, and suitable harvest maturity indices.

Postharvest capacities and demands vary for small, medium and large-scale growers, processors, distributors and market destination—local, regional, or international. Many postharvest technologies are capital intensive and impractical for small-scale producers and processors. Large-scale storage and transportation dictates climate control (humidity, temperature, and possibly controlled atmospheres) and regulating the amounts of ethylene and carbon dioxide gases. Furthermore, due to the extended time en-route to export markets, fungicides, including methyl bromide, are necessary for some commodities. Nevertheless, small and medium-scale producers and processors could prevent significant crop losses and damage with simple, low-input technologies. For example, proper temperature management, including harvesting during cooler parts of the day, or even at night; protection from exposure to the sun; adequate ventilation in containers and non-refrigerated transport vehicles; use of simple and inexpensive cooling procedures, such as evaporative cooling and cool-night ambient air; and expedited handling, can all significantly reduce postharvest losses.

Small-scale and low-cost postharvest techniques can be highly productive, particularly when coupled with effective training programs and the availability of appropriate technology. The International Society for Horticultural Science workshop on Postharvest Technologies for Developing Countries concluded that the most important current issue in postharvest technology for developing areas is the provision of extension training on simple, low-cost applications. In most cases, for commodities already widely grown, solutions to existing problems in the postharvest handling system require use of available information rather than any new research. However, there is little basic postharvest information available for many indigenous vegetables, fruits, medicinals and ornamentals with potential market development.

Food safety

Assuring food safety throughout the postharvest handling chain is critical to successful marketing of produce, particularly to the export market. Food safety for fruits and vegetables demands special attention since they are often consumed raw or with minimal preparation and there are no effective intervention strategies that can completely eliminate food safety risks of uncooked produce (Bracket 1999; Kitinoja and Gorny 1999). The guiding principle for addressing this

challenge is to prevent contamination of fresh produce with human pathogens, dangerous levels of chemical residues, or physical contaminants. Prevention is much more reliable and less expensive than interceding with corrective action once contamination has occurred (USFDA 1998). Commonsense practices during production, harvesting, packaging and marketing provide the best prevention measures. These postharvest practices combine to provide layers of protection at successive steps in the handling system and any breaches in their application can lead to cross-contamination, resulting in an unsafe product.

Fruits and vegetables have a high susceptibility to contamination by infected fieldworkers, use of contaminated irrigation water, contact with contaminated soil, use of inadequately composted manure, or careless harvest and/or postharvest handling. Good Agricultural Practices (GAPs) and Good Handling Practices (GHPs) along the productive chain represent key steps that can prevent produce contamination. Amongst the most critical elements is the availability and use of clean, disinfected water for preharvest (foliar applications) and postharvest (washing, cooling and applications) operations. Both training to ensure high standards of employee hygiene and proper animal waste management are vitally important steps in any food safety program.

In a modern market system, postharvest management cannot be separated from commodity marketing and it represents a critical element linking producers to markets. Priorities within the postharvest sector of developing countries have evolved from a primarily technical focus geared toward the reduction of losses to a more holistic approach designed to link on-farm activities to processing, marketing, and distribution. Despite this evolution in trends, fundamental problems and concerns remain unchanged. High postharvest losses, poor marketing systems, weak research and development capacity, and inadequacies in policies, infrastructure, and information exchange are still considered the major constraints to food production in developing regions of the world (Mrema and Rolle 2002).

Priority research and development activities

1. Develop and disseminate appropriate postharvest technologies for small, medium, and large-scale producers

Postharvest requirements differ based upon the ultimate produce destination and market characteristics. Although creating new technologies is a priority here and in other assessments, in many cases, solutions to existing problems in the postharvest handling system require adaptation of available information rather than any new research (CIDA 2003; DFID 2005). Insufficient knowledge, limited resources, and lack of adapted techniques prevent many small and medium-sized producers and processors from adopting appropriate postharvest technologies and practices.

Hypothesis: Insufficient knowledge of postharvest management and deficient local technologies result in substantial postharvest losses of horticultural products. Prevention of postharvest losses will result in greater quantities of marketable produce and increased profitability.

Activities

- Examine the production-market supply chain on a commodity and regional basis, and determine points of greatest product loss, where cost effective interventions are possible.
- Identify, develop and/or adapt appropriate harvest, storage, transport, processing, and packaging technologies for targeted small and medium producers using locally available materials.
- Develop innovative networking models for shared packaging and transportation of produce from small-scale producers to holding and accumulation centers and markets.
- Develop and institute short-term training of individuals involved in postharvest handling, logistics, storage, and safety, Good Handling Practices (GHP) and Good Manufacturing Practices (GMP).
- Establish and implement Integrated Farming Systems (IFS), product and handling standards such as European Good Agricultural Practices(GAP), British Retail Consortium (BRC), and food safety systems at the farm level.
- Provide extensive scientific training to appropriate personnel on principles and applicable postharvest methodologies. These personnel will serve as adapters and developers of new knowledge to address ever-changing standards and new agricultural challenges.
- Enhance in-country postharvest resources by providing opportunities for students to obtain higher degrees.
- Generate knowledge about basic postharvest data on indigenous vegetables, fruits and ornamental crops with market potential.

2. Enhancement of value-added processing techniques and opportunities

Value-addition processing industries provide an alternative market niche for small producers. Value-added processing such as canning, freezing, and drying could help growers enhance profitability and create local jobs, but the technical know-how prevents producers from accessing these potential markets.

Hypothesis: Adding value through processing decreases producer risk, increases profits, and creates employment opportunities, especially for women.

Activities

- Assess viable value-added markets, favorable production areas, and suitable processes; facilitate market linkages.
- Identify, develop and adapt appropriate, low-cost value-added processing techniques for small-scale producers, adapted to local resources.
- Enhance farmers' capacity to participate in value-addition by demonstrating alternative cultivars or more amenable production practices.
- Build capacity of rural workforce to provide labor for value-addition industries.
- Identify and encourage public/private market linkages to promote the development of agro-processing micro-enterprises for local and regional markets.
- Provide necessary credit infrastructure for small farmers to invest in appropriate technology for value-added production.

3. Development and extension of food safety protocols and quality standards for horticultural commodities

The establishment of food standards, testing and certification systems, and the provision of the training and infrastructure needed to attain these goals is an important first step in the

Case Study 3. Food Safety and Food Trade: Guatemalan raspberries and Cyclospora

The Guatemalan raspberry industry began exporting to the United States in the late 1980s to fill a market niche in the spring and fall when supplies were low. By 1996, Guatemalan raspberry exports had risen to 250 metric tons. In the spring and summer of 1996, the US Centers for Disease Control and Prevention (CDC) and Health Canada received reports of over 1,465 cases of food-borne illness from *Cyclospora cayetanensis*, a protozoan parasite. A second outbreak was also reported in the spring of 1997, and eventually both outbreaks were linked to Guatemalan raspberries. Guatemala imposed a voluntary halt to exports in May of 1997, but not before substantial adverse publicity had occurred. Subsequent to these outbreaks, many buyers opted to no longer purchase Guatemalan raspberries. The *Cyclospora* outbreak also affected Guatemalan blackberry exports, which by 2002 were only 50 percent of 1996 levels. In 1996, prior to the contamination problem, raspberry production was approximately 250 tons; by 2002, only three growers remained in the industry supplying a total of just 45 tons.

The raspberry-associated *Cyclospora* outbreak was a critical event in the produce industry. Producers everywhere noted its devastating impacts.

The entire industry learned four important lessons:

1) Any delay in addressing a potential problem may adversely affect an industry's exports and reputation.
2) The FDA can dictate trade restrictions, even without physical evidence.
3) Reliable traceback may confine trade restrictions to individual growers, rather than the entire industry.
4) Strong grower organizations can improve an industry's ability to deal with food safety outbreaks.

(adapted from IFPRI, Focus 10, 2003)

development of a market-ready horticulture industry. Producers supplying supermarkets and export markets must meet a variety of GAP, GMP, HACCP, and SPS regulations. In local and national markets, food safety and quality standards are often undefined and/or not enforced. Nevertheless, pressures are mounting to adopt stricter standards as supermarkets absorb an increasing share of the market. A trend toward broad adoption of safety and quality protocols is in the best interest of all producers as it facilitates transition into higher-value markets and prevents contamination of export chains with poor quality product. APAARI (2002) identifies food safety practices as especially important in Asia, but the availability of safe and nutritious food is of great benefit to everyone.

Activities

- Study the levels of pesticide exposure, agrochemical residues and sanitary and phytosanitary conditions of marketed produce, along with related management practices, on a regional basis to determine areas of high risk and potential intervention.
- Develop participatory training programs to enable farmer groups to implement Good Agricultural Practice (GAP) and Good Handling Practice (GHP) to meet the standards required for domestic marketing as well as for supermarkets and export markets.
- Create a multi-disciplinary team consisting of marketers, postharvest physiologists, and production experts to establish regional standards for all horticultural commodities.
- Develop effective extension mechanisms to inform producers, marketers and retailers about existing standards and safety protocols, and provide training on how to implement those standards and protocols.
- Develop phytosanitary testing capacity and certification programs including simple low-cost rapid assays and monitoring methods for pesticide levels and microbial contamination at the wholesale level.
- Expand the U.S. IR4 program model to the developing world to regulate and provide guidelines for proper agrochemical use for horticultural crops.
- Institute a multi-faceted, integrated extension program to enhance farmers' ability to recognize and avoid microbial contamination and pesticide abuse, and increase consumer awareness of contamination risks.

Region Specific Context and Focus

Sub-Saharan Africa

The high level of postharvest loss is one of the main constraints to the development of horticulture in sub-Saharan Africa. Postharvest infrastructure, especially transportation and cold chain technologies, is inadequate or non-existent in most regions, preventing producers from delivering quality products to local, regional and export markets. There is great potential for the development of the horticultural sector in Africa, particularly with increasing consumption and demand for "indigenous" leafy vegetables, traditionally planted in home gardens and now demanded by a growing urban population. The expansion of trade and commercialization of indigenous vegetables is hindered by a lack of appropriate postharvest and processing techniques specific to these valuable crops.

Small and medium-sized stakeholders throughout the value chain have difficulty complying with rigorous quality standards required by European export markets. As the number of European importers demanding EUREGAP certification increases, countries that do not support their producers in meeting these requirements reduce their chances of accessing valuable EU markets.

Activities

- Provide short-term training to individuals in postharvest safety, Good Handling Practices (GHP) and Good Manufacturing Practices (GMP) with the intention of meeting EUREPGAP standards for export.
- Develop realistic local and regional standards for horticultural products.
- Support the development of agro-processing and value-added industries for local and regional markets.
- Develop appropriate postharvest techniques for processing, packaging, and storage of indigenous leafy vegetables for both regional export and local consumption.

Latin America and the Caribbean

LAC has a higher percentage of total horticultural production geared towards high-value and export markets than the other regions in this assessment. These up-scale markets have stringent postharvest requirements. Producers must meet phytosanitary requirements for entry into the marketplace. The Guatemalan raspberry *Cyclospora* outbreak in 1996-7 illustrates the food safety risks associated with perishable horticultural products and the economic consequences for an

Traditional tomato drying method.

industry that fails to guarantee food safety (See Food Safety and Food Trade, Case Study 4). This disastrous experience underscores the importance of each supplier, at every point in the supply chain of an export industry, meeting phytosanitary standards through GAP and effective postharvest techniques.

Activities

- Create training centers where producers, packinghouse managers, cooperative members can learn through hands-on demonstration the GAP, GMP, and HACCP systems.
- Provide growers with educational materials illustrating the risks of non-compliance with market standards for food safety.

Asia and the Near East

In ANE, home to the world's two most populous countries, approximately 53 percent of the population works in the agrarian sector, ranging between 12 percent in Jordan and 76 percent in Cambodia. Fully 60 percent of the ANE population resides and farms in rural areas, with great variability and inconsistency in commodity chain handling (FAOSTAT data 2004). Significant direct investment in infrastructure must accompany horticultural development because of the great distances which products travel. Because of the inherent perishable quality of fresh market produce, poor road conditions, hot climates, and vast transport distances, improved infrastructure would play a key role in enabling producers to access markets and maintain quality once product has arrived. China has achieved gains in the apple market by increasing their production almost 500 percent in the past 14 years, from 4,557,334 metric tons 1991 to 20,503,000 metric tons in 2004 (FAOSTAT data 2004). These impressive advances have accrued from infrastructure investments, including processing.

ANE, which has a long history in the production of horticultural crops, has developed a complex of culturally-determined market standards that evidence significant regional variability. This complex of regional standards has compromised the development of a strong export market in many potentially viable species.

Activities

- For high potential species, assess the commodity chain from field-to-fork to identify constraints to the efficient delivery of a high-quality product.
- Develop postharvest handling and processing techniques appropriate to the diversity of crops and cultivars in ANE.
- Develop adapted postharvest storage, transportation, and distribution facilities for high potential crops
- Create regional market standards for export-oriented crops.

III. Genetic resources conservation and development

Horticultural production is dependent upon the optimization of diverse genetic resources to obtain uniform, high-quality products and to adapt those products to changing environmental constraints and market demands. Untapped genetic resources also offer unique potential to develop new commercial opportunities, such as innovative crops or additional products within existing crops. Novel exotic fruits can be developed as a unique market segment, as illustrated by the introduction of "kiwi" fruit *(Actinidia chinensis)*, which has grown from a largely unknown crop in the mid-1970s to a production of 451,000 metric tons in 2000 (FAS 2003). Alternative products can also be developed, such as fruits of smaller and more uniform size (papaya, watermelon), seedless varieties (papaya, watermelon), different colored varieties (carrots), and varieties with higher nutrition or flavor (strawberries).

Regional, commercially unimproved germplasm exists in many parts of the world. These heritage cultivars frequently reflect long-lasting selection by farmers and consumers alike, for local adaptation and culinary or consumer preferences. While generally not associated with the high yields of modern commercial varieties, these traits are important for future breeding and adaptive research. As demand for horticultural products continues to grow, productivity and growth of the industry will depend on the appropriate utilization of genetic resources and on the genetic diversity that sustains it (Weinberger and Lumpkin 2005).

Genetic diversity is maintained within landraces[1], weedy relatives, and progenitor species that store genetic diversity. These sources of genetic variation are under threat from loss of habitat for wild and progenitor species, and from the conversion from landraces to bred varieties developed for a narrow range of highly marketable traits. Though landraces and locally selected cultivars represent an important part of regional or cultural identity for many farmers, local varieties are frequently less productive, less predictable in harvest date, and less compatible with market standards, compared with improved varieties. In much of Africa, 'indigenous'[2] leafy vegetables, such as amaranth and Ethiopian cabbage, are important to local diets. These species, however, are often incompatible with modern horticultural systems due to low or variable productivity, and problems in storage and transportation. In the absence of investment in research and crop improvement, these species will surely be replaced by less nutritious but more 'compatible' species. This failure would represent the loss of a potentially valuable species of cultural importance, and a squandered prospect for product differentiation and hence, market opportunity.

Opportunities, to characterize landraces of major horticultural crops for traits of interest, such as disease resistance or drought tolerance, are rapidly diminishing, as these resources are lost through degradation or replacement. In the highly competitive world of global horticulture, it would be a tragedy if the developing world lost access to its unique genetic advantage.

This Global Horticulture Assessment clearly indicates that current efforts to conserve, improve and disseminate local varieties are failing. Proper utilization and characterization of the genetic diversity present in both landraces and unexploited horticultural crops in developing countries represents an enormous opportunity for the horticultural sector within the region and globally. A strong and dynamic program of genetic resource development will set the foundation for increased and improved production, marketing and profitability of horticulture generally. The following research and development focuses begin to address these areas of need.

Priority research and development activities

1. Development of high-quality seed and planting stock programs

High-quality planting material requires advanced multiplication and protection systems, breeding for adapted germplasm, and certification and regulation to ensure quality standards. These requirements are beyond the capacity of most individual growers, and for many horticultural crops there is no investment by private industry to meet the demand for planting materials. Standardization and certification programs are often inadequate at the national and regional levels.

Hypothesis: Increasing the availability of high-quality, locally adapted, market-demanded seed and planting stock will improve productivity of commercially important commodities.

[1] Crop or cultivar that has been genetically improved by farmer selection, and not influenced by modern breeding techniques.

[2] Many species referred to as indigenous may not be native to the region but have developed unique regional importance over many years of use.

Activities

- Acquire, develop and evaluate cultivars for target horticultural crops and different production systems.
- Develop seed certification and distribution programs at the regional and/or national levels.
- Select and breed local varieties adapted to environmental conditions and disease and pest resistance.
- Establish nursery systems for the distribution of quality planting stock to address commercial demand.
- Facilitate the development of local seed companies and nurseries to provide low-cost, locally adapted seed and planting materials; provide extension and mentoring to these companies to improve competitiveness and probability of success.

2. Exploration, collection, conservation and utilization of indigenous genetic germplasm and knowledge systems

Sub-Saharan Africa, Latin America and the Caribbean, and the Asia/Near East regions are the centers of origin for the majority of the world's commercially important horticultural crops. The rich diversity of indigenous germplasm in these regions is a critical resource for the development and improvement of horticultural crops in varied agro-ecological zones across the globe. Yet much of this resource, in the form of locally adapted, and unique, indigenous species and cultivars, is quickly disappearing from farmers' fields, markets, and diets. Most of this valuable germplasm has not been characterized, properly preserved, or protected against extinction.

Hypothesis: Conservation and evaluation of indigenous genetic resources will lead to improvements and local adaptation of important horticultural crops, as well as the utilization and commercialization of traditional indigenous varieties and species.

Activities

- Document and inventory indigenous horticultural crops (fruits, vegetables, and medicinals) and knowledge about their use and cultivation at the regional or national level.[3]
- Develop replicable propagation systems for select indigenous crops.
- Study the resistance of native relatives to abiotic and biotic stresses for use in breeding programs.
- Develop participatory *in-situ* conservation strategies for landraces of commercially important horticultural crops.
- Improve access to germplasm varieties through novel distribution channels.
- Enhance policy and regulatory mechanisms to protect genetic material and intellectual property rights.
- Develop postharvest and packaging techniques for indigenous crops.

[3] Documentation of the botanical information of thousands of useful plants is already underway through the PROTA and PROSEA projects in Africa and Southeast Asia, respectively. Both are sponsored, in part, by Wageningen University.

Case Study 4. Genetic Diversity of Avocados in Mesoamerica: Foundation of a Global Industry

The avocado has been cultivated in Mexico for more than 10,000 years (Lahav and Whiley 2002). (The Spanish name for avocado, *aguacate* is derived from the Nahuatl Amerindian word *ahuacatl*.) By the time of Spanish conquest, avocados had adapted into three geographically distinct landraces, spread throughout Mexico and Central America. The diverse agroecological conditions in which the avocado was domesticated and evolved have resulted in a number of landraces that form the basis of many modern varieties, now cultivated on six continents. Mexico has contributed diverse and valuable genotypes to modern avocado cultivar development. In 1911, Carl Schmidt (a Californian sponsored by Los Angeles nurseryman Carl Popenoe) brought the cultivar 'Fuerte' to the US from Mexico. Fuerte enjoyed instant success and was the industry's standard variety for over 40 years before the Hass avocado, a scion of a western Guatemala variety, succeeded it. These two varieties of avocados are now planted worldwide. Together they comprise 85 percent of US avocado production, with a farm value of more than 400 million dollars.

Region Specific Context and Focus

Sub-Saharan Africa

Stakeholders repeatedly emphasized the need to improve the availability of high-quality seed and planting stock throughout SSA. Inadequate government regulation and organization, coupled with insufficient input markets and infrastructure, severely limit rural producers' access to planting materials. In addition, many of the available horticultural crop varieties are not adapted to the diverse biophysical constraints of eco-regions in SSA, like drought and low soil fertility.

Despite these constraints, SSA is ripe for expanded cultivation of its underutilized and indigenous crops, including leafy vegetables and perennial fruit, vegetable and medicinal species. The rich horticultural resources of SSA are largely untapped, in part because the majority of commercialized horticultural crops have their origins elsewhere. SSA is home to between 800 and 1,000 species of widely-cultivated or gathered 'indigenous' leafy plants that play a significant role in the food security, nutrition, and incomes of people in rural and urban settings across the continent. Indigenous, in this sense, refers to a crop species or variety that is genuinely native to a region or one that has, over time, adapted and evolved to local conditions, although it may not be native. Examples of SSA indigenous vegetables include *Amananthus spp*, Spider plant (*Cleome gynandra*), and African eggplant (*Solanum aethiopicum and S. macrocarpon*). In the Sahel region of West Africa, a number of unique perennial species are well adapted to the arid conditions and have gained considerable attention in local and export markets, such as the vitamin C-rich roselle (*Hibiscus sabdaniffa*), the apple of the Sahel (*Ziziphus mauritania*), moringa (*Moringa oleifera*), and date palms. As people move to cities and modern varieties replace traditional landraces in commercial agriculture, the role of indigenous horticultural crops in improving diets and enhancing rural incomes is threatened. Nevertheless, there is great potential to expand the markets for these valuable crops for local and export markets, as well as for growing urban centers.

Evaluation of indigenous vegetable cultures in East Africa.

Activities

- Develop horticultural crop varieties adapted to the diverse agroclimatic conditions of SSA.
- Promote trade of indigenous horticultural crops between regions.
- Increase consumer awareness of the nutritional and cultural importance of traditional vegetables and fruits in order to increase food security, nutrient intake, and incomes.
- Analyze the nutritional and beneficial properties of select indigenous vegetable species.
- Create regional and national databases of indigenous horticultural crops to include fruits, vegetables, ornamentals and medicinals.

Latin America and the Caribbean

The two centers of agricultural origin in LAC are Mesoamerica (Mexico to Panama) and South America (coastal regions). Many important horticultural crops have arisen from these centers (Cacao, avocado, tomato, chile peppers, pineapple, papaya, and squash, among others). Numerous LAC horticultural species are currently underutilized and show potential for intensive cultivation, including many native fruit species – *anonnas spp*., mombin, sapote, mamoncillo, guava, etc. While these indigenous fruit species are cultivated in home gardens and available at informal markets, little effort has been invested in improving their production systems. The genetic diversity of crops originating in Latin America is an invaluable resource for breeders, both within the region and around the globe. Underutilized LAC tree fruits represent opportunities to generate new markets, like the creation of the "kiwi" market.

Because the export market accounts for a greater proportion of horticultural production in LAC than in any other region of the world, much of LAC's productive land has been converted to crops that meet US supermarket demands. This widespread planting of US-destined export crops has resulted in the displacement of species of local value. The shortage of quality seed for many indigenous species has exacerbated this trend. With growing competition for the US market and a recognized need for greater local and regional consumption, the development of indigenous crops and novel export products become increasingly important.

Activities

- Document and characterize indigenous and underutilized horticultural species and compile regional knowledge of species cultivation and traditional usage at a regional and national level.
- Conduct feasibility study to determine local and international market potential of indigenous fruits.
- Create participatory *in-situ* conservation systems for landraces of horticultural crops of significant importance (tomato, Capsicum, pineapple, papaya, etc.).
- Harmonize IPR and PVP across the region.

Asia and the Near East

ANE is the center of origin and diversity of many of the world's major horticultural crops. Much of this germplasm has not yet been characterized and little effort is currently extended to preserve genetic resources and protect local cultivars from extinction. Conservation of genetic resources is critical, both for the improvement of economically important crops and for the possible introduction of new crops into international markets. Farmers throughout ANE have extensive knowledge of indigenous crop varieties and their utilization, as well as familiarity with the wild relatives of cultivated horticultural crops, but most of their knowledge has never been systematically assessed. The germplasm and knowledge is a latent resource, which may prove essential for the future of the industry.

The range of germplasm in ANE covers many fruit and vegetable species; this region is particularly rich in species with medicinal or pharmaceutical properties as well as many herbs, spices and flowers. The region has a strong cultural history of employing herbs, spices and medicinal plants. Consequently, there is a wealth of ethnobotanical knowledge and a long oral and written history of uses of these plants. Much of the ANE region lacks adequate systems and mechanisms for protecting indigenous germplasm and the associated intellectual property rights. Because international laws and treaties, such as the International Treaty on Genetic Resources, consider genetic resources the possession of the country in which they exist, these treaties can potentially be used to preserve a country's right to benefit from its genetic resources. In reality, plant species are rarely confined to political boundaries; most species of economic or cultural interest have been widely dispersed throughout the world. The real value of an indigenous plant species results from the commercialization of the species, or the compounds derived from that species.

Countries that harbor valuable germplasm and a wealth of indigenous knowledge on its use, need to protect the economic value of that resource. They must maintain the diversity of the species through *in-situ* and *ex-situ* preservation, by documenting and cataloging indigenous knowledge, and where appropriate, by legally protecting the species' known medicinal properties. Public policy development is needed throughout ANE to promote the just and ethical exchange and protection of genetic resources.

Activities

- Promote partnerships between private enterprises and growers of indigenous crops to preserve germplasm and cultural resources.
- Develop institutions to negotiate and enforce international treaties addressing farmers' intellectual property rights.
- Establish regulatory mechanisms to systematize the exchange of plant genetic resources across geopolitical boundaries.
- Conduct research to document ethnobotanical knowledge, to determine the physico-chemical basis of potential medicinals and to develop patentable commercial products.

IV. Sustainable Production Systems and Natural Resources Management

Horticultural cropping systems are usually diverse and dynamic, and as such, they represent an inherently more sustainable farming system than monoculture cereal production. Horticulture also threatens the environment, however, because the large demand for and frequent misuse of agrochemical inputs in horticultural cropping can have significant negative impacts on ecosystem services. Ultimately, horticulture's impact on the environment will depend upon the manner in which inputs are utilized and the prevalent environmental conditions. Mismanagement can result in damage to ecosystem health and the subsequent erosion of the natural resource base. On the other hand, producers employing good agricultural practices (GAP) can provide valuable ecosystem benefits. As markets become more sophisticated, demands for product quality and safety provide a clear incentive for environmental stewardship.

Detrimental Effects of Horticulture on Sustainability and Natural Resource Management

Amongst the rural poor, where the human capital and information sources necessary for the wise use of agricultural inputs is largely absent, the adoption of horticulture without the requisite training or monitoring can result in the degradation of natural resources. Consequences of horticultural intensification may include loss of biodiversity, water resource depletion or contamination, erosion, deforestation, and/or loss of soil productivity. These effects are the result of three primary mechanisms:

- Detrimental environmental impacts due to the misapplication of inputs, both agrochemicals and water, contributing to contamination of soils and water resources
- High-intensity horticultural industry's utilization of non-recyclable, non-biodegradable plastics for protection, production and packaging
- Soil depletion and erosion

Case Study 5. Using biotechnology to overcome pest pressures in South and South East Asia[1]

Throughout India, Bangladesh and the Philippines, eggplant is a significant traditional crop, produced in both rural and peri-urban systems. The eggplant cultivation area in India is about 510,000 hectares, yielding 8.2 million metric tons; in the Philippines, eggplant cultivation is close to 20,000 hectares, yielding 179,540 metric tons in 2004 (FAOstat data 2004).

In the peri-urban area surrounding Delhi, India, each eggplant is sprayed, on average, 80 times with insecticide to protect the crop against the fruit and shoot borer, which can decrease yield by as much as 70 percent. Chemical sprays account for a substantial portion of production costs and exert potentially harmful effects on the environment and consumers.

Through public-private collaborations, including local universities and private companies, a transgenic eggplant has been developed that is resistant to the fruit and shoot borer. Further, the initial pest-resistant variety has been bred into 12 more varieties, utilizing conventional breeding techniques, to adapt to local preferences. The new selections are currently undergoing testing for biosafety, but may be available commercially as early as December 2006.

The program is funded as part of USAID's ABSPII program[2].

[1] Information obtained from http://www.isaaa.org/Regional_centers/SEAsiacenter/ABSPII/eggplant/borer%20resistance.htm

[2] http://www.absp2.cornell.edu/

Agrochemicals

In developed countries, fertilizers and pesticides are applied disproportionately on horticultural crops (Weinberger and Lumpkin 2005). Over the past thirty years, there has been a rising trend of similar horticultural intensification and fertilizer use in developing countries, namely in Latin America and Asia (FAOSTAT data 2004). Mismanagement of toxic compounds, can result in damage to human health and dire environmental effects, and can lead to market exclusion if products fail to meet phytosanitary standards. Inappropriate timing and volume of applications may result in leaching of fertilizers into the groundwater and acidification of soils. Overuse of ammonia fertilizer can accelerate soil acidification, limiting the availability of some plant nutrients and degrading soil quality. Abuse of pesticides disrupts the ecosystem balance by killing non-target insects, compromising natural biological control and degrading groundwater, compromising health for downstream users. Deleterious health effects on infants and adults are linked to nitrate leaching into the groundwater. Appropriate agrochemical management requires a sound understanding of the principles of use, plus careful monitoring of outcomes. Efficient use of agrochemicals is complicated because chemical efficacy is sensitive to a variety of environmental factors, such as temperature, soil type, and water availability.

Improper agrochemical disposal, impacting water resources in Latin America and the Caribbean.

Water

Export-quality horticultural production demands high quantities of quality water throughout the growing season. While the actual quantity depends on crop/agroecological couplings, the need is usually greater when planting horticultural crops as compared to cereals. Inappropriate timing and volume applications exacerbate water demand. Throughout the developing world, there is a general need for low-cost, low-technology irrigation systems such as drip irrigation. Although access to the adequate quantities of water is a prerequisite, water quality is also important, with low salt and heavy metal content being highly desirable. As with all irrigated crops, management of soil salinity and chemical-ion exchange is critical to long term sustainability of horticultural production.

Plastics

High-value, high-intensity horticulture is increasingly dependent upon plastic, either in protected production systems (shade and greenhouses, etc.), as soil cover to reduce weeds and evaporation, or to suppress soil pathogens. Greenhouses and soil covering are tremendously valuable technologies, altering temperature and humidity levels, and thereby facilitating

Case Study 6. New Cropping Systems for the Sahel

The Sudano Sahel is a region about 600 kilometers wide, stretching a wide swath across northern Africa, from Mauritania on the Atlantic to Eritrea and Somalia on the Indian Ocean. Sahel's agricultural production is limited due to infrequent rainfall and persistent drought. Nevertheless, people in the region rely on subsistence rain-fed agriculture based on such drought-tolerant species as sorghum and millet. Poverty and land degradation are pervasive.
The New Sahel is a program devised by ICRISAT, and supported in part by USAID-WARP, to transform the Sahel's subsistence agricultural system into a diversified, sustainable and market-oriented system through the introduction of new crops and farming system models.

The African Market Garden (AMG) is a low-cost, drip-irrigation farming system that requires less than $100 in initial investment and can pay for itself within the first year. Utilizing the management practices and technology of the AMG, farmers can grow a wide range of high-value horticultural crops, including the date palm (which can yield $200/year/tree), papaya ($50/year/tree), table grapes, figs, citrus, pomegranates and vegetables like tomato, lettuce, collards, onion and a new 'zipper' variety of cowpea (for green pods). Approximately 1,000 AMGs have been established, and plans are underway for an additional 10,000 over the next few years.
The second model system, the Sahelian Eco-farm, is rain-fed and based on the integration of a large number of multi-purpose perennial tree species, each of which provide different marketable products and services in a single field. Crops, adapted to the local climate and capable of coping with low, or poorly distributed, rainfall, include pomme de Sahel (*Ziziphus mauriniana*), *Acacia colei*, moringa (*Moringa oleifera)*, roselle (*Hibiscus sabdariffa*) and sesame (*Sesamum indicum*). Annual grains, pulses and melons sown among the trees and shrubs contribute to household food security and livestock feed. Yields are increased by improved soil fertility from mulching with *Acacia colei* and from crop rotation. This model system can generate an estimated $680 per hectare once established – more than thirteen times the $50 typically eked out of the traditional millet monoculture.

These farm model programs are coupled with information and communication technology initiatives that link farmers to profitable local and export markets, as well as disseminate technical assistance and capacity building to help them reduce land degradation, conserve biodiversity and alleviate poverty throughout the region.

Reference: *The New Sahel: Transforming Sahelian Agriculture Through the Intensification of Rain-Fed and Irrigated Systems.* Abstract of a Presentation at the Science and Technology Conference in Burkina Faso: June 21-23/2004. Dov Pasternak, PhD ICRISAT

off-season production. Plastics can result in significant environmental enhancement because they reduce the demand for agrochemicals. Notably, plastic soil coverings decrease the need for methyl bromide, a non-selective gas used for sterilization of both soil and postharvest storage facilities. Methyl bromide, an ozone-depleting chemical, is being phased out worldwide, in accordance with the Montreal Protocol (Miller and Bird 1999). The phase out of methyl bromide presents a particular challenge to small growers in developing countries who lack the technical skills to develop alternatives and yet must meet the same rigorous export market standards applied to developed markets (COTF 2005). Plastics provide a viable alternative for smallholders. Plastics are also common in irrigation equipment, pots and planting bags. Re-use of these plastic materials can cause the spread of plant diseases and pests, but efficient and cost-effective recycling markets and technologies are poorly developed.

Beneficial Effects of Horticulture on Sustainability and Natural Resource Management

Although the mismanagement of horticultural intensification affects environmental services negatively, horticultural cropping systems can exert positive influences on natural resource management and ecological sustainability. These benefits include: decreases in erosion; increased carbon sequestration; efficient use of resources; and enhanced ecosystem function, including increased genetic diversity and stability.

Horticulture delivers a far greater suite of species and plant architectures than cereal crops offer. This diversity affords flexibility in planting designs that enhance soil management, including agroforestry, contour planting, and integrated cropping systems, which can limit erosion. Diversity can also aid in pest management by increasing numbers of beneficial organisms which attack pests and by hindering the ability of pests to locate their host plants. Agroforestry and perennial systems can contribute to reduced soil erosion, while mixed cropping techniques enhance soil fertility and health if nitrogen-fixing legumes are used. Legumes, which fix atmospheric nitrogen, reduce the need for fertilizer N input and can be intercropped with non-fixing species. Legumes not only provide nitrogen; they also bolster soil health, and in many cases provide forage for animals or additional food for the household.

Horticultural cropping systems contribute significantly to carbon sequestrations; in many environments more efficiently than cereals (Ponce-Hernandez 2004). The particular benefits of horticultural crops, in comparison to cereal crops, arise from their relatively low harvest index and their suitability to no-till and low-till cultivation. Additionally, carbon can be sequestered in the increasing biomass of perennial crops, hence providing a long-lived carbon sink.

The diversity afforded by horticulture increases the stability of the agricultural ecosystem. Various horticultural plant species may be intercropped for a more complementary utilization of resources, such as in traditional intercropping of beans and squash in Latin America. Adjustments in canopy height and rooting depth are common adaptations to maximize resource acquisition. Additionally, diversified horticultural systems may provide resilience and ecological sustainability because the complexity of the systems facilitates their persistence in light of environmental perturbations. For example, diverse agricultural systems were less prone to flood damage from the recent tsunami off Sumatra (De Clerk 2005).

Horticultural intensification is input intensive and has the potential to inflict detrimental or beneficial effects on natural resources. Appropriate knowledge and monitoring of inputs is essential if horticultural intensification is to be sustainable.

Priority research and development activities

1. Development of integrated crop management strategies to address horticultural production demands

Integrated crop management (ICM) is a systems-based approach to crop production that integrates technical solutions to pest, disease, soils, nutrition and weed problems with an understanding of the agroecological, sociological and economic context in which farmers operate. The development of locally adapted, integrated crop management practices will increase productivity and quality of horticultural crops while reducing stress on natural resources.

Technical information required to produce quality traditional and non-traditional crops is accessible in the developed world, but is unavailable in the developing world or has yet to be adapted for local cropping systems or specific agroecological zones. The development and adaptation of this information to the local context is a complex challenge that will require

the close involvement of developing country scientists and producers. The importance of establishing sound integrated crop management systems, specifically in resource-limited environments, is widely recognized (IAC 2004; CAADP 2003; Johnson *et al.* 2004; UN 2005a; ICARDA 2003; SPAAR/FARA 2000 cited in Rubin *et al.* 2005).

Hypothesis: The optimization of integrated management programs for local agroecological conditions will help minimize ecosystem degradation and improve crop quality to link small holders to the modern food industry's dynamic market.

Activities

- Encourage research, development, and training in ICM practices at educational institutions and extension services to improve information dissemination to producers.
- Evaluate the effectiveness of ICM techniques at improving soil fertility, water availability, pest and disease control and the production of horticultural crops.
- Establish and optimize best management practices for new production techniques including protected cultivation (greenhouses, plastic houses, net houses, shade production) and hydroponic cultivation to reduce seasonality of production and limit input needs.
- Collaboratively research and develop locally and regionally-appropriate IPM practices for important horticultural crops.
- Document and evaluate the effectiveness of indigenous cropping systems, and pest and disease control measures, to increase crop productivity.
- Research and develop integrated plant nutrient management systems to minimize nutrient losses and leaching of nutrients into the groundwater.
- Research, develop and implement soil fertility and conservation measures (supported by FARA 2004 Volume II; APAARI 2002) compatible with horticultural production.
- Develop and disseminate techniques to optimize water use efficiency for local horticultural crops, volume and timing (Rubin *et al.* 2005).
- Improve training and knowledge transfer by providing extension agents, NGOs and others with training in current ICM practices including IPM, soil fertility, and water use efficiency.
- Develop participatory farmers' training programs to improve access to information about ICM practices, and the training necessary for sustainable and profitable production.

2. Access to appropriate inputs and resources

Fertilizers and pesticides are frequently inaccessible to producers in rural areas. Where they are available, high costs and low quality may render these inputs unaffordable. The technology, knowledge and policy environment to effectively manage water resources is lacking in much of the developing world.

Hypothesis: Increasing access to inputs and providing the necessary technical support for their use will enhance productivity and minimize misuse and waste.

Activities

- Identify gaps in input and credit markets on a national and regional basis; develop innovative ways to provide credit to small producers to purchase essential inputs.
- Assist in the development of local, private agribusiness enterprises to provide seed and agrochemical inputs to small and mid-size horticultural producers.
- In collaboration with suppliers of agricultural inputs, develop mechanisms and safeguards to ensure delivery of accurate advice to rural producers.
- Support the development of local biopesticide industries.
- Provide producers with access to information and training about Good Agricultural Practices (GAP) standards, and the safe and appropriate use of agrochemicals.
- Support development of voluntary producers' organizations to facilitate group procurement and extension strategies. Explore the development of micro-enterprise certified input applicators to assume the responsibility of fee-for-service management of all agrochemical inputs.
- Research, develop and implement efficient irrigation systems to reduce water use and optimize crop quality.

Region Specific Context and Focus

Sub-Saharan Africa

Water shortages, insufficient irrigation systems, and poor soil quality are major constraints to the development of sustainable horticulture production systems in SSA. The majority of arable land in SSA is dependent upon inadequate and irregular rainfall. Less than 3.7 percent of sub-Saharan agricultural land is irrigated, compared with 10 percent in South America, 29 percent in Southeast Asia, and 41 percent in South Asia (NEPAD 2003). Furthermore, 16 percent of all soils in Africa

Protected production systems of tomatoes in Asia.

are classified as having low nutrient content, while that figure is only 4 percent for Asia (NEPAD 2003). Technologies such as water harvesting, drip irrigation, and improved plant varieties, combined with appropriate soil and water management practices, could increase production efficiency, but these technologies are often inaccessible or not adapted to the local socioeconomic and environmental conditions prevalent in SSA.

Activities

- Analyze the economic and production feasibility of a variety of water management techniques (drip irrigation, soil management strategies, etc.) for enhanced horticultural production.
- Disseminate information about appropriate water harvesting techniques to optimize and conserve water resources in horticultural production systems (deficit irrigation, etc.).
- Develop cost-effective irrigation systems (micro-irrigation, drip irrigation systems) and rainwater harvesting technologies appropriate for small producers.
- Devise and promote effective cropping systems to achieve maximum water use efficiency.
- Breed select species for increased drought tolerance and efficiency of water use.

Latin America and the Caribbean

Due to the high density of export and high-value market-oriented production systems in the region, there has been a greater focus on input-intensive agriculture and adoption of export-oriented crops in LAC than elsewhere in the developing world. When these 'market driven' crops and production systems are not well adapted to local agro-ecological conditions, their production has resulted in significant environmental degradation throughout LAC.

In regions striving to produce crops for an export market or local supermarkets, the question of 'What to grow, where and when?' is complex. Answers require knowledge of markets, agroecological zones, prevalent biotic and abiotic stresses, availability of required agrochemicals and processing, and shipping capacity. In areas where crops must be aggregated for sale, there is an absolute need for consistency in cultivar

selection and management of planting and harvesting windows. To realize the agricultural and ecological benefits of integrated cropping systems, the selection and timing of the mixture of species/cultivars is vital. These decisions are beyond the capacity of small producers to manage effectively in the absence of adequate information and training.

One of the priorities raised by workshop participants, and addressed by previous assessments, is the management of natural resources for the region (Rubin *et al.* 2005). This is especially important for the rural poor, who are cultivating on marginal lands, such as hillsides. Most prior extension and production research in the region has been geared toward the larger producers, who farm the most productive soils.

Activities

- Collect and develop the knowledge base required for effective decision-making.
- Develop a decision support system that integrates available agroecological data with market demand analysis.
- Promote alternative horticultural crops suited for specific production zones. Encourage crop diversification through farmer seed networks and field demonstrations.
- Adapt technological packages to meet local needs.
- Emphasize technologies and management practices for hillside agriculture, especially soil management.

Asia and the Near East

In many parts of Asia and the Near East, water is a critical factor affecting human health and crop production. FAO (2003a) noted that enhanced water use efficiency is of the highest importance to the region and indicated that water use may be the primary limiting factor in alleviating poverty in ANE. Two widespread problems in horticultural production are inefficient water use caused by inadequate irrigation practices, and soil salinity due to insufficient drainage of irrigation water. Irrigation systems in ANE range from rain-fed agriculture (no irrigation) to furrow and sprinkler irrigation. To date, only a small proportion of small to mid-sized horticultural producers use drip systems. Water quality is another critical issue in many parts of ANE. Irrigation water is often high in sodium and heavy metals, so groundwater contamination caused by horticultural activity can adversely affect human and ecosystem health. Inadequate water management is often a major constraint to horticultural productivity. Promotion and implementation of efficient water-use strategies will increase horticultural productivity while protecting product and water quality, as well as human health.

Stakeholders throughout ANE also emphasized the need for improved protected cultivation strategies in order to produce horticultural crops off-season and early in the season to take advantage of high prices and new markets. Protected cultivation can range from low-input plastic coverings or net houses to highly sophisticated greenhouse systems. Currently, many producers lack access to or knowledge about these technologies and techniques.

Activities

- Establish and optimize best management practices for new horticultural production systems, including covered production (greenhouse and plastic houses), shade production and hydroponic cultivation.
- Design/adapt low-tech, low-cost irrigation methods and techniques to promote more efficient use of irrigation water.
- Implement hydroponic cultivation and water recycling systems in protected horticultural production.
- Develop and utilize crop varieties with high tolerance to salinity, drought and waterlogging.
- For protected cultivation methods, design low-cost structures made with locally available materials.

V. Capacity Building

Because modern horticulture is a knowledge and technology-based enterprise, limited human and institutional capacity inhibits innovation, technology adoption, and the ability to address key constraints in the horticultural industry. Any initiative aimed at horticultural development will require ongoing capacity building programs that are both dynamic and relevant. In the Global Horticulture Assessment, stakeholders identified capacity building as the core component of each global primary issue, and deemed it essential to the improvement of the horticultural sector on an individual as well as institutional level.

Information sharing

The information and technology needed for effective horticultural production and marketing is complex and dynamic. To be truly effective, information must be shared freely between those involved in all stages of the production chain, from farm to retail store. To address this issue, major producers and marketers of horticultural products have increasingly developed vertically integrated purchasing systems that allow for control of the production system from farm to consumer. For a small grower this market integration does not exist and consequently, new production knowledge, standards, regulations and innovations do not reach small producers. In the absence of this information, small producers are at an economic disadvantage and often find their product excluded from the marketplace for lack of compliance with poorly understood regulations. Farmers' organizations, which can act as a nexus for information exchange and increase market access, are often inadequately prepared to communicate effectively with wholesalers, traders and processors. This absence of communication between all stakeholders in the value chain reduces the efficiency and productivity of the sector as a whole and increasingly favors the large producer to the disadvantage of the smallest, most resource poor growers. Each of these problems is a direct result of limited educational opportunity, inadequate communication infrastructure and the absence of viable public and private extension networks.

Strengthening extension systems

In many regions, the absence of an effective, well-trained extension network is a significant constraint to the development of the horticulture industry and the capacity of small producers in particular. Research institutions and extension and education services are hamstrung by resource constraints, and particularly by insufficient funding. With limited resources, institutions are unable to conduct adequate research, and lack necessary equipment and qualified personnel. Similar funding concerns may restrict an institution's ability to provide extension services to test and share findings. Other challenges associated with gender, culture, and language may prevent extensionists from reaching those most in need of assistance. Program delivery deserves special consideration. While excellent research and technology may be available, poorly adapted information can prevent its adoption and limit use of new knowledge and techniques.

Challenges for farmworker safety in agrochemical application.

Irrespective of the mode of delivery of extension information (public, private or NGO), the development of a pool of well-trained extension individuals is of core importance to a viable horticulture system.

Research and institutional capacity

Limited capacity and funding for horticultural research represents a long-term constraint to the development of the industry. Many NARES, overextended financially, lack sufficiently trained personnel to address the issues of the horticultural sector. Historically, most research has focused on the improvement of cereal crops; institutions and funding focused on horticulture are limited. Market information systems, improved postharvest systems, the development of improved and adapted cultivars, the protection and utilization of indigenous germplasm, and the development of integrated cropping systems are all activities that will require significant scientific training and collaborative partnerships between universities, NARES, international organizations and the private sector. As the majority of horticultural producers in these regions are smallholders, research should be participatory in nature and practically-oriented towards the needs of the smallholder.

Priority research and development activities:

1. Information management and knowledge sharing systems for the horticultural value chain

Lack of access to current information about production and postharvest practices, consumer demands, prices, and quality standards severely limits producer access to markets. Effective information dissemination systems are underdeveloped or inaccessible as a result of infrastructure and technology constraints (telephone, electricity, computers), or inadequate communication between players in the production and marketing chain. Timely access to appropriate information allows producers and marketers to respond to changes affecting production, such as weather or changes in market demands.

Hypothesis: Enhanced information sharing throughout the value chain (producers, wholesalers, marketers, exporters, researchers) will lead to increased production and economic growth in the horticultural industry.

Activities

- Design an information database to provide technical production and marketing information to all levels of production.
- Develop networking and information exchange 'best practices' for retailers, wholesalers, growers and other participants in the production chain.
- Design low-cost and innovative methods of information sharing, including cell phones, text messaging, radios, and computer technology.
- Strengthen the role of farmer organizations as information brokers.
- Develop public/private partnerships to facilitate information exchange among and between institutions, industry, and producers.

2. Strengthening human capacity through the development of innovative, effective extension and education networks

Ineffective and inaccessible extension and education networks have resulted in inadequate human technical capacity and expertise throughout the horticultural market chain in developing countries. The horticultural industry changes rapidly, and extension and education networks must have effective mechanisms to ensure that all parts of the market chain are trained in currently required methodologies and practices. The donor community, NGO's and private sector must be involved in helping to train existing extension agents or to deliver information and impart technical skills where extension systems are weak. The development and strengthening of new and existing educational networks will increase knowledge and skill levels in producers, thereby enhancing productive capabilities and competitiveness on regional, national, and international levels.

Hypothesis: Improvement of extension delivery mechanisms will help to strengthen capacity throughout the horticultural value chain.

Activities

- Develop North-South and South-South partnerships between research institutes, universities, and extension agents to enhance learning and build research capacity.
- Ensure educators are well informed about appropriate information and technologies and the most effective means of delivering information to stakeholders.
- Examine the potential of the modern food industry segments and companies or buyers, to provide technology dissemination services to improve small farmer competitiveness and profitability.
- Identify the technical assistance activities that, if replicated in part or in whole, would assist government/donor/private sector in profitably linking small farmers to the modern food industry.

Case Study 7. Capacity Building: Connecting small farmers to high value markets

Small producers in developing countries are often unable to participate in profitable supermarket and export marketing chains because they do not have the capacity to meet the stringent quality, quantity and food safety standards. The following examples highlight instances where the private sector has collaborated with donors and governments to build the capacity of small producers through specialized training and investment.

- **Hortico:** A Zimbabwean exporter sources directly from more than 4,000 Zimbabwe small producers organized into 20 collection centers who supply a Hortico central packing facility. The firm provides a number of services including: preweighed inputs on credit, funded in part by a revolving fund established by an overseas donor; pesticide application and extension advice on production practices, and assistance in identifying emerging problems (Boslie *et al.* 2003; Witherspoon and Reardon 2003; Rondot *et al.* 2005).

- **Carrefour, Columbia:** The PNUCID (United Nations Programme for control of International Drugs) is responsible for developing economic alternatives to illicit crop production. The PNUCID, supported by both the U.N. and the Columbian government, invests in the commercial capacity of local producer organizations. The organization provides packaging training and contracts consultants in quality control and postharvest. Carrefour sees the benefits both from buying directly from producers and from the sales of socially responsible marketing strategies of PNUCID supported production of hearts of palm, beans and coffee (Rondot *et al.* 2005).

3. Strengthen local research capacity with a focus on participatory methodologies

Many growers fail to adopt new technologies and management practices because they do not see the relevance of remote research projects to their particular constraints and conditions. Participatory research, in contrast, is carried out in farmers' fields in collaboration with local growers, researchers, and extension agents. This process validates research to farmers so that producers are more likely to adopt new practices. The producers involved in this process become researchers and problem-solvers in their own fields and can more effectively overcome future constraints to horticultural production and marketing.

Hypothesis: Participatory research leads to appropriate solutions for production and marketing constraints, facilitates farmer training, and enhances the probability of technology adoption and implementation.

Activities

- Enhance opportunities for regional scientists to gain advanced degree training in the fields of production, postharvest management, marketing and trade with a focus on participatory research methodologies.
- Provide training in critical production management strategies; design mechanisms to encourage farmer participation and innovation.
- Evaluate the impact of participatory research on technology adoption and improved management practices.

4. Develop local capacity to conduct advanced research and development and to train the necessary extension personnel, private consultants and industry leaders

Horticulture is complex, knowledge intensive and dynamic. Short-term technical assistance and training programs, while essential, cannot provide the human skills needed to guide the development of horticulture over the long term. Ongoing training in the fundamentals of horticultural science and research and learning methodologies are essential for long-term viability. Investment in research and training facilities is essential to the local development of human capacity and the development of improved crops and cropping systems.

Hypothesis: The development of local scientific capacity and provision of associated infrastructure and support is essential for the ongoing health of the horticultural system.

Activities

- Develop creative, cost-effective and relevant long-term training programs to foster local human capacity, ensuring long-term viability of the industry.
- Create public-private partnerships to ensure long-term viability of local research and training facilities.
- Develop North-South and South-South research and training programs.
- Develop the enabling environment to ensure long-term support for human capacity development.

Capacity Building – Region Specific Context and Focus

Sub-Saharan Africa

In addition to the priorities mentioned above, stakeholders throughout the region identified management skills training for entrepreneurial development as an important component of capacity building in the horticultural sector. Horticulture is a competitive, market-driven industry, meaning that stakeholders throughout the value chain must have business management skills and be able to communicate effectively with one another. Management training for micro-enterprise development would in turn, help to promote small agro-processing industries that may fuel local economic growth and increase marketing options for producers. Limited investment and commercial development in the horticultural sector may be due, in part, to lack of training for business development. Improved training in management of horticultural enterprises will improve producer competitiveness and encourage the development of local and regional horticultural value chain industries.

SSA also needs increased capacity in the National Agricultural Research and Extension Systems. Of the 6,000 NARES scientists in the region, 50 percent work for three countries: South Africa, Nigeria and Sudan. The remaining 3,000 scientists work for the rest of the NARES, many employing fewer than 70 scientists with MSc and above qualifications (Rubin *et al*. 2005). The research programs, many focused on cereal crops, are spread too thin in terms of funding and personnel, and the development of national agricultural research programs suffer as a result.

Activities

- Develop effective extension mechanisms for improving management and entrepreneurial skills among producers and entrepreneurs. Involve the private sector in the creation, dissemination and training of these management extension modules.
- Increase opportunities for high-level education and training in the field of business management throughout the horticulture value chain.
- Build North-South, South-South and public-private partnerships in research and development.

Latin America and the Caribbean

Given the existing and increasing market demand for testing, certification and compliance with standards, the presence of these services has become a prerequisite for market success. Throughout LAC, certification and compliance services are poorly organized, badly integrated and inconsistent in quality. With no viable public sector to provide these services, expensive private businesses fill that gap for the wealthier growers and international enterprises. The absence of a public or semi-private services sector represents a real barrier to market participation for the poorer grower and for resource-limited farmer organizations. Strengthening the existing horticultural services sector through additional partnerships with research institutions and regional networks would help to make testing, certification and quality assurance programs more effective and accessible for smallholders.

Activities

- Determine the capacity of institutions serving the horticultural industry to reach smallholders, especially those institutions that provide a quality and compliance certification function.
- Provide technical training and tools needed to test and regulate commodity standards.

Asia and the Near East

There are very great differences across ANE with respect to human capacity in horticulture. Egypt and India benefit from a wealth of agricultural knowledge and PhD-level scientists, but they lack coordinated information dissemination systems. Much of the rest of the ANE region, however, is characterized by a dearth of scientific and institutional capacity.

Across all regions, appropriate utilization of information technology was identified as a critical challenge. Listed as

underutilized opportunities for information dissemination were: text messaging and TV in South East Asia, and radio transmission in the Near East and North Africa. Both South East Asia and North Africa emphasized the need to build human capacity and identified lack of skilled labor and inadequate knowledge of GHP and GAP as significant constraints to effective utilization of horticultural crops. South Asian participants emphasized the need to build institutional and scientific capacity in order to enhance their ability to develop and adapt new technologies. North-South and South-South training and knowledge exchange could utilize available distance and digital learning facilities.

Activities

- Assess the human capacity needs on a country-by-country basis.
- Develop long-term training partnerships to adapt technologies in-country.
- Integrate information technologies to facilitate the rapid transmission of information across the region as a whole.
- Create regional training programs utilizing the local knowledge base.

VI. Enabling Environment

An enabling environment can be defined as the necessary set of interrelated economic, social, and political elements including legislative frameworks, policies, infrastructure, and institutions which support the research and development initiatives highlighted in the above sections. Appropriate trade agreements, the regulation and protection of intellectual property rights and the support of fair policies and institutions are critical for the development of a horticultural industry that encourages economic growth while providing opportunities for smallholders and other disenfranchised members of society.

Brazil, Chile, Kenya and Mexico, leaders in fresh and value added fruit and vegetable exports, illustrate the need for stable political and economic conditions and favorable terms of trade for horticultural production and marketing (Jaffee 1993). Trade agreements, such as the North American Free Trade Agreement (NAFTA), other treaties within the Pacific Rim region (Chile and Singapore, for example), and African, Caribbean, and Pacific (ACP) economic partnerships with the European Union (EU), have unfolded within and across regions with a distinctive set of opportunities and challenges to nations, markets and producers. Trade agreements, however, do not necessarily ensure equity or growth and there is evidence to suggest that treaties such as the EU-ACP treaty favor developed nations as opposed to developing nations and in the short and medium term, are harmful towards smaller producers and subsistence farmers (IFPRI 2005). Prior to implementation, policymakers need to critically evaluate the impacts associated with subsidies, tariffs, quotas, required measures, and price structures for both developed and developing nations.

Although the genetic resource base for much of the world's horticultural crops is found in developing countries, there has been an increased emphasis in developed countries on a western-based framework of Intellectual Property Rights (IPRs) for genetic resources. Patenting of these resources continues to be controversial and not well articulated at the global level. Recent examples highlight these problems, as seen in the patenting of neem extracts by both US and Japanese companies resulting in widespread protest in India, and is the patenting of the Enola yellow bean by a US firm (Gepts 2004). Recent international treaties, such as the Convention on Biological Diversity (CBD), Trade-Related Intellectual Property Rights (TRIPS) and Plant Variety Protection (PVP) have met with limited success at initiating IPR frameworks for individual

countries that both protect national rights to those resources and simultaneously stimulate and encourage research.

Effective and equitable socio-political and economic policies and institutions are critical for encouraging economic growth and promoting the participation of marginalized sectors of society. Prerequisites for a thriving horticultural industry include secure systems of land tenure, reliable credit markets geared towards resource limited producers and firms, equal opportunities for education, and adequate infrastructure. Effective policy frameworks aimed at improving agricultural production and poverty alleviation will also take into account the "critical triangle" of how agricultural growth and poverty affect natural resources (Vosti and Reardon 1997). Regulatory mechanisms for protecting natural resources, worker and food safety, and the rights of small producers and firms in contractual relationships with larger companies will promote a sustainable and just horticultural sector.

The above section highlights constraints to horticultural production. All proposed activities in this assessment aim to alleviate constraints in the enabling environment. Success in any individual horticulture enterprise will occur only if there is an enabling environment at each stage of the commodity production-consumption chain. Proposed activities will be developed with recognition that the environment at every stage of production must be considered, *a priori*.

Hypothesis: An enabling environment is the foundation for a fair and sustainable horticultural industry. Both the private and public domains must collaborate on appropriate strategies for market access to producers, efficient market function and on methods to strengthen capacity of players throughout the horticultural value chain.

Activities

- Identify public policies and options needed for the development of efficient and competitive agricultural markets, and improve the access of small farmers, women and traders to these markets.
- Facilitate and promote market alternatives to poor farmers who face the effects of global restructuring of food and agricultural, such as direct exchanges between rural and urban counterparts.
- Identify and analyze constraints and alternatives to the rural horticultural industry including postharvest activities, credit, infrastructure, and institutions for product certification.
- Critically evaluate the impacts associated with subsidies, tariffs, quotas, and trade agreements for both developed and developing nations.
- Develop and implement appropriate IPR frameworks that protect a nation's rights to equitable profits from utilization of their genetic resources, while encouraging research and development of those resources.
- Communicate and make public strategies and policy options derived from research at the national and international levels.

VII. Gender and Horticultural Development

Historically, research and development institutions have overlooked or slighted women's roles in household food production. Only recently have researchers begun to highlight the critical roles women play in food systems. Gender-based research has also illuminated how women are often neglected in agricultural development projects. A landmark study by Ester Boserup (1970) emphasized the fact that despite women's vital contributions to farming systems across Africa, the majority of the continent's female farmers were not experiencing significant improvements in their quality of life as a result of their increasing agricultural commercialization. Future horticultural development must consider women's roles and needs in culturally specific food systems.

In today's horticultural industries, women participate as farmers, agricultural business laborers, entrepreneurs, and consumers. In horticultural agribusiness, including fruit, vegetable and flower production, women compose a majority (50 to 91 percent) of agribusiness horticultural labor supply in vegetable, cut flower and fruit sectors (Barrientos 1999; Hamilton et al. 2001; Korovkin 2003; Dolan 2004). The demographics of this sector are predominately young women from ages 15 to 30, who are either single or de facto single female household heads. Education levels range from 0 to 12 years, and most of these women are landless or land poor.

Women face a variety of constraints in horticultural production systems including:

- Land
- Labor
- Knowledge
- Credit and technology
- Organizations and networking

Gender-based research has informed development agencies of the critical importance of the specific roles and needs of women to ensure a project's success. The following section highlights women's unique constraints, as well as some specific opportunities in the horticultural sector.

Woman selling produce in a traditional market.

Land

Globally, women control much less land then men. How women benefit from profitable horticultural production can often depend on whose land they farm and their rights to that land. In Guatemala, snow pea and broccoli export production has increased opportunities for women in landholdings and decision-making. In Africa, where horticultural production has traditionally been a female activity, increased profits have displaced many women from their traditional farming lands (Wooten 2004). Some women lose traditional horticulture usufruct rights on household land when men enter export markets (Dolon 1997). Wooten's (2003) case study on market gardens in rural Mali highlights land constraints faced by rural women. He found that market gardening has become a lucrative option for rural farmers who can meet the demands for specialized horticultural produce. Women participating in market gardening (considered traditionally women's work) have been systematically marginalized to smaller plots, often lacking access to water.

Labor

Women's work in agribusiness includes field and greenhouse production, packaging and processing. Although women are preferred for these types of tasks because of their care, patience, dexterity, commitment and collaboration with fellow employees, they are generally concentrated in lower-waged, non-permanent positions. For example in Kenya, women do 72 percent of farm labor and receive 38 percent of the income (Dolon 1997). In women-run enterprises, women are often less well-financed to hire labor and they control less of the family labor. On the other hand, women may be better able to negotiate family labor exchanges and may have stronger social capital networks for sharing labor than do men. In the Dominican Republic tomato-processing sector, women constitute approximately half of the labor force. Laura Raynolds (2002) has reported that women who benefit from tomato harvesting or processing have more power in household decisions, higher self-esteem, and are more likely than men to spend their earnings on household needs.

Knowledge

In much of the developing world, formal education is male biased. Furthermore, women have been marginalized from the benefits of agricultural training, extension, and export market communications. In some regions, women agriculturalists prefer working with and would thus benefit most from female extension agents (Moore et al. 2001). In many parts of the world, such as Tanzania, Iran, Madagascar and Afghanistan, horticultural crops are "women's crops" rendering the women in those countries reservoirs of horticultural production and marketing knowledge and experience.

Credit and technology

Largely due to cultural barriers, women are less likely to possess the traditional collateral required by formal banking institutions. Furthermore, if women do not have equal access to credit, they will also suffer from unequal access to technology development and dissemination.

Organizations and networking

Women face a number of constraints in organizing and networking. Although women's networks may be well established in domestic production in local markets, export-orientated production and marketing institutions are male dominated in many settings. Women's organizations may not meet production capital requirements for export production and contracting, thus marginalizing women from the benefits of horticultural production.

Gender differentiated control of production factors limits not only women's productivity, but also their ability to respond to market incentives, and to generate and control income. Their effectiveness as agents of sustainability and health is also limited by gender differentiation, because women are more likely to respond to adverse health affects of pesticide use will implement IPM strategies. Women's access and control of factors in production can enhance the supply chain of products, environmental sustainability, economic growth, poverty reduction, and overall well-being.

There have already been tremendous payoffs for reducing gender inequalities in household food production. But there is continued work to be done in reducing constraints faced by women in the horticultural sector, such as:

- concentration in lower-waged and temporary jobs
- occupational health and safety
- available recourse to enforceable fair labor standards
- husbands, fathers controlling women's wages

Horticultural sectors may be the best or only wage opportunity for women in rural areas. They often get equal pay for equal tasks, receive medical and social benefits, and have increased visibility as economic providers. A potential solution to constraints faced by women may be to link women's production to NGOs, providing literacy and basic education, leadership skills, knowledge of agrarian code legal frameworks, and the advocacy of women's property rights.

Trends in horticultural production include satisfying growing urban demands for horticultural products and the integration of small farm businesses into the agro-industrial sector through the use of production contracts. This trend can result in a heightened demand for women's farm labor. Raynolds (2002) has highlighted this phenomenon in her study of tomato contract farming in the Dominican Republic. She reports that 79 percent of male growers draw on their wives' labor and that processing firm managers typically refuse to sign contracts with single men.

The bottom line for gender and horticultural development is that women are experienced producers and value-adding agribusiness employees who are poised to increase productivity and expand the horticultural market. Horticulture offers women unique opportunities to improve their own and their families' standards of living. The following highlights a gender based research agenda that will be pervasive throughout all proposed activities. This is essential to ensure that women benefit from horticultural development.

Hypothesis: Women in developing countries are the traditional cultivators and marketers of horticultural crops. For equitable distribution of the benefits of and increased decision making power in horticultural production, women require equal access to horticultural resources, such as land, labor, credit and networks.

Activities

- Actively recruit female farmers, scientists and engineers for participatory research.
- Emphasize research on women's participation in small-scale export production.
- Prioritize comparative research on gendered dimensions of horticultural production for export and for domestic production and marketing in all regions.
- Document region-to-region variations of women's constraints and opportunities in the horticultural sector.

Case Study 8. Market Gardens in rural Mali

Stephen Wooten's (2003) case study of market gardens in rural Mali highlights rural African women's disadvantaged position in changing economic contexts, seen in socioeconomic transformation and increasing commodity production. He illustrates how existing gender relations of production support men's participation in and women's marginalization from the commercial gardening realm. Traditionally horticultural crops in much of rural Africa are women's crops which complement the grain production done by males. However in the 1970s and 80s, market gardening became a lucrative business as urban demands grew for horticultural products. As a consequence, men eventually displaced women in garden cultivation. Market land has become a key resource and it has been shown that access to it is highly gendered and defined by lineage identity, where a patrilineal orientation prevails. Women as wives, and thus lineage outsiders, are at a clear disadvantage in terms of their ability to obtain land for market-oriented agricultural activities.

As is custom in Bambara society in this region of Mali, wives and husbands do not pool household resources. Culturally, a man is only responsible for supplying a house and grain to his wife, and thus men do not share their garden earnings with their wives. Wives are responsible for their own personal expenses as well as expenses associated with their children. Without access to garden land, women are relegated to marketing bush resources, such as charcoal production, shea nut butter production and hand-broom production which have low earning potential, as compared to market garden production, and may have limited sustainability.

VIII. Nutrition & Human Health

Micronutrient deficiencies, and associated complications resulting from poor dietary quality, hinder the development of human capacity and creativity, which is the foundation for economic growth, and ultimately, poverty alleviation. Horticultural crops play a valuable role in food systems by diversifying diets and fostering increased dietary consumption of micronutrients and other plant products known to benefit human health (fiber, antioxidants, etc.).

Changes in production systems over the past 40 years favor an increase in cereal-based diets. The emphasis on staples has resulted in reduced dietary diversity and the displacement of traditional crops that were important sources of micronutrients such as iron, vitamin A, B-12 and zinc. In South Asia, where cereal production has multiplied four-fold since 1970, the production of iron and zinc-rich pulses such as mungbeans, has declined by approximately 20 percent (Demment *et al.* 2003). In other parts of the developing world, the consumption of fruits and vegetables is also declining (UN 2004). This reduction in dietary diversity has aggravated existing micronutrient deficiencies, particularly among women and children. Today, more than two billion people suffer from these deficiencies (UN Standing System Committee on Nutrition 2004). Staple grains such as rice and wheat cannot provide a healthy diet by themselves due to their inherently low density of some nutrients that are critical for human health. Consumption of horticultural crops such as vegetables, fruits and pulses, are essential for enhancing the health and productivity of populations.

Nutrient deficiencies disproportionately affect resource-poor, rural communities that derive the majority of their income from subsistence farming (Aphane et al. 2002). Vitamin A deficiency (VAD) affects 40 percent of children in developing countries, increasing their risk of dying from infectious diseases such as diarrhea, measles, malaria and HIV/AIDS (Sommer and West 1996). VAD is also a major cause of preventable visual impairment and blindness, which affects 250,000 to 500,000 children each year (Aphane *et al.* 2002). In South Asia, VAD is most severe during seasons when vitamin A- rich foods, such as leafy greens and mangos, are unavailable. Iron deficiency is perhaps the most widespread nutritional disorder, affecting between 2 billion and 3.5 billion people around the world (Demment *et al.* 2003). In developing countries, 52 percent of pregnant women, 39 percent of children under the age of 4, and 48 percent of children between 5 and14 years of age may suffer from anemia due to inadequate consumption of iron-rich foods and foods rich in ascorbic acid (fruits), which enhance iron absorption. FAO data suggest that approximately one-third of the world's population is at risk of low zinc intake.

There are hidden consequences to micronutrient deficiencies that ultimately affect a population's productivity and its potential for economic growth (Demment *et al.* 2003). Inadequate nutrition severely limits a person's ability to develop skills and capacities through education and ultimately reduces the productivity of his or her labor. Micronutrient deficiencies early in life (6 to 24 months) can cause stunted growth, which correlates to low physical activity, impaired motor and mental development, lowered immune function, and higher youth fatality rates. These early deficiencies can impair cognitive development, leading to behavioral problems, a reduced capacity to learn, and ultimately a reduction in lifetime productivity (Welch and Graham 1999; Demment *et al.* 2003). The World Bank estimates that deficiencies of vitamin A, iron and zinc decrease the GDP of developing countries by as much as 5 percent (Bouis *et al.* 1999; Demment *et al.* 2003).

In the past, donors have favored fortification and supplementation strategies to alleviate micronutrient deficiencies. While these strategies often afford short-term results, they have limited efficacy. Supplementation, often a necessary component of therapeutic treatment for severe nutrient deficiencies, is difficult to supervise where infrastructure is lacking (Vijayalakshmi *et al.* 2003). Fortification can be a cost-effective way to enhance micronutrient availability for large populations, such as vitamin A fortification of sugar in Central America, but it requires sophisticated management, quality-control, communications, and monitoring, as well as a favorable policy environment (Demment *et al.* 2003). Food-based approaches, such as dietary diversification, require long time commitments, but are more likely to be sustainable because they are a part of a development process that leads to long-term economic growth. Appropriate introduction of marketable horticultural species has the potential to simultaneously boost income and improve diets. So, while supplements and fortified foods can be effective ways of addressing immediate micronutrient deficiencies, food-based solutions such as increasing the consumption of vegetables, legumes, and fruits, are the most sustainable ways of reducing and controlling micronutrient deficiencies in resource-poor communities, and at the same time helping

grow economies (Aphane *et al.* 2002). The effectiveness of this approach is well documented. Daily consumption of cooked, pureed green leafy vegetables or sweet potatoes has been shown to have a positive effect on vitamin A stores in populations at risk for vitamin A deficiency. A recent study in Nepal concluded that eating pureed green leafy vegetables or cooked pureed carrots was equally as efficacious as vitamin A capsules for treating night-blindness in women of child-bearing age (Haskell *et al.* 2004; 2005). Mungbeans, when prepared in combination with foods capable of enhancing its bioavailability, was proven to alleviate iron deficiencies in Indian school-children (Vijayalakshmi *et al.* 2003).

The aim of food-based approaches is to increase access to micronutrient-rich foods, as well as to increase the consumption and bioavailability of micornutrients that can be absorbed and utilized by the body. Food-based approaches can include:

(1) Increasing production and therefore availability of micronutrient-rich horticultural crops;
(2) Increasing the intake of micronutrient-rich foods through education;
(3) Enhancing the bioavailability of micronutrients in foods through proper preparation and food combinations;
(4) Developing cultivars that increase the amount of micronutrients, decrease content of inhibitors, or increase content of substances that promote absorption.

These methods have the advantage of addressing several deficiencies at once. In addition, the physiological interactions between vitamins and minerals in foods enhance the body's ability to absorb essential micronutrients.

Increased consumption of horticultural crops can also enhance the well-being and longevity of people affected by HIV/AIDS, as well as prevent obesity and related diseases, which are emerging problems in the developing world. The Joint United Nations Programme on HIV/AIDS (UNAIDS) estimates that, globally, 38 million people live with HIV and the rate of infection is rising, particularly in sub-Saharan Africa and Asia (UN AIDS 2004). The Food and Agriculture Organization (FAO) and the World Health Organization (WHO) continue to study the role of micronutrients in combating HIV. Evidence has emerged that increased intakes of vitamins A, B-complex, C, and E, as well as iron and zinc, can help to combat weight loss and diarrhea and improve immune status, especially in nursing mothers. The effectiveness of antiretroviral therapy (ART) is also enhanced by a well-balanced diet (FAO 2003). Increased consumption of less calorie dense foods can help to prevent and control obesity related diseases; research has shown that consumption of bitter gourds can help to control Type II diabetes (Platel *et al.* 1997). Fruits and vegetables are also rich in antioxidant compounds, which reduce the risk of chronic diseases (Southon 2000).

FAO and AVRDC-Regional Center in Africa are collaborating to combat vitamin A and iron deficiencies through increased production and consumption of indigenous vegetables. The incorporation of indigenous vegetables into the local diet has several advantages: Indigenous vegetables are especially micronutrient rich and when consumed together with cereals, they can enhance the bioavailability of nutrients in staple crops (Aphane *et al.* 2002); cultivation of indigenous varieties protects local biodiversity; the species themselves are easy to grow, resistant to local pests and diseases, acceptable to local tastes; and the diversity of species allows for year-round production (Aphane *et al.* 2002). Encouraging home and school gardens, which can incorporate indigenous vegetables, is a food-based strategy aimed at improving food security and alleviating micronutrient deficiencies by ensuring direct access to a diversity of nutritionally rich foods, increased purchasing power through sale of surpluses, and food security in times of seasonal lean periods (FAO 2005b). Selective and targeted plant breeding for increased nutritional value is another example of a food-based strategy to alleviate micronutrient deficiencies. Agronomic and genetic improvements have led to the development of varieties with increased nutritional properties that are easily cultivated and accepted by local communities.

The sustainability of food-based solutions to nutritional deficiencies is derived in part from its inherent educational value. Recognition by consumers of the importance of dietary diversity, the health benefits of sound diet, and the linkage between child development and nutrition will help perpetuate the system, and represents a lesson in human nutrition that could not easily be delivered in any other way.

Research and education play important roles in alleviating micronutrient deficiencies and contribute to building the health and capacity of the people in the developing world. Collaborative research between agricultural scientists and nutritionists will result in more effective, integrated approaches

to both agricultural production and the enhancement of health and nutrition. Educating consumers, industry, and policy makers about the importance of dietary diversity and the role of micronutrients in improving health and economic growth is also an essential component of any development activity.

Hypothesis: Nutritional improvement is a core objective of all horticultural activities and an expected outcome of any investment in fruit and vegetable production. The improvement of human health and nutrition through increased consumption of horticultural crops will optimize the capacity for individuals to contribute to economic growth.

Activities

- Evaluate select indigenous horticultural crops and cultivars for their nutritional properties.
- Analyze the bioavailability of specific nutrients from enhanced mineral-rich foods and food mixtures, and examine the effects of food processing and postharvest techniques and the effects of soil/fertilizers on mineral content of foods.
- Conduct integrated cropping systems research with the explicit goal of enhancing dietary nutrient consumption. Manipulation of the cropping mix, optimization of irrigation and fertilization regimens, postharvest handling and storage and control of pests and diseases can all contribute to the density of nutrients in a diet.
- Analyze the constraints to utilizing horticultural crops to enhance nutritional status of high-risk subgroups such as women and children. Examine limiting factors, such as amount consumed, absorption, how infection affects bioavailability, and the influence of culture.
- Examine ways to enhance the bioavailability of certain crops through processing to reduce volume and fit within cultural norms.
- Involve women and families in the establishment of home gardens, coupled with nutrition education to promote the health of families and increase incomes from the sale of surplus produce.
- Investigate the possible ranges of dietary consumption by different age groups and the cultural acceptability of consuming different horticultural crops.
- Conduct a public awareness campaign to encourage consumption of balanced, nutrient-dense diets.
- Develop a rapid appraisal system for food systems to determine the constraints on adequate and balanced nutrition in communities. The appraisal system would identify production, processing, purchasing and policies that impede consumption. The analysis would be a rapid means to provide information for effective design of intervention at various spatial and social scales to solve micronutrient malnutrition and grow local economies.

Case Study 9. Amaranth: a weedy species with nutritional potential

One of the world's most common weeds is rapidly becoming one of the world's most important vegetables. *Amaranthus spp*., a grain crop native to the Americas, is utilized primarily as a leafy vegetable throughout sub-Saharan Africa and in many parts of Asia. Vegetable amaranth (*A. hypochondriatus, A. curentus,* and *A. hybridus*), which flourishes in abandoned fields and along roadsides, contains levels of iron, zinc and betacarotene many times higher than those found in spinach. Like most "indigenous" vegetables, amaranth grows under a wide range of environmental conditions and can be quite resistant to pests and diseases, which means it requires fewer inputs than many introduced and widely commercialized crops, such as cabbage and spinach. Today in Africa, where farm labor and farming practices have been decimated by HIV/AIDS, mothers harvest the nutritious weed from roadsides and cultivate it in home gardens. Food security experts see amaranth as a vital crop in Africa and in the tropical lowlands of Asia. Researchers at AVRDC-The World Vegetable Center, who have collected more than 100 different types of amaranth, are in the process of testing yield potential and developing improved production practices in order to make this nutritious crop more widely available to people around the world.

www.avrdc.org/news/04/amaranth.html/

IV. CONCLUSIONS & RECOMMENDATIONS

The Global Horticulture Assessment has identified the primary issues that constrain horticultural development worldwide. The GHA has also articulated the research and development activities that must be addressed if investment in horticulture is to reduce poverty, stimulate economic growth and improve human well-being. Horticultural production is complex and dynamic, and involves a chain of closely interdependent activities from crop production to consumption. To address the development needs of horticulture will require the application of the full range of development instruments including infrastructure and institution building, technology transfer and development, creation of an enabling environment, technical training programs, research and capacity building. Research and development activities that address these global issues in an integrated and cohesive way are essential if development investments are to have a significant positive effect on global production and economic growth.

The great potential for horticulture to contribute to economic growth in the developing world, coupled with the complexity of the issues to be addressed and the diversity of skills that are needed, provides opportunity for the participation of a wide diversity of NGOs, development companies, NAREs, IARCs and universities. NGOs and development companies are well suited to conduct broad-based, on-the-ground interventions, while IARCs and universities are better equipped to help generate new knowledge, integrate and interpret information, and provide capacity building. To date, there has been very little investment into research for horticultural production in the developing countries. Many current USAID-funded activities have a short-term focus and do not strive to develop the human resource base or new knowledge essential for program sustainability. There has also been very little coordination between U.S.-based programs and the Missions.

Horticulture is a highly technical, knowledge dependent and dynamic industry. Sustained growth in horticulture requires investment in human capacity building and knowledge generation. Investments in the horticultural education and research in Chile in the 1960s through the 1980s, for example, were instrumental in developing a core resource of local scientific capacity and strong public and private institutional support that has facilitated the many Chilean innovations and changes in production systems that were essential to sustainable growth. Only a few nations have achieved sustained growth in their horticultural markets over the past decade, namely Mexico, Chile, Kenya, Brazil, and China. Significantly, each of these countries has made a substantial investment in human capacity and knowledge generation to support horticultural innovation. These observations support the conclusion that investment in capacity building and knowledge generation provides the highest return on investment of any development activity (Alston 2000).

The potential contributions of horticulture to regional economic development and human well-being are clearly significant, and yet assistance programs dedicated to this goal are uncommon and uncoordinated. The goal of the Global Horticulture Assessment was to “develop a framework for the implementation of a new research and technical support program in horticulture that will provide a mechanism for USAID, U.S. universities, and commercial enterprises to contribute to the development of global horticultural capacity” (Horticulture Sector Development Grant, UC Davis 2004).

It was not the mandate of this assessment to provide a list of high-impact, ready-to-implement projects (although a select few such projects were identified by participants). Rather the process was designed to highlight the primary issues and

identify the broad project needs of highest priority, with the expectation that this information will be used to guide the subsequent project development and selection.

The selection of project activities should commence with a planning and assessment process that would encourage broad, flexible team-building and result in the development of detailed descriptions of development problems and their underlying processes. The project assessment process would not only involve researchers in the development of projects, but also identify and seek out stakeholders and policy makers as full members of the team.

Implementation Guidelines

Several options could be considered for implementation of an aggressive horticulture research and development strategy. It is clear, however, that the chosen implementation vehicle must recognize the following principles:

1. To sustain growth in the highly technical, knowledge-dependent and constantly changing horticulture industry, there is a fundamental need for investment in human capacity building and knowledge generation. The development of a local capacity for independent and creative knowledge generation is essential.

2. The production and marketing of horticultural products is a vertically-integrated and strongly-interdependent activity. All activities and interventions must reflect this context.

3. A diversity of scales and modes of interventions are necessary. Thus, a portfolio of activities that address local and/or global scales and includes the continuum of activities from short-term infrastructure investment and technology transfer to long-term research and capacity building will be required.

4. Creative mechanisms for program coordination, knowledge sharing and adaptive research must be emphasized so that coordination of projects is maximized and lessons learned in one activity can inform and improve activities elsewhere.

5. Public-private partnerships are critical to the equitable development of horticultural enterprises. Private industry has a unique role and stake in the provision of inputs and services for horticultural production. Public agencies have an obligation and an opportunity to ensure that these inputs are made available to the poor and that the use of inputs is environmentally appropriate.

6. Activities must strive to reduce poverty, stimulate economic growth, improve the environment, and support gender and social equity.

Recommendation
Establishment of a Horticulture CRSP

A number of mechanisms could be proposed to address the issues highlighted by the Global Horticulture Assessment and to realize the opportunities of horticultural in development. Whatever mechanism is developed must recognize the relative advantage of the U.S. universities, must be responsive to USAID-Washington and USAID Missions, and should play a role as an integrator of horticultural development knowledge and a key partner in program development in the horticultural sector.

Given the dependence of horticulture on knowledge generation, human capacity building and integration across scale and discipline, it would be inefficient to fund isolated, targeted or site-specific activities in the absence of a core integrating program. The development of such a core program in horticulture would provide for a degree of program integration, synergy and efficiency that is currently lacking. Short- and mid-term targeted activities will continue to play an important role in horticultural development but their benefit would be greatly enhanced through coordination and integration.

A Collaborative Research Support Program should be established for a renewable multi-year term at a major U.S. university with preeminent capacity in horticulture. The new Horticulture CRSP will partner closely with the World Vegetable Center and its CGIAR partners in the newly developed Global Horticulture Initiative. This partnership ensures synergy and efficiency of programs and will directly enhance the capacity to identify and implement key development programs in horticulture.

In addition to its role as a center for knowledge generation, capacity building and integration, the Horticulture CRSP would also partner with individual, regional and global consortia

of Missions, and private and public partners to design and implement specific targeted short and mid-term projects that address the core challenges in horticulture identified in this analysis. These projects would be selected on the basis of their regional or global relevance and would be implemented with a goal to develop a product that can be adapted for use by missions globally. The following projects are provided as illustrative examples of high priority projects:

1. Development of Phytosanitary and Postharvest Protocols for the Small Producer.
2. Development of Small Scale Agrochemical and Seed Supply Micro-enterprises
3. Establishment of a Global Horticulture Knowledge Bank and Extension System

This initiative would be designed to provide the research, capacity building and knowledge extension support essential for the development of the global horticulture sector. The initiative would strengthen the ability of USAID-Washington and the Missions to develop and implement effective programming in the horticulture sector, and strengthen existing USAID funded programs that have a horticulture component and serve a coordinating and integrating role. The initiative would also partner with existing CRSPs to reinforce their ability to achieve their development goals.

A core principle of this initiative is to support USAID and Missions by providing program design and implementation advice, technical expertise and coordinated knowledge generation and extension programs.

The principal role of the Horticulture CRSP would be to:
1. Coordinate USAID funded activities in horticultural research and training;
2. Integrate lessons learned and provide technical support; and
3. Conduct collaborative research, training and development activities to support USAID Mission activities in the field of horticulture.

As such, the Horticulture CRSP would serve as the principal liaison with USAID on matters relating to development in the horticulture sector, and as liaison between the U.S. university community and other donors in this sector.

The core funding for the Horticulture CRSP would be provided by USAID-Washington, with supplemental funding to be obtained in collaboration with USAID-Missions and third-party agencies. The Horticulture CRSP would also pursue independent funding opportunities in support of its mission.

Horticultural development has the potential to increase human well-being for much of the developing world. The realization of this promise will require adherence to the principles established in the Global Horticulture Assessment and prioritized investment to address the identified primary issues.

The adoption of the the Horticulture CRSP initiative would provide a mechanism for an exciting and mutually beneficial engagement between U.S. universities and USAID and its Missions.

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APPENDIX I

SYNTHESIS WORKSHOP ON GLOBAL HORTICULTURE CHALLENGES

UNIVERSITY of CALIFORNIA, DAVIS
October 18th-19th 2004

This workshop will bring together leading experts and key stakeholders to discuss the potential of horticulture to enhance the well being of developing countries and their peoples. The specific goal of the workshop is to develop the guidelines for implementation of a 9 month regional assessment project that will help to inform USAID activities in this sector.

Workshop Goal: Identification of the primary challenges and opportunities for global development in horticulture to: alleviate poverty, meet domestic human nutritional needs and stimulate economic growth in emerging economies. Identification of target regions, appropriate technologies, region specific constraints, opportunities, and unifying themes. Development of regional workshop themes, structure and identification of key partners.

Attendees: Leading development colleagues including: USAID-Washington, USDA, university horticultural scientists, horticultural industry private sector representatives, NGO's and donor agencies.

Location: Buehler Alumni Center, Alpha Gamma Rho Lecture Hall
October 18th
Program:

7:45am Registration and Coffee

8:15 Welcome and Introduction
William Lacy, Vice Provost – University Outreach and International Programs, University of California Davis

8:25 Keynote Address
'US AID's New Agricultural Strategy'
Emmy Simmons, Assistant Administrator of Economic Growth, Agriculture and Trade, USAID

8:55 'Food Security for the Smallholder: Opportunities in Horticulture'
Dr. Deborah Delmer, Associate Director, Rockefeller Foundation

9:30 'Food Safety, Global Standards and Postharvest Biology. Challenges for the Resource Poor Farmer'
Dr. Devon Zagory, Senior Vice President, Davis Fresh Technologies.

10:05 Coffee

10:25 'Dynamic Transformation in Domestic and International Horticulture Markets in Developing Regions: Focus on Retail and Wholesale Sector Change and Opportunities and Challenges for Farmers'
Dr. Thomas Reardon, Professor, Michigan State University

11:00 "Gender Issues in Development'
Dr. Sarah Hamilton, Director, M.A. International Development, Denver University

11:35 'Horticulture and Sustainable Production Systems'

Dr. Louise Jackson, Professor, University of California Davis

12:10 Closing remarks
Dr. Patrick Brown, Director, International Programs, University of California Davis

12: 30 Lunch

Afternoon Concurrent Sessions
1:30 - 3:30
Session 1A: Biotechnology, Biodiversity and Horticulture Development: Panel Discussion

Session 1B: Marketing of Horticultural Crops, Global Standards and Opportunities: Panel Discussion

3:30 Coffee Break

3:50 – 5:50
Session 2A/2B: Human Nutrition and Food Safety, Postharvest Technology, Value Added Chains, Transport: Panel Discussion

Session 2C: Sustainable Production Systems, Abiotic and Biotic Stress: Panel Discussion

5:50 **Closing**

6:00 Cocktail and Social Hour, Moss Patio

7:00 Dinner at Moss Patio, Buehler Alumni Center

8:30 Meeting with Moderators and session recorders

October 19th 2004
Location: Buehler Alumni Center, Alpha Gamma Rho Lecture Hall

8:15 'AVRDC - The World Vegetable Center and the Global Horticulture Initiative'
Dr. Thomas Lumpkin, Director General, World Vegetable Center.

8:45 'The New Sahel: Horticultural Transformation of Agricultural Systems in Semi-arid Areas'
Dr. Barry Shapiro, Director, Project Development and Marketing, ICRISAT

9:15 Presentation of thematic session outcomes

Morning Concurrent Sessions (Region selection is currently underway)

10:15 Region 1- Africa: Development of Workshop Structure, Program and Participants

Region 2 – Latin America/Caribbean: Development of Workshop Structure, Program and Participants

Region 3 – Asia /Near East: Development of Workshop Structure, Program and Participants

12:30 Lunch

1:30 Summary Session

3:00 Program Completion

SUB-SAHARAN AFRICA

Global Horticulture Assessment
Africa Regional Workshop
Arusha International Conference Center, Arusha, Tanzania
February 14-16, 2005

Workshop Goals: Identify the primary challenges and opportunities for regional development in horticulture to: alleviate poverty, meet domestic human nutritional needs, and stimulate economic growth in emerging economies. Identify and prioritize principal and potential crops constraints. For each crop-specific constraint identified, appropriate technologies, potential partners and beneficiary are identified. Criteria will then be developed in order to rank these potential projects. Logistic framework models will be completed for the highest-ranking projects.

Attendees: Leading African horticultural scientists, horticultural industry private sector representatives, NGOs and donor agencies.

Program:
Monday, 14 February

7:45 Registration

8:15 Official Opening/Welcome
Dr. Thomas Lumpkin, Director General, AVRDC - The World Vegetable Center

8:30 Keynote Address: Growth of Horticulture in Africa: Status, Opportunities and Challenges - A Case Study of Kenya
Prof. Stephen G. Agong, Deputy Vice Chancellor (Administration, Planning and Development), Jomo Kenyatta University of Agriculture and Technology

9:00 International Society for Horticultural Science (ISHS) Initiatives
Dr. Norman Looney, ISHS President

9:20 Results from the opening Synthesis Workshop for the Global Horticulture Assessment held at UC Davis, October 18-19, 2004
Dr. Farbod Youssefi, University of California Davis

9:50 Break

10:15 Results from the pre-workshop survey
Erin Hardie, Kraig Kraft, and Todd Rosenstock, University of California Davis

10:45 Overview of the Workshop: Objectives/process/schedule
Dr. Paul Marcotte, University of California Davis—Workshop Facilitator

11:15 Organizational aspects and logistics
Dr. Greg Luther, AVRDC – The World Vegetable Center - Program Coordinator

11:20 Establish Regional Working Groups

12:15 Working Lunch: Participants remain in groups to begin identification of overarching constraints and opportunities in horticulture for their respective regions

2:00 Regional Groups Reconvene: Define overarching (or meta-) issues related to horticulture; establish 'rich hypotheses' and develop potential projects to address constraints and capitalize on opportunities

4:30 Plenary session: Presentation from each of the regional groups

Evening Finalize descriptions of meta-issues and potential projects by region

Tuesday, 15 February

8:15 Priority Setting Exercise in Regional Groups
Establish and rank criteria for prioritization
Select and rank projects based on criteria

12:00 Lunch

1:00 Revisit Priority Setting Criteria: Each group will revisit their criteria discussion in light of their respective issues/opportunities to ensure that the selected projects are representative of the regional needs

3:00 Logical Framework Project Planning Exercise: Complete logical framework for the highest-ranking projects

5:00 Break for Dinner

6:30 Dinner reception

Wednesday, 16 February

8:15 Plenary Presentations:
Each regional group presents their final issues/ opportunities, selection criteria and prioritized projects; each group will be given 30 minutes for their presentation with a 15-minute discussion period

12:00 Lunch

1:00 Summary/Conclusion
Dr. Thomas Lumpkin, Director General, AVRDC – The World Vegetable Center

2:00 Closing Remarks

3:00 Field Trip: Tour of local horticulture farms/industries

LATIN AMERICA AND THE CARIBBEAN

Global Horticulture Assessment
Latin America and Caribbean Regional Workshop
Centro Internacional de Capacitacion W.K. Kellogg, Zamorano, Honduras
March 29-31, 2005

Workshop Goals: Identify the primary challenges and opportunities for regional development in horticulture to alleviate poverty, meet human nutritional needs, and stimulate economic growth in emerging economies. The workshop seeks to identify and prioritize present and potential crop constraints. For each crop-specific constraint identified, appropriate technologies, potential partners and beneficiaries should be identified. Criteria will then be developed to rank these potential projects. Results framework models will be completed for the highest-ranking projects.

Attendees: Leading Latin American and Caribbean horticultural scientists, horticultural industry private sector representatives, NGOs and donor agencies.

Program:
Tuesday, 29 March

8:00 Registration

8:30 Official Opening/Welcome
Paul Tuebner, Mission Director, USAID/Honduras

8:40 Opening/Welcome from the Host
Dr. Kenneth Hoadley, President, Zamorano University

8:45 Introduction and Welcome
Dr. Thomas Lumpkin, Director General, AVRDC - The World Vegetable Center

9:00 Keynote Address: Retos Para Competir en la Producción Hortícola Dirigida por el Mercado - Challenges to Compete in Market led Horticultural Production
Dr. Andrew Medlicott, Director, Fintrac CDA, Honduras

9:30 Invited Address: The Challenge for Small and Medium Producers to Access and Compete in Dynamic, Supermarket Driven Markets – Regionally and Globally
Dr. Thomas Reardon, Michigan State University

10:05 Organizational aspects and logistics
Dr. Greg Luther, AVRDC – The World Vegetable Center - Program Coordinator

10:10 Break

10:30 Results from the opening Synthesis Workshop for the Global Horticulture Assessment held at UC Davis, October 18-19, 2004
Dr. Patrick Brown, University of California Davis

10:50 LAC survey results presentation
Erin Hardie, Kraig Kraft, and Todd Rosenstock, University of California Davis

11:10 Overview of the Workshop: Objectives/process/schedule
Dr. Paul Marcotte, University of California Davis—Workshop Facilitator

11:30 Establish Regional Working Groups

12:00 Working Lunch: Participants remain in groups to begin identification of overarching constraints and opportunities in horticulture for their respective regions

1:15 Regional Groups Reconvene: Define "meta-issues" related to horticulture – Utilizing visualization technique, list and group related issues including constraints and opportunities for horticultural development in the region

3:00 Break

3:15 Regional Groups continue to meet

4:00 Reconvene Plenary
Presentation of "meta-issues" by each of the regional groups (15 min. each)

Evening Finalize descriptions of overarching issues and potential projects by region

Wednesday, 30 March

8:30 Priority Setting Exercise in Regional Groups - establish and rank criteria for prioritization

10:00 Break

10:15 Develop researchable issues & interventions that address the group's "meta-issues"

12:00 Lunch

1:00 Apply Priority Setting Criteria: Select and rank research issues and interventions based upon selected criteria

2:45 Break

3:00 Results Framework: Complete results framework for highest ranking issues/interventions

5:00 Break for Dinner

6:30 Dinner reception at Kellogg Center

Thursday, 31 March

8:30 Plenary Presentations:
Each regional group presents their final issues/opportunities, selection criteria and prioritized projects; each group will be given 20 minutes for their presentation with a 15-minute discussion period

10:15 Break

10:25 Plenary presentations continue

11:00 Summary/Conclusion
Dr. Thomas Lumpkin, Director General, AVRDC – The World Vegetable Center

11:30 Lunch

1:00 International Society for Horticultural Science (ISHS) Initiatives
Dr. Norman Looney, ISHS President

1:20 Closing Remarks: USAID, Workshop Facilitator, others

2:00 Field Trip: Tour of local horticulture farms/industry

ASIA AND THE NEAR EAST

Global Horticulture Assessment
Asia and Near East Regional Workshop
Helnan Shepheard Hotel, Cairo, Egypt
12-14 April 2005

Workshop Goals: Identify the primary challenges and opportunities for regional development in horticulture to alleviate poverty, meet human nutritional needs, and stimulate economic growth in emerging economies. The workshop seeks to identify and prioritize present and potential crop constraints. For each crop-specific constraint identified, appropriate technologies, potential partners and beneficiaries should be identified. Criteria will then be developed to rank these potential projects. Results framework models will be completed for the highest-ranking projects.

Attendees: Leading Asia and Near East horticultural scientists, horticultural industry private sector representatives, NGOs and donor agencies.

Program:
Tuesday, 12 April

8:00 Registration

8:30 Official Opening/Welcome
Dr. Thomas Lumpkin, Director General, AVRDC - The World Vegetable Center

8:50 Keynote Address: Herbal Products as a Natural Source of Healthcare
Dr. Adnan A. Badwan, Director General, Jordanian Pharmaceutical Manufacturing Co., Naor, Jordan

9:20 Invited Address: Horticulture: A Tool for Sustainable Development and Welfare
Prof. Dr. Ayman F. Abou Hadid, Professor of Horticulture, Ain Shams University, Cairo

9:50 Invited Address: Opportunities for Fruits and Vegetables in Asia with Emphasis on Market and Supply Chain Management
Dr. Murugappan Chandrasekaran, Professor of Agricultural Economics, Tamil Nadu Agricultural University, Coimbatore, India

10:10 Organizational aspects and logistics
Dr. Greg Luther, AVRDC – The World Vegetable Center - Program Coordinator

10:15 Break

10:30 Results from the opening Synthesis Workshop for the Global Horticulture Assessment held at UC Davis, October 18-19, 2004
Dr. Patrick Brown, University of California Davis

10:50 ANE survey results presentation
Erin Hardie, Kraig Kraft, and Todd Rosenstock, University of California Davis

11:20 Overview of the Workshop: Objectives/process/schedule
Dr. Paul Marcotte, University of California Davis—Workshop Facilitator

11:50 Establish Regional Working Groups

12:15 Working Lunch: Participants remain in groups to begin identification of overarching constraints and opportunities in horticulture for their respective regions

1:15 Regional Groups Reconvene: Define “meta-issues” related to horticulture – Utilizing visualization technique, list and group related issues including constraints and opportunities for horticultural development in the region

4:00 Reconvene Plenary
Presentation of “meta-issues” by each of the regional groups (15 min. each)

Evening Finalize descriptions of overarching issues and potential projects by region

Wednesday, 13 April

8:30 Priority Setting Exercise in Regional Groups - establish and rank criteria for prioritization

10:00 Develop researchable issues & interventions that address the group's "meta-issues"

12:00 Lunch

1:00 Apply Priority Setting Criteria: Select and rank research issues and interventions based upon selected criteria

3:00 Results Framework: Complete results framework for highest ranking issues/interventions

6:30 Dinner reception (Cruise on the Nile)

Thursday, 14 April

8:30 Plenary Presentations:
Each regional group presents their final issues/ opportunities, selection criteria and prioritized projects; each group will be given 25 minutes for their presentation with a 15-minute discussion period

11:15 Summary/Conclusion
Dr. Thomas Lumpkin, Director General, AVRDC – The World Vegetable Center

11:45 International Society for Horticultural Science (ISHS) Initiatives
Dr. Ian Warrington, ISHS Vice President

12:05 Closing Remarks: USAID, Workshop Facilitator, others

12:30 Lunch

2:00 Field Trip: Tour of local horticulture farms/industry

APPENDIX II

Participants at the Synthesis Workshop Global Horticulture Assessment Davis, Calfornia, 18-19 October, 2004

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APPENDIX III

SURVEY LETTER

Dear Sir or Madam:
In September 2004, the University of California, Davis, in partnership with the World Vegetable Center – AVRDC, and supported by USAID, initiated an in-depth, highly collaborative analysis of regional horticulture sectors. The production of horticultural commodities, including fruits, vegetables, nuts, and ornamentals, offers potential to alleviate poverty, meet domestic human nutritional needs, and stimulate growth in emerging economies of the world.

The yearlong global assessment will include three regional workshops to take place during the Winter and Spring of 2005 in Latin America, Africa and Asia. These workshops will provide local stakeholders with the opportunity to discuss and analyze the constraints associated with horticultural development in their regions. As space will be limited and travel to the meeting sites may not be possible for many stakeholders, we have developed this survey to ensure that a broad range of input is included in the regional workshops and final assessment. Your participation in this survey is critical to our accurate analysis of the opportunities and constraints associated with horticultural production and marketing in your region.

Identifying the Priorities for Investment in Africa's Horticulture Industries
Goal: The purpose of this survey is to obtain accurate information about the local and regional constraints and opportunities for horticultural development in Africa, Latin America and the Caribbean and Asia and the Near East regions. Participants in this survey have been selected from diverse backgrounds including farmers, farmer associations, researchers and government agencies and the business sector. Your answers to these questions should be based on your own knowledge. There is no expectation that you will provide information on crops or regions outside your own expertise.

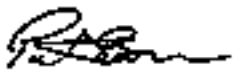
Outcome: The results of this survey will be used as the basis for a Regional Horticulture Workshops to be held in Arusha, Tanzania in February of 2005, Zamorano, Honduras in March 2005, and Cairo, Egypt in April 2005. The survey and workshop will then be used to define the primary challenges and opportunities for development in horticulture in Africa and will be used to guide funding in this area.

Benefits to Participation:

- Sponsorship is available for individuals to attend the Regional Horticultural Workshops. Individual participants will be selected from survey respondents.
- Your analysis of the important issues in your region will help define development investment in horticulture in Africa.
- All participants will given access to the project Global Horticulture Web site and to the reports generated from this activity.
- A database of participants will be developed to allow for rapid communication of new opportunities and development of new partnerships.

Thank you for taking the time to complete the survey. We welcome your assistance in distributing this survey widely and in collecting information from others involved in horticulture in your region.

Sincerely,



Patrick H. Brown, Ph.D.
Professor, Department of Pomology
Director, International Programs
College of Agricultural and Environmental Sciences

UCDAVIS AVRDC The World Vegetable Center

Global Horticulture Sector Development Survey

Please return by e-mail, fax or mail to:
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260 Hunt Hall; One Shields Avenue
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530-752-9480 (office)
530-754-7160 (fax)
eehardie@ucdavis.edu (email)
http://www.caes.ucdavis.edu/intlprgrms

Please feel free to use additional pages, if necessary, and contact us if you would like an electronic copy of the survey.

I: Institutional Information

Name:

Position/ Title:

Institution/Company:

Contact Information:

1. Please identify the regions / locations and corresponding agroecological characterization where your institution operates:

2. Please identify your institutions' major stakeholders involved in the horticulture sector:

3. Please list and briefly describe the current horticultural activities / projects of your institution (Please indicate if they are funded by or affiliated with any existing USAID programs):

4. Please provide us with names and contact information of individuals with whom we should consult as we attempt to understand horticulture in your region. The most appropriate individuals will be sponsored for participation in a regional workshop on this topic in early 2005.

Name Institution Contact Information

5. What, in your opinion, are the most important horticultural crops/markets (fruits, vegetables, and ornamentals) in your region? Please list at least five crops/markets:

6. What, in your opinion, are five underutilized but potentially valuable horticultural crops/markets in your region? Please list the crops and explain their potential and current constraints:

7. In your opinion what are the top 5 constraints to horticultural production in your region? For each constraint, please identify whether the solutions are short-term, medium-term, or long term.

8. Please describe any additional issues, concerns or opportunities related to horticultural-development not addressed in the survey and that you feel are a high priority for a regional workshop on horticulture sector constraints to take into consideration.

II: COMMODITY CONSTRAINTS ANALYSIS

Based on your professional experience please complete one table for each of the 3-5 horticultural crops of greatest current or potential value in your region. Not all themes or constraints need be addressed. Please see the example on the following page.

CROP:	Please rank each constraint from 1-5. 1=mild constraint 5=severe constraint	Please elaborate on the specific constraints encountered for this particular crop. Please be as specific as possible and use additional sheets if necessary.	Identify one or more regional or international partners that may help to address this constraint
GENETIC DIVERSITY eg. Limited germplasm, no locally adapted varieties, etc.			
BIOTECHNOLOGY eg. Poor tissue culture, no scientific capacity, etc.			
ABIOTIC STRESS eg. Drought, wind, poor soil nutrition			
BIOTIC STRESS eg. Pest, disease pressures, weeds			
SUSTAINABLE PRODUCTION eg. Reduction of chemical inputs, water use efficiency, water use			
POSTHARVEST eg. Poor transport, poor storage, etc.			
FOOD SAFETY eg. Pesticide residues, microbial contamination			
GLOBAL STANDARDS eg. Market standards for export, etc.			
VALUE ADDED eg. Processing, dehydration, etc.			
SUPPLY CHAIN/MARKETING eg. No regional market, poor credit, poor infrastructure suppliers, credit, insurance, etc.			
SOCIAL eg. Labor issues, Gender concerns, cooperatives, land tenure, etc.			

APPENDIX IV

PRIMARY ISSUES AND CONSTRAINTS OF INTER-REGIONAL AND INTRA-REGIONAL IMPORTANCE

The following information was consolidated from survey responses and used to determine priority sub issues within primary issue results.

The degree of impact of each primary issue and specific constraints within each issue varies between regions and subregions. **Figures 1, 2, 3, 4** represent the frequency of mentions of each of the six primary issues identified at the regional workshops. These graphs are based upon survey responses to question 7: *In your opinion what are the top 5 constraints to horticultural production in your region?* This analysis should be examined intra-regionally for each primary issue. Thus, primary issues with consistent response rates across divisions may suggest coordinated effort on a regional or global scale, whereas, large variations between regions suggests a need for targeted interventions towards specific subregions or regions.

Tables 1, 2, 3, 4 provide a greater specificity of information concerning the constraints to horticultural production within a region. Respondents also identified these constraints in their responses to question 7 of the survey, but the answers are not aggregated to the primary issue level. They remain discrete constraints to compare the most important constraint within primary issue inter-regionally and intra-regionally.

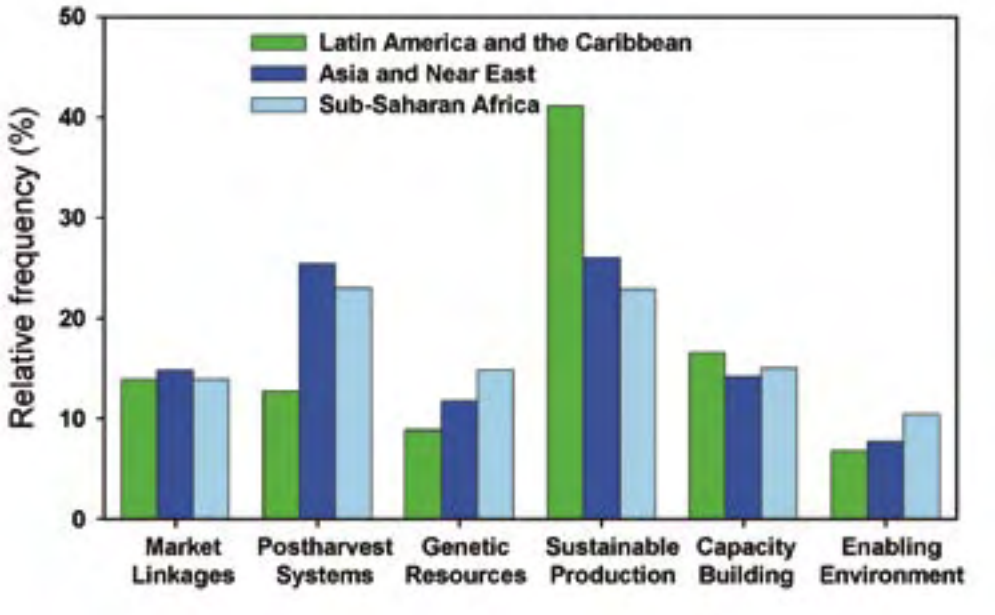

Figure 1. Frequency of Mentions of the six primary issues in the three regions. The graph is based on the constraints mentioned in the survey responses across all regions. The total number of named constraints, each of which was assigned to one of the primary-issues, was 2376; 1006 from Sub-Saharan Africa, 492 from Asia and the Near East, and 878 from Latin America and the Caribbean.

APPENDIX IV

Constraint	Sub-Saharan Africa	Asia and Near East	Latin America and the Caribbean
Market Linkages			
Market information	•	•	•
Organization	•	•	•
Access to markets	+++	+++	+++
Postharvest Systems and Food Safety			
Standards	•	•	+
Food safety	•	•	•
Processing	++	++	•
Infrastructure	+++	+++	++
Postharvest practices	++	+++	+++
Genetic Resource Development and Conservation			
Germplasm conservation	++	+	+
Adapted varieties	++	+	++
Propagation	+++	++	+
Sustainable Production Systems and Natural Resource Management			
Agrochemicals	•	•	+
Pests and diseases	+++	+++	+++
Appropriate technology	+	+++	+++
Climate	•	•	•
Water	++	++	+++
Soil	+	•	+
Productivity	+	•	++
Capacity Building			
Lack of information	+++	•	++
Skilled labor	++	++	+++
Extension	+	++	++
Research	+	+	+
Enabling Environment			
Capital / Land	+++	+++	++
Policy	+	•	•
Risk	•	•	•

Table 1. **Importance of the different constraints to horticultural production across all regions.** The symbols in the table indicate the relative frequency at which the specific constraint was mentioned in the survey as a proportion of the overall survey responses received from the region. Here +++ indicates that the constraint was in the first quartile (top 25%) of all regional survey responses, while constraints marked ++, + and • were in the second, third and forth quartile, respectively (following the top 25% in intervals of 25%).

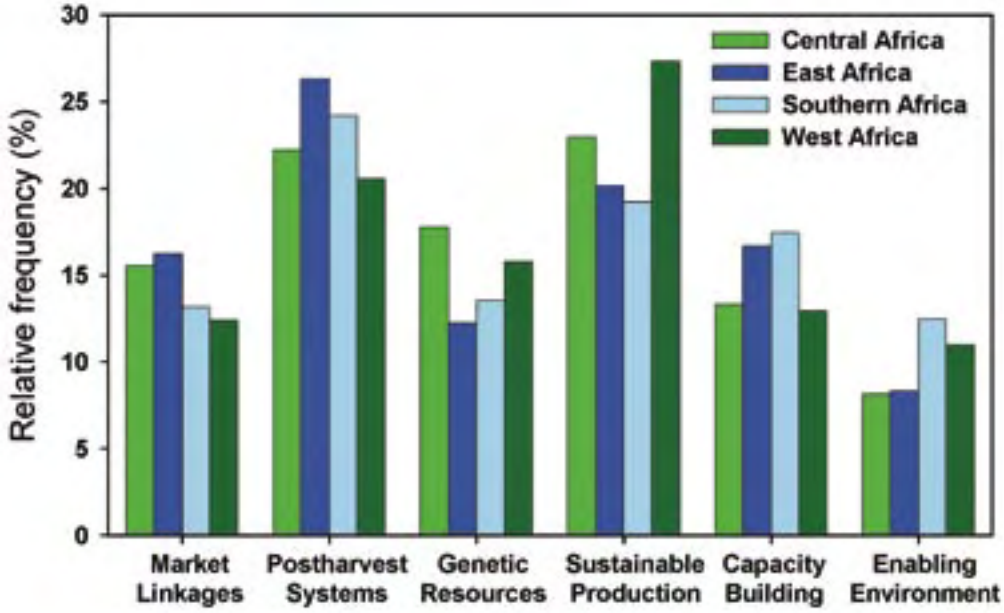

Figure 2. **Frequency of mentions of the six primary issues in the four subregions of sub-Saharan Africa.** The graph is based on the constraints mentioned in the survey responses from sub-Saharan Africa. The total number of named constraints was 999, each of which was assigned to one of the primary issues: 135 from Central Africa, 228 from East Africa, 281 from Southern Africa, and 355 from West Africa.

APPENDIX IV

Constraint	Central Africa	East Africa	Southern Africa	West Africa
Market Linkages				
Market information	•	•	•	•
Organization	•	•	•	•
Access to markets	+++	+++	+++	+++
Postharvest Systems and Food Safety				
Standards	•	+	•	•
Food safety	•	•	•	+
Processing	+	++	++	++
Infrastructure	+++	+++	+++	+++
Postharvest practices	++	++	++	++
Genetic Resource Development and Conservation				
Germplasm conservation	+++	+	++	++
Adapted varieties	+	++	+	++
Propagation	+++	+++	+++	++
Sustainable Production Systems and Natural Resource Management				
Agrochemicals	•	•	•	•
Pests and diseases	+++	+++	++	+++
Appropriate technology	+	++	+	++
Climate	•	•	+	+
Water	+	+	+++	+++
Soil	+	•	•	+
Productivity	+	+	+	+
Capacity Building				
Lack of information	+++	+++	+++	+++
Skilled labor	+	+	++	+
Extension	+	++	+	•
Research	•	++	+	•
Enabling Environment				
Capital / Land	++	+++	+++	+++
Policy	+	•	++	•
Risk	•	•	•	•

Table 2. **Importance of the different constraints to horticultural production in the subregions of sub-Saharan Africa.** The symbols in the table indicate the relative frequency, at which the specific constraint was mentioned in the survey, as a proportion of the overall survey responses received from the subregion. Here +++ indicates that the constraint was in the first quartile (top 25%) of all subregional survey responses, while constraints marked ++, + and • were in the second, third and forth quartile, respectively (following the top 25% in intervals of 25%).

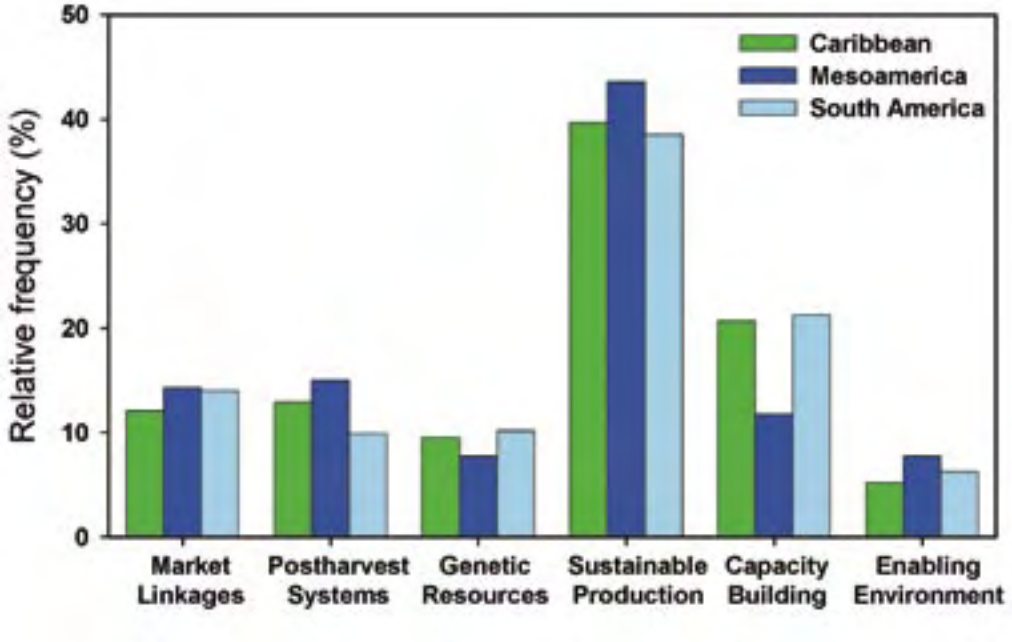

Figure 3. **Frequency of mentions of the six primary issues in the three subregions of Latin America and the Caribbean.** The total number of LAC constraints named in the survey was 878, each of which was assigned to one of the primary issues: 116 from the Caribbean, 427 from Mesoamerica, and 335 from South America.

APPENDIX IV

Constraint	Caribbean	Mesoamerica	South America
Market Linkages			
Market information	•	+	•
Organization	•	•	+
Access to markets	+++	+++	+++
Postharvest Systems and Food Safety			
Standards	+	++	•
Food safety	•	•	•
Processing	•	•	•
Infrastructure	++	+++	+
Postharvest practices	++	+++	+
Genetic Resource Development and Conservation			
Germplasm conservation	+	+	+
Adapted varieties	+++	++	+
Propagation	•	+	++
Sustainable Production Systems and Natural Resource Management			
Agrochemicals	++	•	+
Pests and diseases	+++	+++	+++
Appropriate technology	+++	+++	+++
Climate	•	•	•
Water	+	+++	++
Soil	•	+	+
Productivity	++	++	+
Capacity Building			
Lack of information	++	++	+++
Skilled labor	+	++	+++
Extension	++	+	+
Research	++	•	+
Enabling Environment			
Capital / Land	++	++	+
Policy	•	+	•
Risk	•	•	•

Table 3. **Importance of the different constraints to horticultural production in the subregions of Latin America and the Caribbean.** The symbols in the table indicate the relative frequency, at which the specific constraint was mentioned in the survey, as a proportion of the overall survey responses received from the subregion. Here +++ indicates that the constraint was in the first quartile (top 25%) of all subregional survey responses, while constraints marked ++, + and • were in the second, third and forth quartile, respectively (following the top 25% in intervals of 25%).

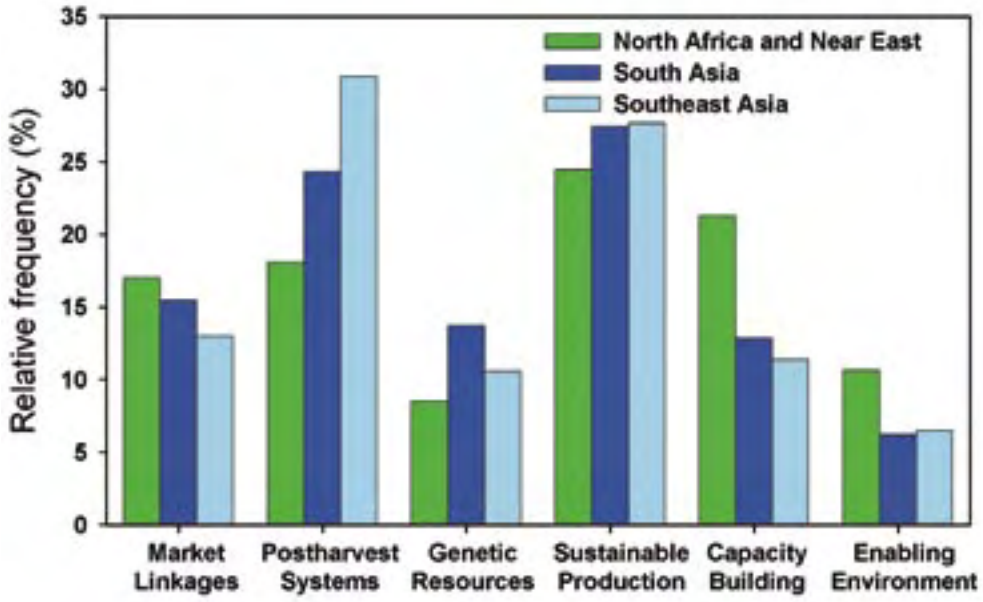

Figure 4**. Frequency of mentions of the six primary issues in the three subregions of Asia and the Near East.** The total number of constraints for ANE named in the survey was 442, each of which was assigned to one of the primary issues: 94 from North Africa and the Near East, 226 from South Asia, and 123 from Southeast Asia.

Market Linkages			
Constraint	**North Africa / Near East**	**South Asia**	**Southeast Asia**
Market Linkages			
Market information	•	•	•
Organization	+	•	•
Access to markets	+++	+++	+++
Postharvest Systems and Food Safety			
Standards	•	•	++
Food safety	•	•	•
Processing	++	+++	++
Infrastructure	++	+++	+++
Postharvest practices	+++	+++	+++
Genetic Resource Development and Conservation			
Germplasm conservation	+	+	++
Adapted varieties	+	++	++
Propagation	•	+++	++
Sustainable Production Systems and Natural Resource Management			
Agrochemicals	•	+	+
Pests and diseases	++	+++	+++
Appropriate technology	++	++	+++
Climate	+	•	+
Water	+++	++	•
Soil	•	+	•
Productivity	•	•	•
Capacity Building			
Lack of information	•	•	+
Skilled labor	+++	++	++
Extension	+++	++	•
Research	++	++	+
Enabling Environment			
Capital / Land	+++	+	+++
Policy	•	•	•
Risk	•	•	•

Table 4. **Importance of the different constraints to horticultural production in the subregions of Asia and the Near East.** The symbols in the table indicate the relative frequency, at which the specific constraint was mentioned in the survey, as a proportion of the overall survey responses received from the subregion. Here +++ indicates that the constraint was in the first quartile (top 25%) of all subregional survey responses, while constraints marked ++, + and • were in the second, third and forth quartile, respectively (following the top 25% in intervals of 25%).

APPENDIX V

CROPS

Survey recipients were asked to name the most important crops for their region, and also crops with high potential for their area (questions 5 and 6). Respondents named a total of 212 commodities as most important, and 199 as having high potential. Although a great many crops were mentioned, the top ten to fourteen crops represented nearly 50% of the responses in each of the regions and subregions. The following graphs show the distribution between commodity groups and the rankings of the most important crops and commodities on the global, regional and subregional scale. Following, a listing of all of the crops mentioned is included.

APPENDIX V

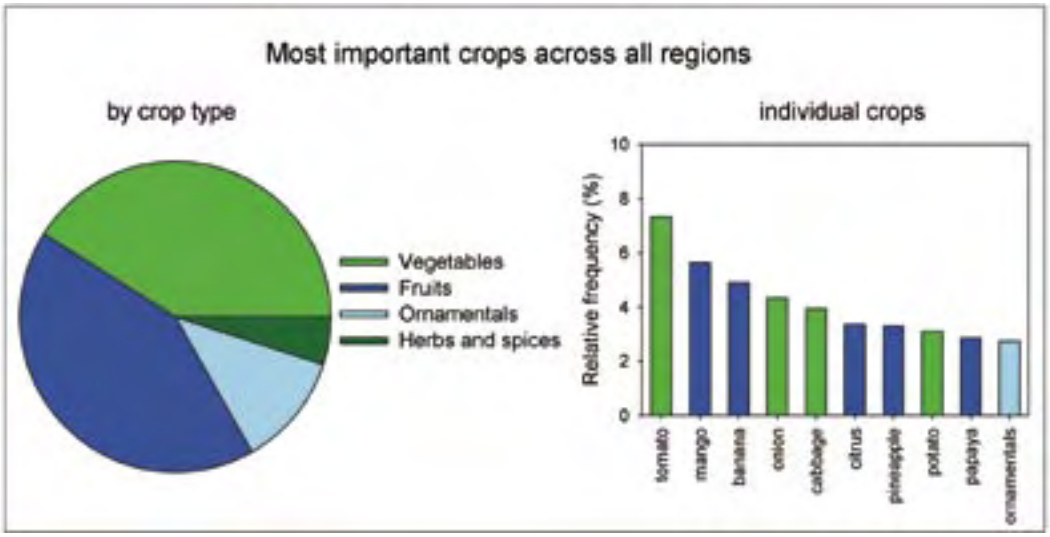

Figure 1. **Most important crops across all regions as mentioned by the survey respondents.** The pie chart shows the relative frequency of the four main types of horticultural crops among the responses, while the bar graph illustrates the relative frequencies of the ten most frequently mentioned individual crops within the total sample of 3602 survey responses.

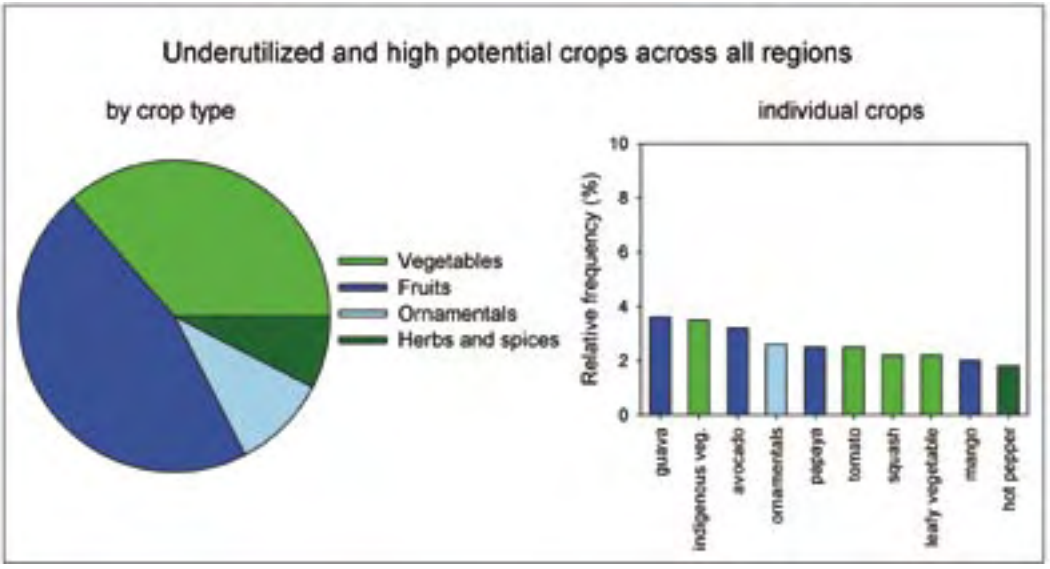

Figure 2. **Underutilized or high potential crops across all regions as mentioned by the survey respondents.** The pie chart shows the relative frequency of the four main types of horticultural crops among the responses, while the bar graph illustrates the relative frequencies of the ten most frequently mentioned individual crops within the total sample of 1815 survey responses.

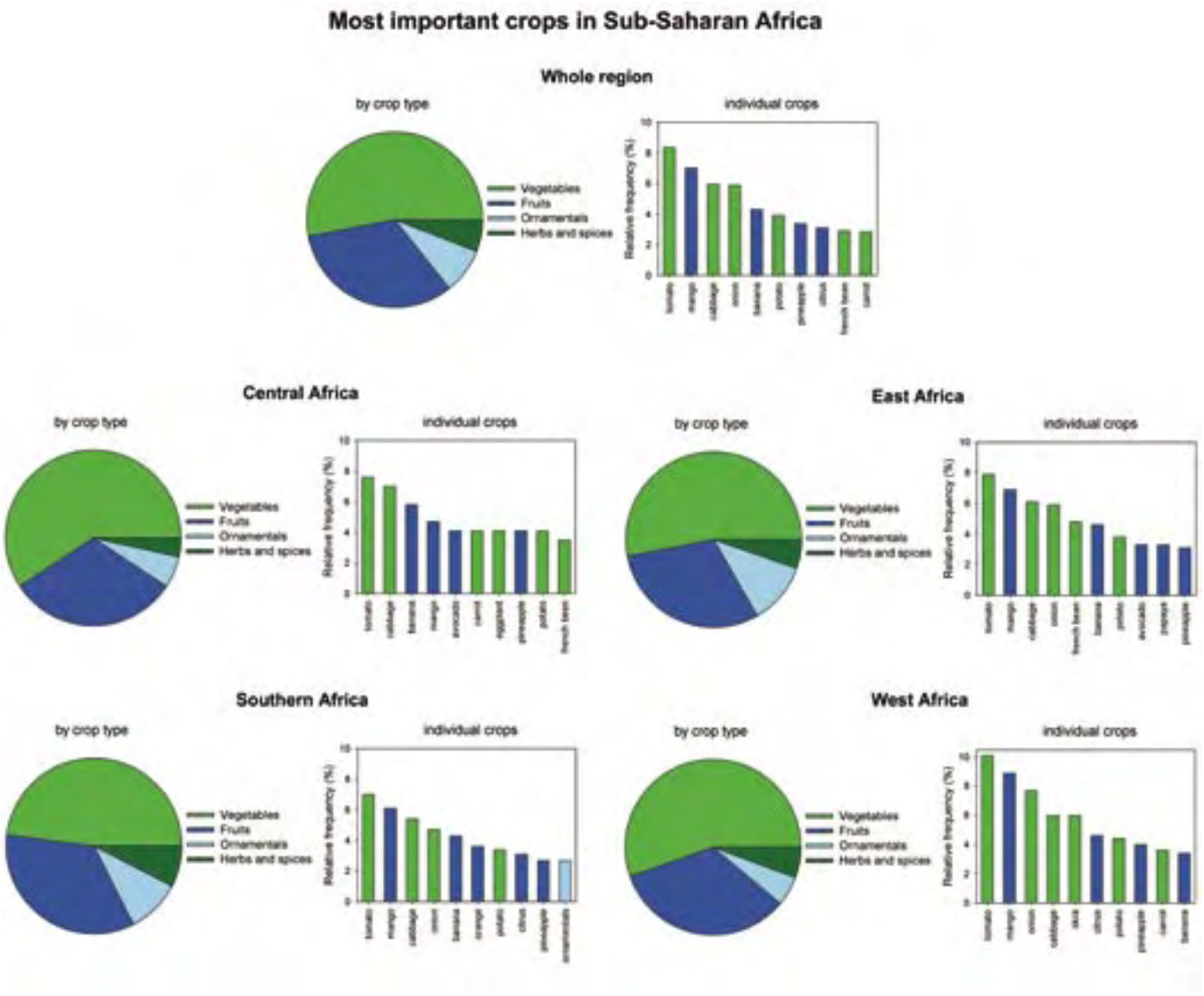

Figure 3. **Most important crops for sub-Saharan Africa and the four subregions, as mentioned by the survey respondents.** The pie charts show the relative frequency of the four main commodity groups among the responses, while the bar graph illustrates the relative frequencies of the ten most frequently mentioned individual crops. Number of responses: Entire region *n=1510*, Central Africa *n=171*, East Africa *n=392*, Southern Africa *n=445*, West Africa *n=496*.

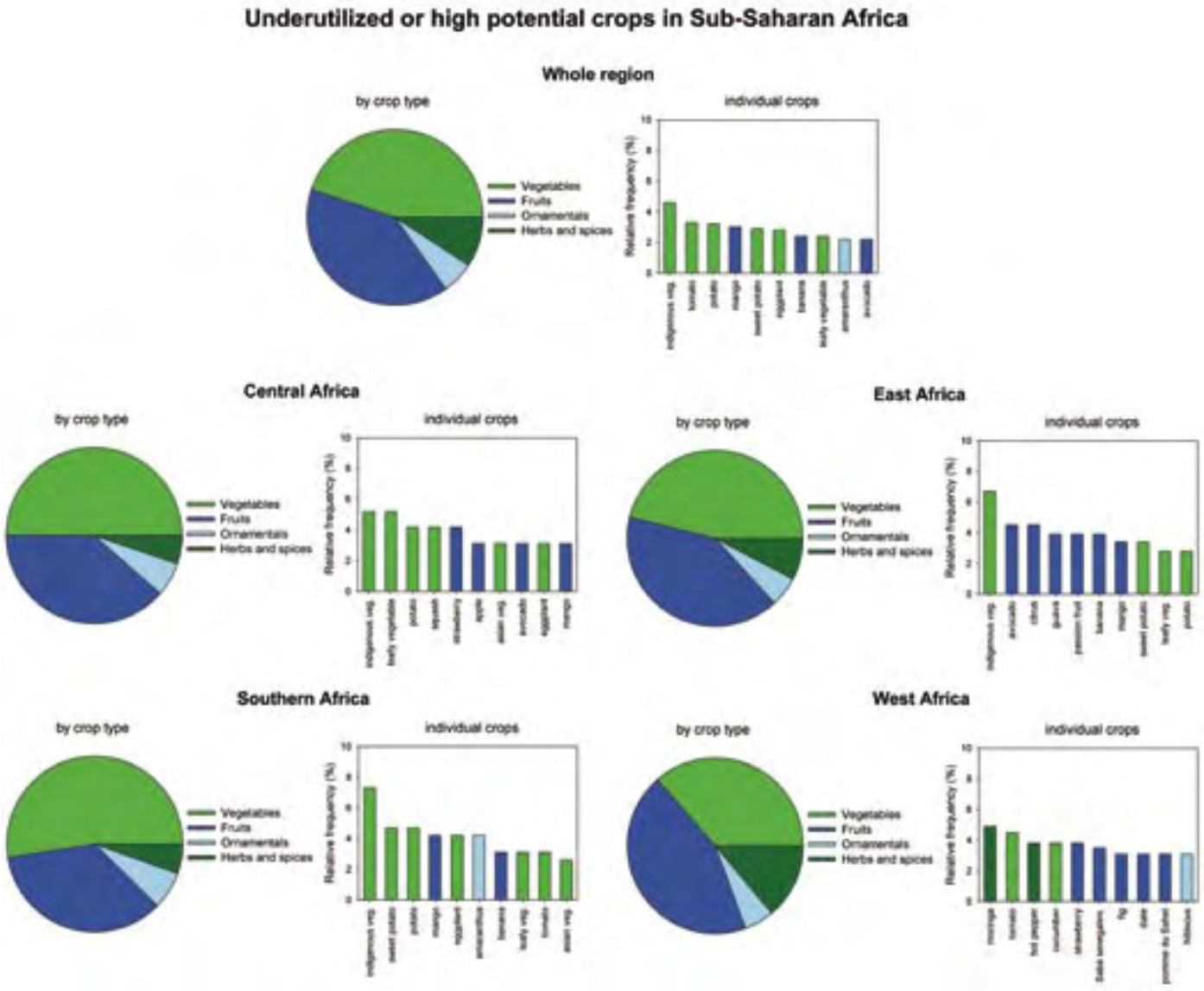

Figure 4. **Underutilized or high potential crops in Sub-Saharan Africa and the four subregions, as mentioned by the survey respondents.** The pie chart shows the relative frequency of the four main commodity groups among the responses, while the bar graph illustrates the relative frequencies of the ten most frequently mentioned individual crops. Number of total responses: Whole region *n=759*, Central Africa *n=96*, East Africa *n=178*, Southern Africa *n=192*, West Africa *n=288*.

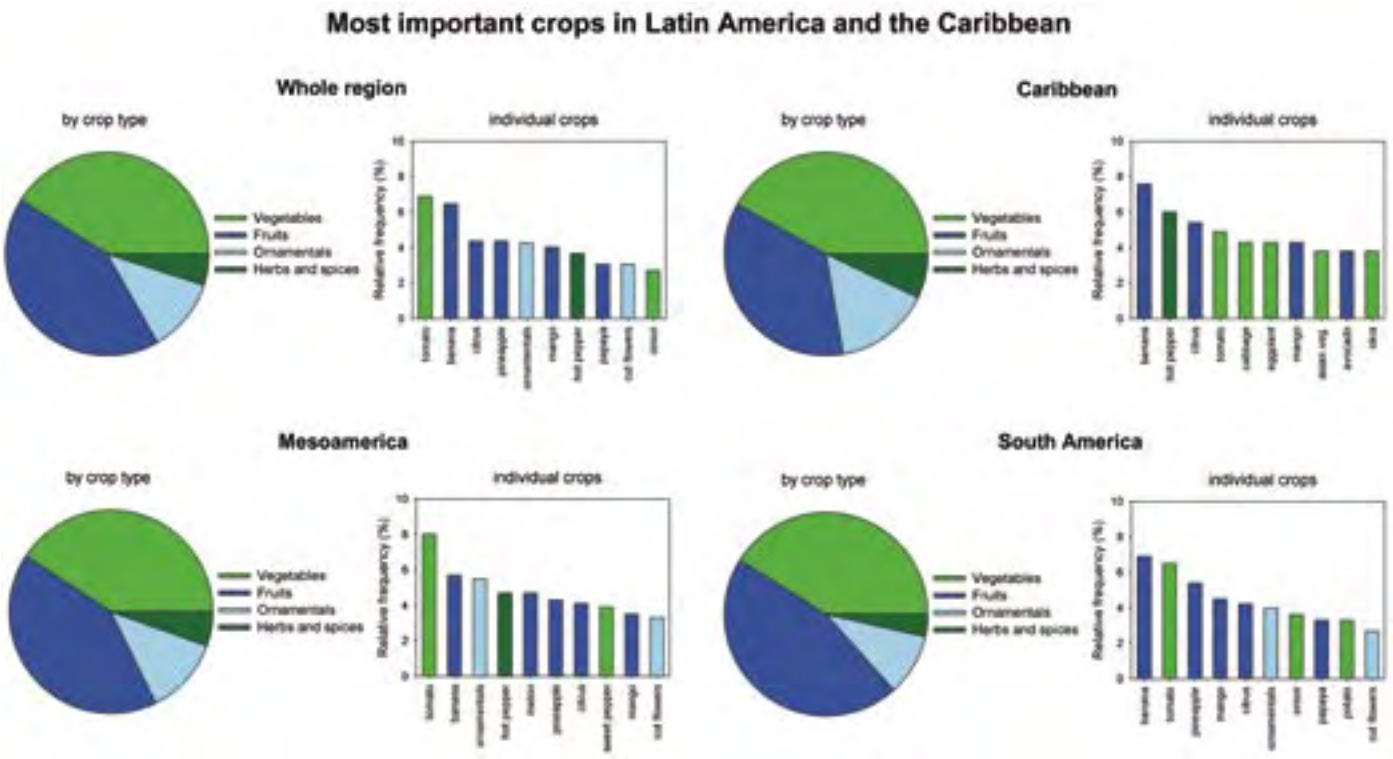

Figure 5. **Most important crops for Latin America and the Caribbean and the three subregions, as mentioned by the survey respondents.** The pie charts show the relative frequency of the four main commodity groups among the responses, while the bar graph illustrates the relative frequencies of the ten most frequently mentioned individual crops. Number of responses: Entire region *n=1145,* Caribbean *n=184*, Mesoamerica *n=513*, South America *n=448.*

APPENDIX V

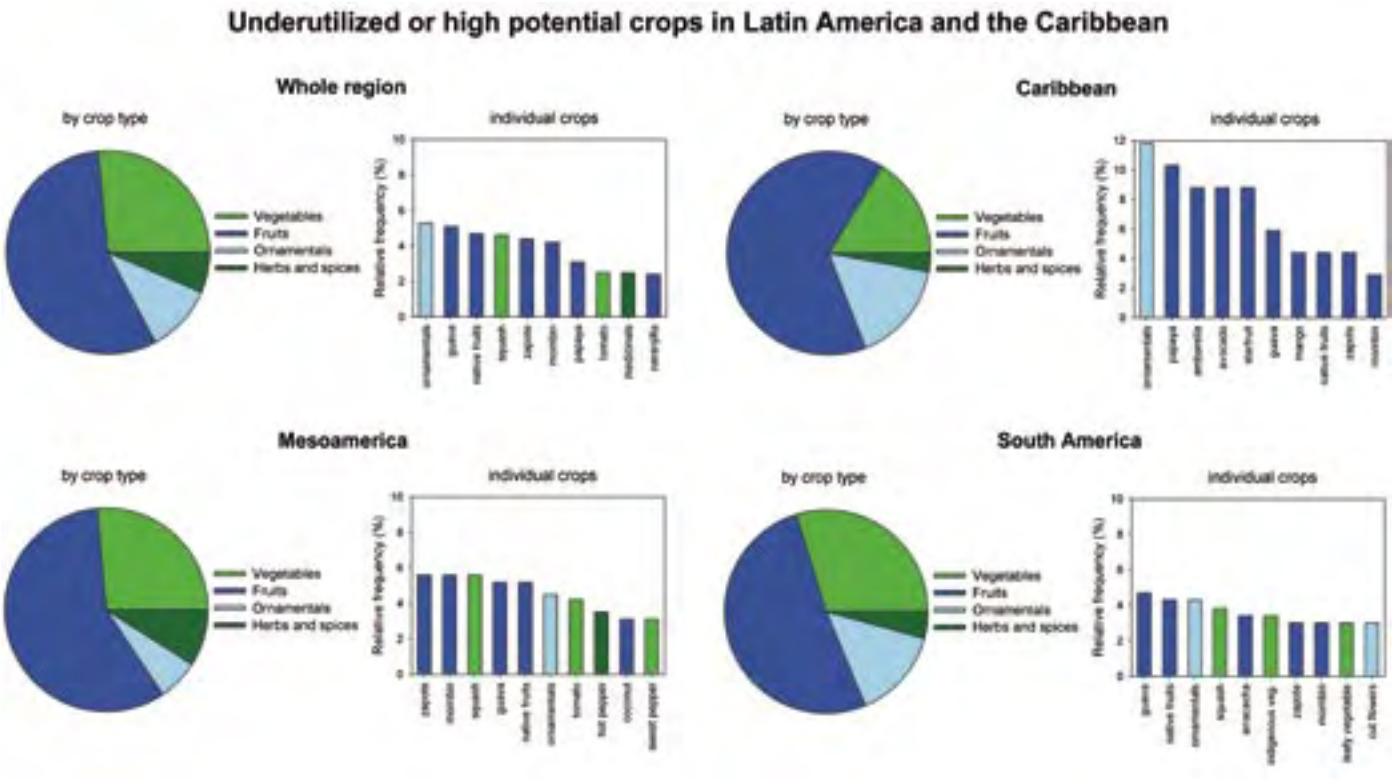

Figure 6. **Underutilized or high potential crops in Latin America and the Caribbean, and the three subregions, as indicated by the survey respondents.** The pie chart shows the relative frequency of the four main commodity groups among the responses, while the bar graph illustrates the relative frequencies of the ten most frequently mentioned individual crops. Number of total responses: Entire region *n=590*, Caribbean *n=68*, Mesoamerica *n=287*, and South America *n=235.*

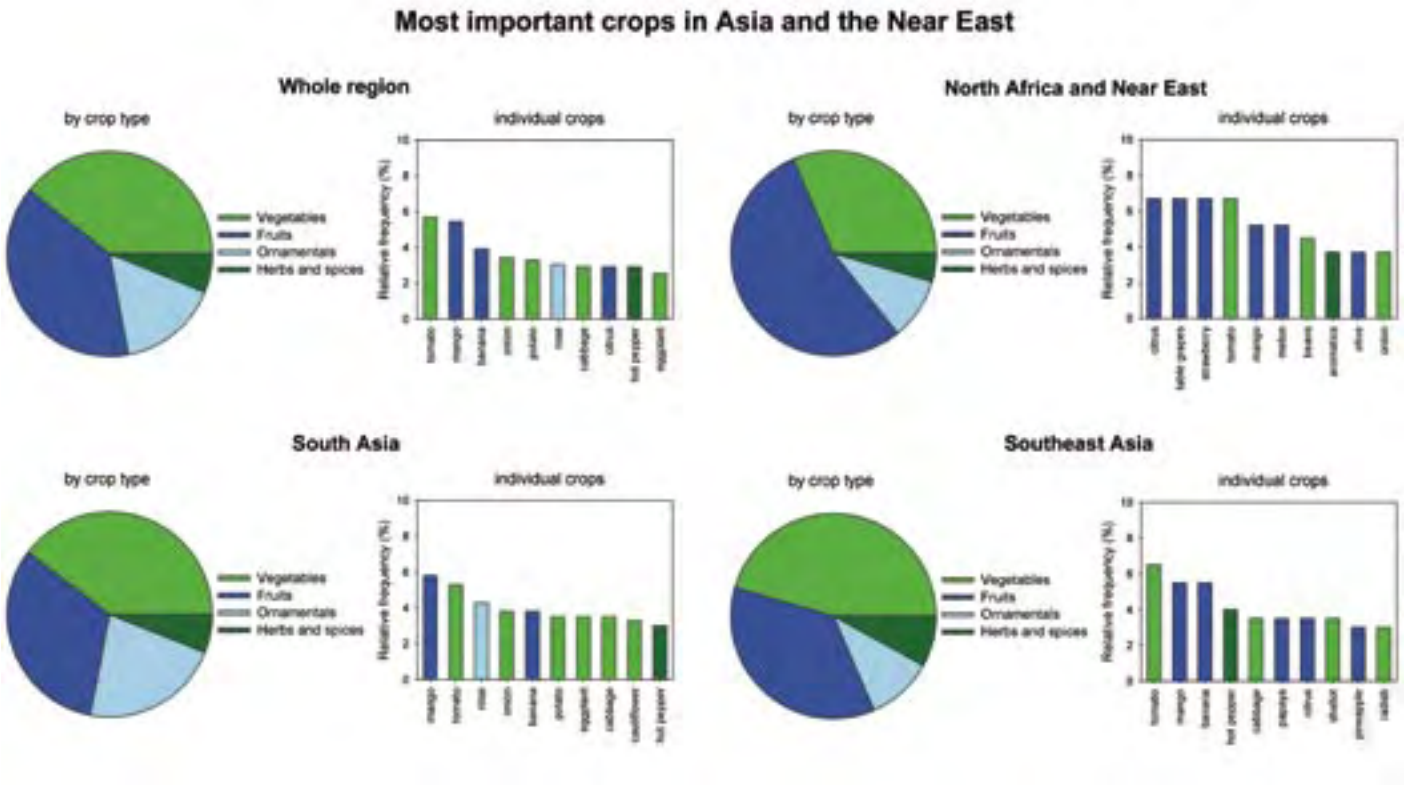

Figure 7. **Most important crops for Asia and the Near East, and the three subregions, as mentioned by the survey respondents**. The pie charts show the relative frequency of the four main commodity groups among the responses, while the bar graph illustrates the relative frequencies of the ten most frequently mentioned individual crops. Number of responses: Entire region *n=789*, North Africa and the Near East *n=134*, South Asia *n=396*, Southeast Asia *n=200*.

APPENDIX V

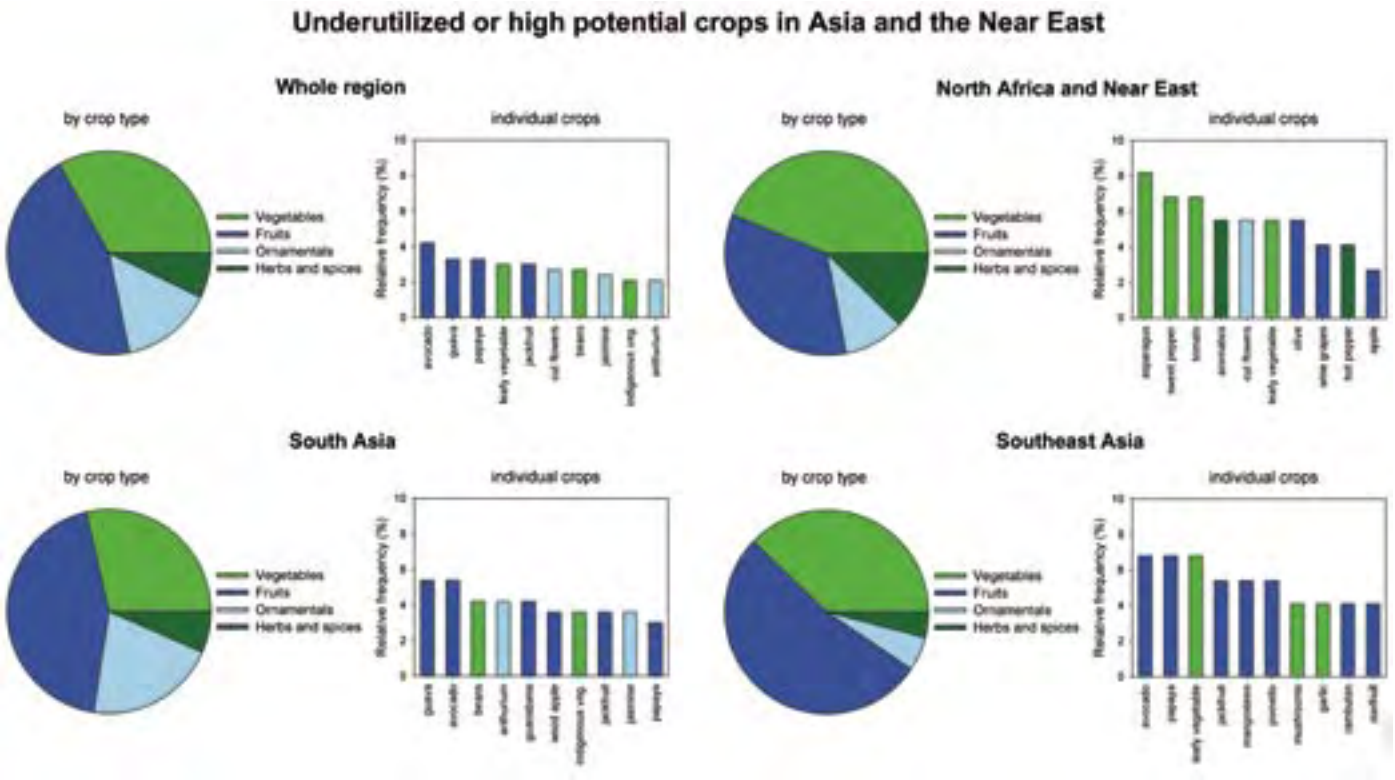

Figure 8. **Underutilized or high potential crops in Asia & the Near East and the three subregions, as mentioned by the survey respondents.** The pie chart shows the relative frequency of the four main commodity groups among the responses, while the bar graph illustrates the relative frequencies of the ten most frequently mentioned individual crops. Number of total responses: Entire region *n=335*, Near East and North Africa *n=73*, South Asia *n=168*, Southeast Asia *n=74*.

HORTICULTURAL CROPS MENTIONED IN THE SURVEY

Fruit crops

Botanical name	**vernacular name**
Actinidia deliciosa (A.Chev.) C.I.Liang	kiwi
Aegle marmelos Correa	bael, wood apple
Anacardium occidentale	cashew
Ananas comosus L.	pineapple
Annona cherimola Mill.	attemoya, custard apple
Annona cherimola Mill.	cherimoya
Annona muricata L.	guanabana, soursop, Dutch durian
Artocarpus altilis	breadfruit
Artocarpus heterophyllus Lam.	jackfruit
Averrhoa carambola L.	starfruit, carambola
Baccaurea sapida Muell.-Art	Burrmese grape, lutqua
*Bactris gasipae*s HBK.	pejibaye, peach-nut
Butyrospermum parkii (Don) Kotschy	Sheanut
Byrsonima crassifolia HBK.	nance
Carica papaya L.	papaya, paw paw
Casimiroa edulus Llave.	zapote, sapote
Castanea sativa Mill.	chestnut
Cereus peruvianus	pitaya
Citrullus lanatus Masf.	watermelon
Citrus aurantifolia Christm.	lime
Citrus limon L.	lemon
Citrus paradisi × *Citrus reticulata*	tangelo
Citrus reticulata	mandarin
Citrus reticulata Blanco	tangerine
Citrus sinensis L.	orange
Citrus spp.	citrus
Citrux maxima	pomelo
Cocos nucifera L.	coconut
Coffea arabica L, *Coffea robust*a L.	coffee, café
Corylus avellana L.	hazelnut
Cucumis melo L.	cantaloupe
Cucumis melo L.	melon
Cyphomandra betacea Sendt.	tree tomato
Dacryodes edulis	african pear
Detarium senegalensis	ditah
Dimocarpus longan Lour.	longan
Dioscorea sylvatica (Kunth) Ecklon	Elephant's foot apple
Diospyros kak Thunb.	persimmon
Durio zibethinus L.	durian
Emblica officinalis Gaertn syn. *Phyllanthus emblica* L.	aamla, aonla
Emblica officinalis Gaertn. syn. *Phyllanthus emblica* L.	Aonla
Eriobotrya japonica Thunb.	loquat
*Euterpe olerac*ea	Assai
Feijoa sellowiana Berg.	feijoa, pineapple guava
Ficus carica L.	fig
Fragaria virginiana	strawberry
Garcinia indica	kokum

APPENDIX V

Garcinia kola	bitter cola
Garcinia mangostana L.	mangosteen
Hancornia speciosa Gomes	mangaba
Heliconia spp.	heliconia
Irvinga spp.	irvinga spp
Juglans nigra L. (black), *Juglans regia* L. (Persian)	walnut
Litchi chinensis	lychee
Macadamia integrifolia	macademia
Malus domestica	Apple
Malus domestica Borkh.	apple
Mammea americana L.	mamey
Mangifera indica L.	mango
Manichara zapotilla Gilly	sapodilla
Melicocca bijuga L	mamoncillo
Musa spp.	Apple banana
Musa spp.	banana
Musa spp.	plantain
Myrciaria dubia	camu-camu, rumberry
Nephilium lappaceum L.	rambutan
Olea europaea L.	olive
Opuntia spp. L.	prickly pear, tuna
Passiflora edulis Sims.	passion fruit
Passiflora spp.	granadilla
Phoenix dactylifera	date
Physalis ixocarpa Brot. ex Hornem	tomatillo
Physalis peruviana	cape gooseberry
Pistacia vera L.	pistachio
Pouteria lucuma O. Ktze.	lucumo
Prunus amygdalus Batsch.	almond
*Prunus armeniac*a L.	apricot
Prunus cerasus	cherry
Prunus domestica L.	plum
Prunus persica C. Schneider	nectarine
Prunus persidca L.	peach
Psidium guajava L.	araca-pera
Psidium guajava L.	guava
Punica granatum L.	pomegranite
*Pyrus communi*s L.	pear
Rheedia edulis Tiana & Planch.	mameyito, arrayan
Rubus idaeus L.	raspberry
Rubus spp.	blackberry
Saba senegalensis	wedga
Sclerocarya birrea	marula, wild plum
Solanum quitoense Lam.	naranjilla
Spondius dulcis Forst. syn. *Spondius cytherea* Sonn.	ambarella
Spondius mombin L.	mombin
Spondius Pinnata L.	hog plum
Tamarindus indica L.	tamarind
Theobroma cacao L.	cacao, chocolate
Theobroma grandiflorum Schuman	cupuaçu, cupassu
Vaccinium corymbosum L.	blueberry

Vaccinium macrocarpon Ait.	cranberry
Vaccinium myrtillus L	bilberry
Vitis spp.	grape (table)
Vitus spp.	grape (raisin)
Vitus spp.	grape (wine)
Ziziphus jujuba Mill.	jujube
Ziziphus jujube Mill.	masan, jujube
Zizyphus jujuba Mill.	ber, pitni, bari

Vegetable crops

Botanical name	**vernacular name**
Agaricus bisporus	mushrooms
Allium cepa G. Don	shallot
Allium cepa L.	onion
Allium cepa L.	scallion
Allium cepa L.	scallion
Allium sativum L.	garlic
Apium graveolens	celery
Arracacia xanthorrhiza Bancr.	arracacha, Peruvian carrot
Asparagus officinalis L.	asparagus
Beta vulgaris	beetroot
Beta vulgaris Lam.	chard
Brassica oleracea L.	broccoli
Brassica oleracea L.	cabbage
Brassica oleracea L.	cauliflower
Brassica oleracea L.	kale
Brassica parachinensis Bailey	chinese cabbage
Brassica spp.	brassica
Capsicum annuum L.	sweet pepper
Capsicum spp.	paprika
Carchorus olitorius L	jute mallow
Cichorium endivia Lam.	endive
Cichorium intybus L.	radicchio
Cleome gynandra	spiderplant
Colocasia esculenta L.	taro
Corchorus olitorius L.	corchorus, nalta jute
Coriandrum sativum L.	cilantro
Crassocephalum spp.	Ebolo, ragleaf, Yoruban bologi
Cucumis sativus	cucumber
Cucurbita pepa L.	squash
Cucurbita pepo L.	pumpkin
Cucurbita pepo L.	Squash
Cynara scolymus L.	artichoke
Daucus carota Hoffm.	carrot
Dioscorea alata L.	yam
Glycin max L.	soybean

APPENDIX V

Hibiscus esculenta	okra
Ipomea aquatica	kangkuna (Ipomea aquatic)
Ipomea aquatica	kangkuna (Ipomea aquatic)
Ipomoea batatas	sweet potato
Latuca sativa L.	lettuce
Leptadenia hastata	Leptadenia hartata
Luffa acutangula (L.) Roxb., *L. cylindrica* (L.) Roem, *Lagenaria* sp	gourd
Luffa acutangula L.	luffa
Lycopersicum esculentum	tomato
Lycopersicum esculentum Mill. syn. *Solanum esculentum* L.	cherry tomato
Manihot esculenta	cassava
Opuntia spp. L.	nopal cactus, nopales
Persea americana	avocado
Phaseolus vulgaris L.	french bean
Phaseolus vulgaris L., *Phaseolus lunatus* L.	beans
Phseolus vulgaris L.	green beans
Pisum sativum L.	pea
Pisum sativum L.	snow pea, Chinese pea, sugar snap pea
Raphanus sativus L.	radish
Rheum×hybridum Murray	rhubarb
Sechium edule	chayote
sesbania grandiflora L.	West Indian pea
Solanecio aethipicum	indigenous African leafy vegetable
Solanum aethipicum	solanum aethipicum
Solanum macrocarpon	gboma, African eggplant
Solanum melongena L.	eggplant, aubergine, brinjal
Solanum tarderemotum	african nightshad
Solanum tuberosum L.	potato
Spinacia oleracea L.	spinach
telfairia occidentalis	fluted pumpkin, oysternut
Vigna subterranea L.	groundnut
*Vigna unguicula*ta L.	cowpea, long bean, black-eyed pea
Zea mays L.	baby corn
Zea mays L.	sweet corn

Herbs & Spices

Botanical name	**vernacular name**
Zingiber officinale Roscoe	ginger
Acacia cyclops A. Cunn. ex. G. Don	fynbos
Aloe ferox Mill.	aloe ferox
Brassica napus L.	Rape, colsa
Camellia sinensis (L.) Kuntze	tea
Capsicum spp. L.	green chilies
Capsicum spp. L.	hot pepper
Cassia tora L. syn. *Cassia obtusifolia* L.	Cassia tora, chakod, charota

Cinnamonium zeylanicum Garc. ex Blume	cinnamon
Coriandrum sativum L.	coriander
Curcuma longa L.	tumeric
Elettaria cardamomum (L.) Maton.	cardomon
Helianthus annuus L.	sunflower
Mentha spp.	mint
Moringa oleifera L.	moringa
Myrciaria spp.	murta, myrtle
Phyllanthus emblica Linn.	nelli, Indian gooseberry, uririkai
Piper nigrum L.	black pepper
Pogostemom cablin	patchouli
Rumex acetosella	sorrel
Saccharum officinarum L.	sugar cane
Syzygium cumini Skeels	jambul, Indian blackberry, Java plum
Vanilla planifolia Andr.	vanilla

Ornamentals

Botanical name	**vernacular name**
Aglaonema spp.	silver queen
Alstroemeria spp.	alstroemeria
Amarathus spp.	amaranthus
Anthurium spp.	anthurium
Bauhinia spp.	bauhinia
Bougainvillea spectabilis Willd.	bougainvillea
Brassica spp.	crucifers
Calendula officinalis L.	marigold
Celosia argentina L.	celosia
Chrysanthemums spp.	chrysanthemums
Delonix regia	Flamboyant, royal poinciana
Dianthus caryophyllus L	carnation
Fernaldia pandurata	loroco
Gerbera jamesonii	gerbera
Gladiolus spp.	gladiolus
Hibiscus spp.	hibiscus
Jasminum spp.	jasmine
Lilium spp.	lilium
Limonium spp.	limonium
Orchidacea	orchid
Paeonia spp.	peony
Palmaceae	fan palm
Palmaceae	palm
Palmaceae	palms
Polianthes tuberosa	tuber-rose
Rosa spp.	rose
Rumohra adiantiformis	leatherleaf fern
Tulipa spp.	tulip

APPENDIX VI

COMMODITY CONSTRAINT ANALYSES

A commodity constraint analysis allows for penetration into the dynamic interactions between crops and constraints. Survey respondents ranked constraints to specific crops important to their region using eleven different categories and designating a score between one and five (1=mild, 5=severe). Tomato was chosen as an illustrative example to compare inter-regional constraints because that commodity was identified as the most important horticultural crop in the world. In addition, tomato was the sixth most frequently mentioned crop, displaying latent potential for its utilization. Constraints to tomato supply are described for each region. Following tomato, five additional crops per region are detailed, based upon regional significance and accompanied by descriptions of specific issues.

TOMATO

In Sub-Saharan Africa, all components of the supply chain exert significant stress upon the successful production of tomato, but respondents identified biotic stress as having the greatest importance. Specific issues mentioned include: *Phytoptera*, viral diseases (especially Tomato Yellow Leaf Curl Virus), Nematodes, *Alternaria*, *Fusarium*, *Helicoverpa*, and *Bemisia*. Many of these diseases and pests are controlled with fungicides and pesticides. Alternative production methods such as soil solarization, and genetic improvement were suggested as possible opportunities to reduce agrochemical use and abuse. Agrochemical use is exacerbating food safety issues because farmers spray fungicides to extend postharvest life. Rapid quality degradation is common to many areas with inadequate infrastructure. Fresh tomato requires cold storage in order to reach export markets, and storage-life is enhanced through proper handling practices. The demand for cold storage was prevalent, but simple practices like using appropriate containers and not over-packing boxes would also be effective. Value-added processing presents an opportunity for tomato paste production in remote areas, but investment and access to credit for building the proper facilities is insufficient. Some respondents mentioned that tomato production has the capacity to empower women in the production system.

In Latin America and the Caribbean, survey respondents highlighted biotic stress, food safety, and postharvest techniques as equivalent constraints to tomato production. Postharvest and food safety concerns centered around transportation and infrastructure inadequacies, including difficulties in logistics, cold storage and transportation. While standards and grading are prevalent for product destined for the export market, local markets do not differentiate product quality. Food safety protocols, including pesticide residues, phytosanitary issues, and knowledge of global standards

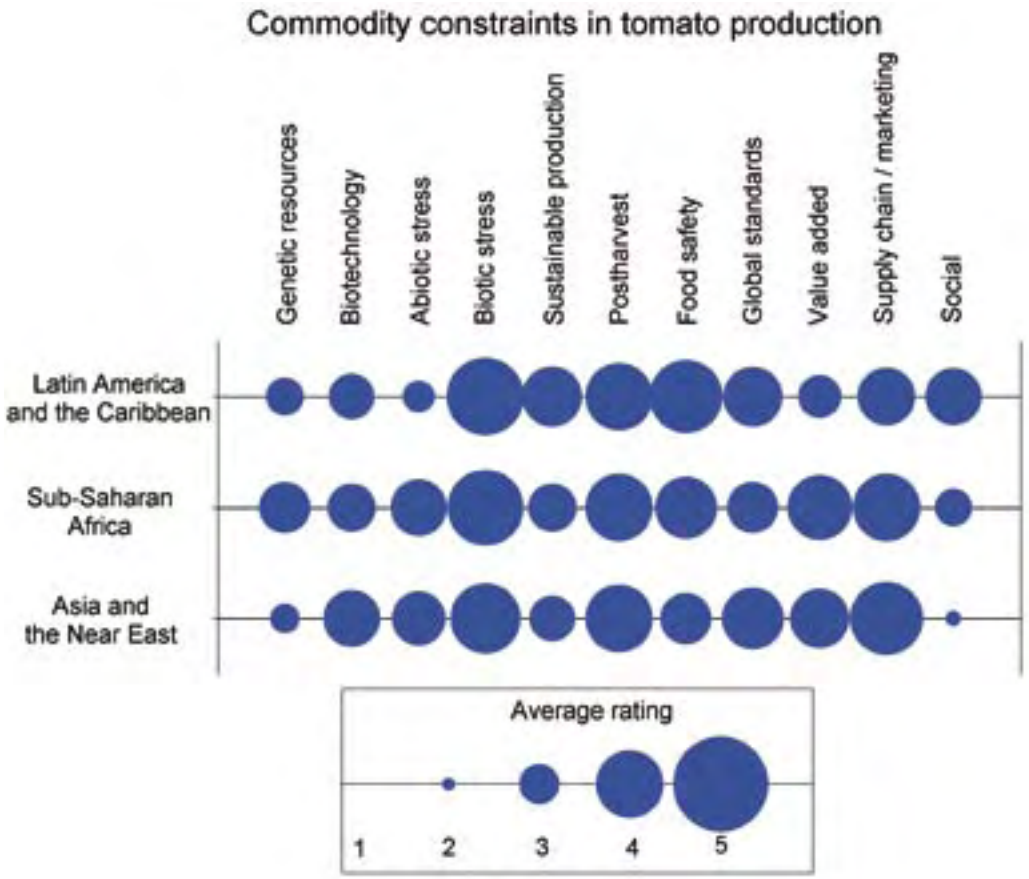

Figure 1. **Results of the commodity constraint analyses for tomato for the three main regions.** Constraints were rated on a scale from 1 (low constraint) to 5 (high constraint). The size of the circles indicates the average of the responses for the respective constraint and crop.

are not well dispersed. Lack of information aggravates agrochemical misuse, particularly in efforts to control pests and diseases. White flies and Gemini virus impose significant restrictions on production. In addition, respondents mentioned *Pseudomonas* and *Ralstonia*. In the area of seed supply, there is a lack of genetic diversity of commercial varieties, improved seed availability is low, and indigenous varieties are not available. Irregularity of water availability is an issue. Respondents mentioned that fluctuating water supply is exacerbated by deterioration of watersheds, which also impacts arable land through erosion.

In Asia Near East, while biotic stress, postharvest, global standards, and supply chain/marketing were the most significant constraints to tomato, the entire production-supply chain affects the commodity. Most constraint ranks were 3 or 4 out of 5, suggesting moderate to severe constraints. As in SSA, the viral diseases and bacterial wilts received particular attention, but many insects were also named, notably aphids, tomato fruit borer, and leafminers. Protective plastic house production systems were suggested to minimize use of chemical sprays and to regulate inputs. In addition, genetic improvement, through both biotechnology and traditional breeding, might prove valuable to building resistance to these pests. Many of the cultivars desired in the global marketplace are unavailable in ANE. Information concerning global standards of microbial contamination, agrochemical residues, and grading is not well distributed. In many places, quality is not rewarded in the marketplace. Instituting standards may lead to product differentiation, enhancing marketing and rewarding producers. The primary hindrance to marketing was identified as a lack of farmer organizations.

SSA - Leafy/indigenous Vegetables, Mango, Cabbage, Potato, Pineapple

Indigenous/African leafy vegetables (***Amanranthus spp., Solanum spp. etc.)***
Indigenous/African leafy vegetables were mentioned frequently, both in surveys and at the workshops, due to their nutritional value and the potential to improve the livelihoods of small farmers throughout the region. Survey respondents noted opportunities for exploiting the wide range of indigenous germplasm throughout the region, but there are few centralized efforts aimed at collection and conservation, and knowledge associated with their production and use is scarce. Production is constrained due to lack of recommended agronomic practices. Postharvest constraints, the most severe limiting factor for indigenous vegetables according to *figure 2,* include phytosanitary issues like the use of clean water in processing to prevent consumer illnesses due to water-borne diseases. Other postharvest issues include accessing local markets quickly as the leafy vegetables deteriorate rapidly after harvest. Stakeholders also mentioned the need for cold storage facilities, as well as drying and other methods of processing leafy vegetables to prevent postharvest nutrient loss. Marketing of leafy vegetables is constrained by a poverty stigma that is attached to the consumption of indigenous vegetables. Women stand to benefit most from increased production of leafy vegetables, because they often produce and market the vegetables from their homes.

Mango ***(Mangifera indica)***
Mango is identified as one of the most important crops in all four subregions, as well as being listed as an underutilized, but high potential crop in Central, Southern and Eastern Africa. Survey respondents stated that few varieties of mango are available, especially varieties suitable for drying and juicing. Biotic stresses, such as fruit flies and powdery mildew destroy crops both preharvest and postharvest. Limited water availability is a constraint in many areas. There are few standards in place for postharvest grading, handling, and storage. The lack of cold-storage facilities severely limits the shelf life of this crop. While respondents noted the marketing potential for dried mangos and juice, the required processing facilities are limited and costly.

Cabbage ***(Brassica oleracea)***
Survey respondents throughout sub-Saharan Africa identified cabbage as one of the top 2 to 5 crops. Biotic stresses in cabbage can be severe as the crop is highly susceptible to pests, resulting in producer abuse and misuse of pesticides. Food safety is a concern due to high levels of pesticide residue as well as water-borne diseases that result from washing the crop in unsanitary water. Storage facilities, especially cold storage, is limited throughout the subregions and can limit rural producers' access to markets. Respondents noted that little is known about potential value-added methods. Cabbage, generally sold locally, is not highly constrained by export standards.

Potato ***(Solanum tuberosum)***
Potato, which appears as both an important and currently underutilized crop throughout sub-Saharan Africa, differs from the other crops in that genetic resources is mentioned as its largest constraint. Potato is a New World crop and a fairly recent arrival on the African continent. Survey respondents mentioned the need for higher availability of quality germplasm and varieties adapted to specific SSA agroecological zones. Tolerant varieties are needed to withstand heat and drought, while other varieties were requested to withstand climatic conditions during the rainy season. Overall, new varieties should be less susceptible to pests and disease, specifically red spider mites and early and late blight. Respondents also remarked on the need for clean germplasm, noting problems with bacterial and viral contamination. Stakeholders noted the marketability of potatoes and constraints related to postharvest activities and value-added products. Marketing begins with producers choosing a variety that processors find favorable – high dry matter content, big tuber size, quality of frying and crisping, and perhaps most important, taste. Respondents noted that refrigerated storage and processing facilities are scarce, and while local quality standards may be in place, they are not enforced. Some people felt that domestic and local markets should be targeted because competition in the global potato market is fierce. Opportunities do exist on the local level for potato drying, with financial support.

Pineapple ***(Ananas comosus)***
Respondents noted the availability of few cultivars. Pests and poor soil fertility were mentioned most in terms of production constraints. In some areas, the local, fresh market was limited while canning was most important. Few standards for grading exist for exporting to markets, especially to Europe. Processing, specifically drying, and storage facilities, could increase shelf life and improve export opportunities.

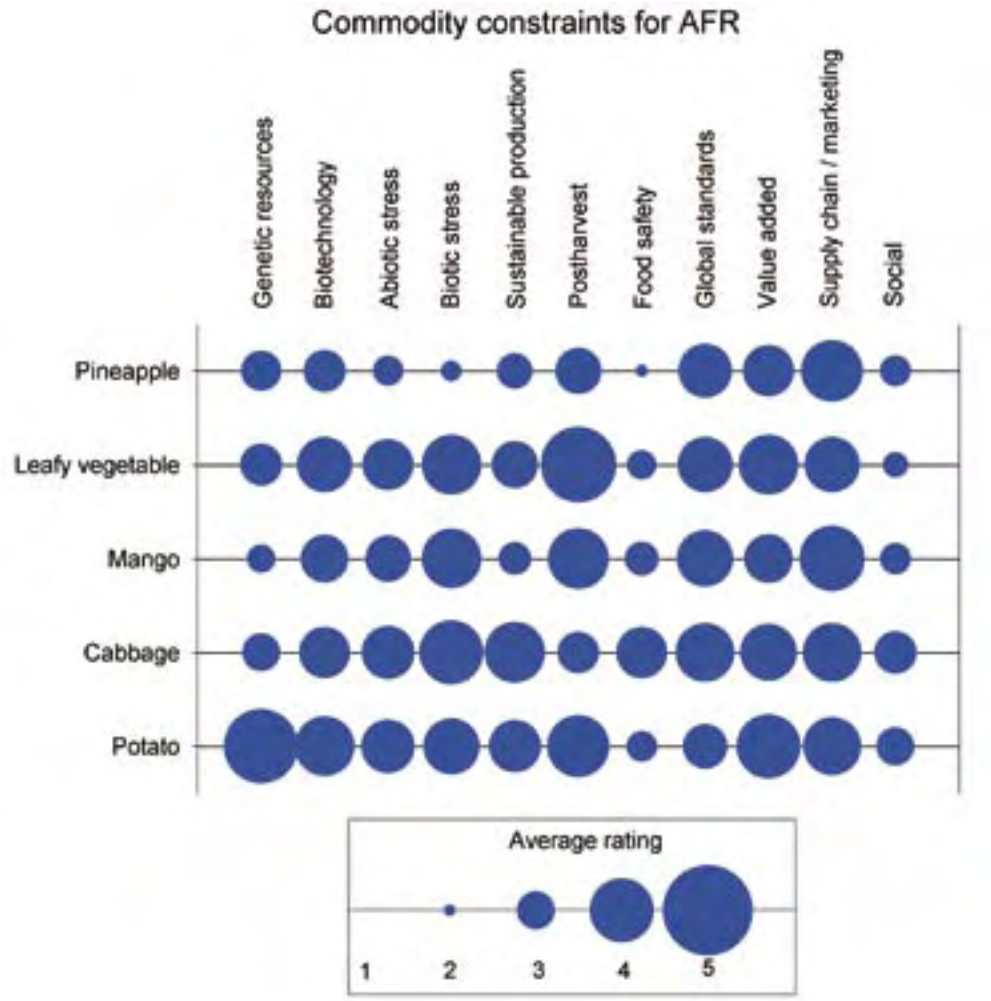

Figure 2. **Results of the commodity constraint analyses for five of the most important horticultural crops in sub-Saharan Africa.** Constraints were rated on a scale from 1 (low constraint) to 5 (high constraint). The size of the circles indicates the average of the responses for the respective constraint and crop.

LAC - Avocado, Citrus, Peppers, Potato, Onion

Avocado *(Persea Americana)*

The avocado was first domesticated in the Americas, and only relatively recently commercialized. Globally, the single most economically important avocado variety is the Hass. The Hass and the Fuerte varieties comprise over 85% of the world's export production of avocados. Latin America, with over 50% of the world's export Hass avocados originating form Mexico or Chile, is competing globally with Australia, the U.S., South Africa, Israel, and Spain.

Within the commodity constraint analysis, the highest constraint to avocado production was global standards. The U.S. has extreme protectionist measures in place to ensure that California and Florida avocado growers have minimal competition from overseas. These measures are enforced in the form of strict phytosanitary regulations. The second highest avocado production constraint was postharvest. Postharvest is paramount for avocados because a variety of diseases (*Anthracnose*, *Dothiorella* stem rot) can cause severe reduction in saleable fruit, and because avocados are notorious for bruising. Hass is the number one variety in the world for its postharvest qualities because it packs and transports well. Many varieties of avocado are not so amenable to shipping or packing and must be consumed locally. Producers also cited as severe constraints the market/marketing chain, and lack of value-addition. The marketing constraint is related primarily to the global standards issue. In Mexico, a few producers make

guacamole for export, but that is the extent of value-addition opportunities.

Citrus *(Rutaceae spp.)*

Citrus species (lemon, orange, lime, tangerine, etc.) were ranked the region's third most important commodity (Fig 3). Within each subregion, citrus was never lower than sixth highest and was ranked as the third most important in the Caribbean region. As illustrated in the bubble graph, social constraints ranked as one of the highest limiters of citrus production, although there is no one emerging social issue. Individual surveys discussed a variety of issues, from land tenure issues and size restrictions in El Salvador, to few farmer organizations for these commodities. Other significant impediments to the development of the citrus industry in the region are global standards, postharvest and sustainable production. In many cases, standards exist for export but few are applied and few growers attempt to target the export market. Many survey respondents cited the complete lack of postharvest infrastructure for this commodity (packing houses and packing material). The absence of synchronized production and mismanaged agrochemical usage were cited as examples of the imperative to move towards more environmentally sustainable production systems.

Peppers *(Capsicum spp.)*

This commodity constraint analysis refers to both pungent and non-pungent forms of pepper, or chile. Aggregating the two would place them among the top three crops in the entire region. *Capsicum* (the two varieties combined) ranks as the most important crop for the Central America and Mexico subregion. Respondents identified biotic stresses as the greatest limiting constraint for *Capsicum*. A number of diseases and pests were mentioned – viruses, especially Gemini viruses transmitted by the whitefly *Bemisia tabaci*; fungi, such as *Phytophthora*, *Verticilium*; pests such as mites, *Aphis gossipeae*, and thrips. Other constraints identified as limiting *Capsicum* development were postharvest and supply chain/marketing issues. Postharvest constraints are the lack of adequate storage facilities and the lack of postharvest information. One salient example of how all of these constraints interact and interrelate is the need for postharvest fumigation, a requirement for peppers exported to the U.S. Fumigation meets standards and enables market access, but raises the cost of production. Postharvest and market constraints often act in concert, and this is certainly true for Capsicum peppers across Latin America.

Potato *(Solanum tuberosum)*

Potato is a crop of global importance with origins in South America, specifically in Peru, which harbors a rich archive of potato genetic diversity. This genetic diversity could potentially contribute to improved and locally-adapted varieties and potato cultivars with increased frost and drought tolerance. Insufficient knowledge of global standards, sustainable production, postharvest, food safety and biotic stress, are the largest constraints to potato commodity development in the region. The use of highly toxic pesticides is a stumbling block to compliance with global standards, food safety, and sustainable production. Marketing of potato is limited to local areas, and the crop is not being utilized for niche marketing or in value-added production. Postharvest losses can be high because of poor storage practices and transport, which further limit market options. Biotic stresses can be intense in tropical areas, but throughout its growing region, potato production may be limited by endemic diseases and insects, such as late blight, Andean potato weevil and potato tuber moth. Potato production may also be constrained by diseases caused by *Ralstonia solanacearum*, *Erwinia carotovora*, and *Streptomyces* bacterias, among others. The potato is a food staple in the Andean highlands, where populations are vulnerable to unstable harvests.

Onion *(Allium cepa)*

Onion was ranked as the tenth most important commodity in the LAC and the seventh most important in South America. The commodity constraint graph displays the top three constraints as postharvest, supply chain/marketing and biotic stress. Postharvest constraints are inadequate infrastructure, and insufficient storage and curing facilities. Low input, inexpensive bulk-curing systems, using a fan and slatted floors, may be appropriate for on-farm storage in some areas (Kitinoja and Kader 2002). Marketing constraints are consistently emphasized as a lack of regional marketing options. Value-added production is also cited as a constraint. Lack of knowledge and experience in value-added strategies, insufficient resources and lack of credit, further limit producers' options for value-addition. Biotic stresses such as fungus-related diseases and pests, including thrips, *Pseudomonas,* pink rot and purple blotch are problems in the LAC region. Inappropriate and limited genetic material may be exacerbating fungus-related diseases in tropical regions. Sustainability of production was also cited as a constraint, including environmental contamination and mounting costs of

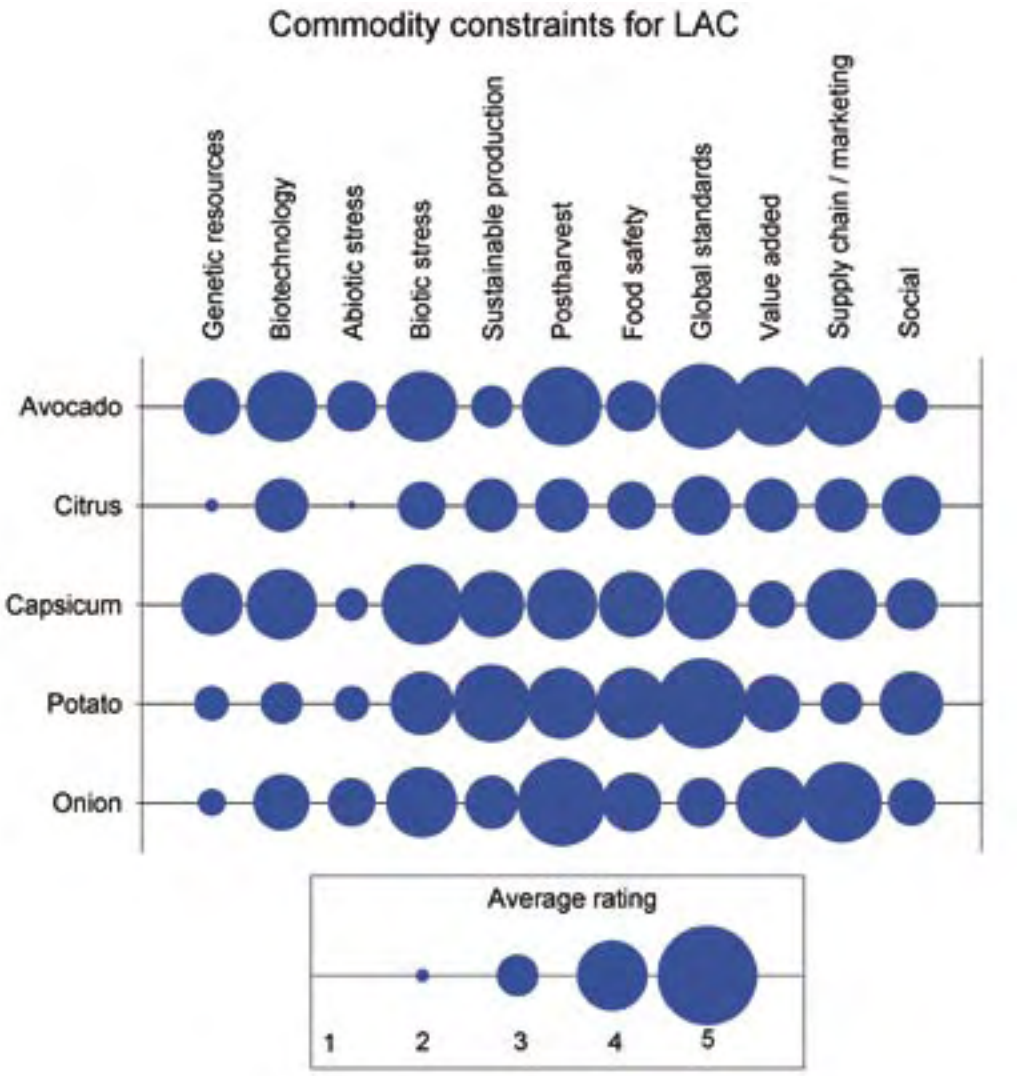

Figure 3.. **Results of the commodity constraint analyses for five of the most important horticultural crops in Latin America and the Caribbean.** Constraints were rated on a scale from 1 (low constraint) to 5 (high constraint). The size of the circles indicates the average of the responses for the respective constraint and crop.

production, especially the high cost of seed. Social constraints were mentioned relating to lack of farmer organization and insufficient qualified labor for onion production.

ANE - Mango, Banana, Potato, Hot Peppers, Eggplant

Mango *(Mangifera indica)*

Mango ranks as the second most important commodity in ANE and within the top five most important crops for each of the subregions. As illustrated in the graph, postharvest and marketing constraints remain the most significant impediments to mango utilization, especially when attempting to gain access to export markets. Generally, farmers have insufficient knowledge concerning global standards. Quarantine of fresh product due to the possibility of pest and disease transmission demands significant postharvest treatment. Minimal postharvest procedures include hot water baths and infrared radiation to control white fly and fruit fly larvae. Other postharvest issues for mango producers are inadequate knowledge of prime harvest maturity, insufficient storage facilities and packaging materials, and subsequent damage to the fruit in transport. Many respondents mentioned food safety as a significant factor but mostly in regard to pesticide residues. Commonly cited pest and disease organisms include *Anthracnose, Bactrocera zonata*, and fruit flies. Chemical sprays employed to control the calamites exacerbate food safety concerns. There was little or no mention of microbial

contamination. Opportunities in value-added products, including juice and dried fruit, are offset by the multitude of varieties cultivated. Respondents often noted that there was a significant amount of untapped genetic resources for mango, especially in South Asia. The lack of human capacity capable of utilizing improved horticultural techniques prohibits functional improvement via this resource.

Banana *(Musca spp.)*
Banana ranked as the third most important crop in ANE, and within the top five in both South East Asia and South Asia. Postharvest and biotic factors were identified as the two most constraining issues in banana. Forty percent of the crops are lost postharvest due to poor packing, storage and transportation systems. Value-added processing in the form of banana chips, dehydration and fibers are opportunities within the banana market, but processing facilities are insufficient to address volume and food safety demands. Food safety and global standard concerns centered upon lack of information and mismanagement of agrochemicals. Biotic pests dictate the use of pesticides and fungicides to control viral diseases and their vectors, nematodes, *Fusarium* wilt, *Sigatoka, Erwinia, Pseudemonas,* and Banana Bunchy Top Virus (BBTV). Maintenance, evaluation, and characterization of germplasm may provide the key to developing resistance to many of these biotic constraints. Unfortunately, due to the fruit's unique physiology, traditional methods for conservation and improvement are difficult to implement, therefore biotechnology and tissue culture might be the best ways to address this problem.

Potato *(Solanum tuberosum)*
Potato, which ranked as the fifth most important crop in ANE, is mostly constrained by postharvest issues. Not only is there a lack of information about the crop and limited transportation systems, but cold storage is either non-existent or inadequate throughout much of the region, leading to substantial loss. Biotic factors intensifying this loss are late blight, bacterial wilt, potato tube moth, and leaf miners. Aphids and their role in viral transmission were of particular concern. Sustainable production was mentioned in the context of the general dearth of information and lack of access to technologies concerning integrated crop management, such as, nutritional mismanagement and plant protection. Marketing and global standard concerns mention both the absence of standards and the often-restricted trade in fresh product. "French fries" or "chips" might present value-added opportunities.

Chile (Hot) Peppers *(Capsicum spp.)*
Chile peppers are among the top ten most important crops in South East Asia and South Asia and Capsicum was listed as a crop with high potential in North Africa/Near East. Chile pepper supply is moderately constrained by marketing and production gaps. Inadequate knowledge severely affected all aspects, through global standards, food safety, and pesticide safety. Integrated crop management is needed to help mitigate low fertility soils, erosion, lack of quality irrigation water, and pest problems. Pest and disease pressures include fruit flies, *Anthracnose*, thrips, mites, fruit flies, fruit and bud borer and leafhoppers. The abundant germplasm available may possess keys to resistance, but no coordinated effort has been made across the region to harness that resource.

Eggplant *(Solanum melongena)*
Eggplant was ranked as the tenth most important crop in the region, but the production of eggplant is constrained in much of the supply chain. Marketing impacts include: lack of grading, standards, transportation, and storage. Although value-addition processing facilities are poor or unavailable, pickles are a possibility. High levels of chemical residues, resulting from control measures for fruit and shoot borer, require particular attention. In addition, bacterial wilt, little leaf, and damping off are significant issues.

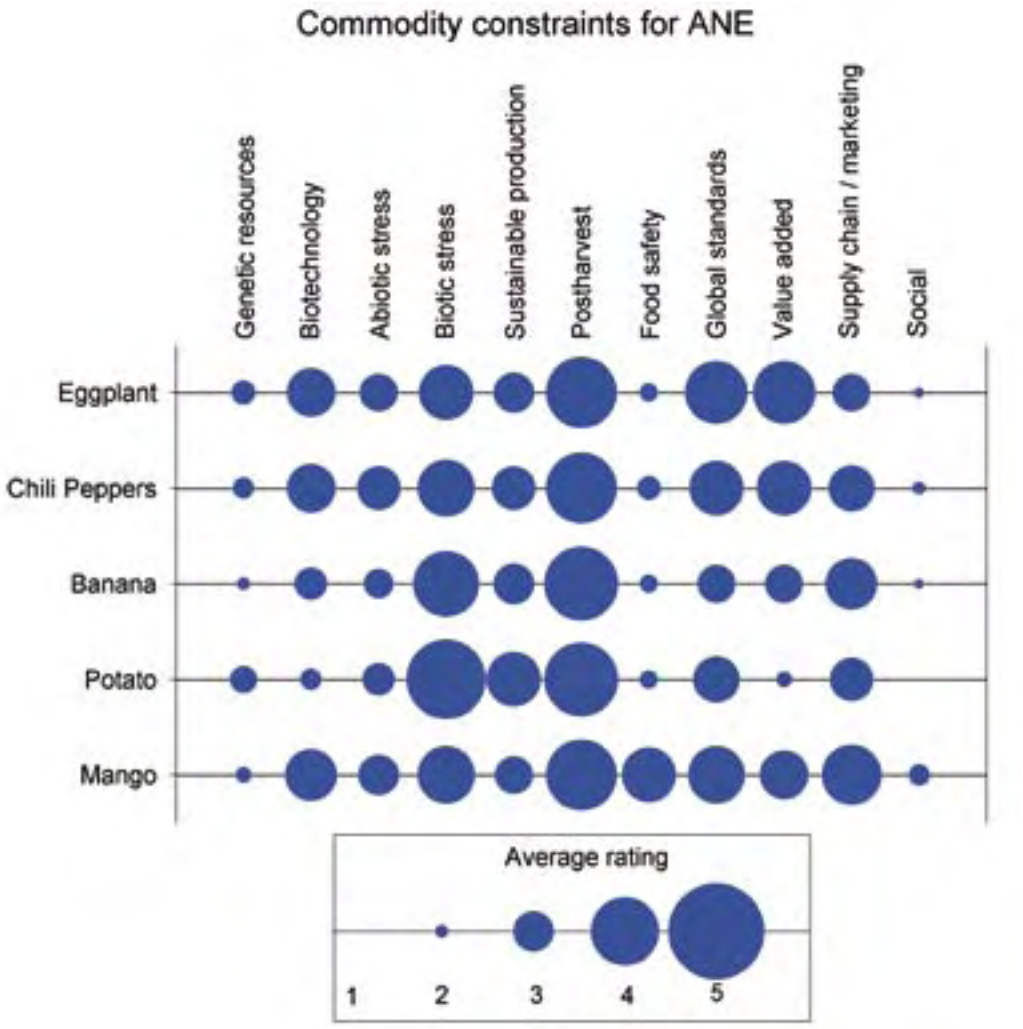

Figure 4. **Results of the commodity constraint analyses for five of the most important horticultural crops in Asia and the Near East.** Constraints were rated on a scale from 1 (low constraint) to 5 (high constraint). The size of the circles indicates the average of the responses for the respective constraint and crop.

APPENDIX VII

Regional Priority Project Charts

During the regional workshops, subregional breakout groups ranked their highest priority projects. They used the criteria they had identified for judging projects as a filter for their choices (see Methodology section for further explanation). In many cases, this process concluded with four or five projects honed from approximately twenty. The following are priority project charts divided by primary issues and classified by subregion.

Sub-Saharan Africa: Arusha, Tanzania, February 14-16, 2005

Table 1

Market Linkages	
East Africa A	Commodity-based market chain analysis; Develop market information, collection and dissemination systems.
East Africa C	Study range of markets, their characteristics and requirements and identify new opportunities they offer horticultural production.
Southern Africa	Improve harvest and post-harvest handling of tomatoes for sale on local markets.
Postharvest Systems and Food Safety	
West Africa/Francophone	Improve postharvest, storage and processing methods for horticultural crops.
East Africa A	Identify appropriate postharvest technologies that minimize losses in quantity and quality of produce; asses market demand for value-added horticultural commodities; market survey to determine pesticide/microbial contamination of currently marketed fruits and vegetables.
East Africa C	Determine appropriate harvest, storage, transport, processing and packaging technologies for small and medium scale producers.
Southern Africa	Improve harvest and postharvest handling of tomatoes for sale on local markets.
Genetic Resources Development and Conservation	
West Africa/Francophone	Development of varieties adapted to local conditions, viruses and other diseases.
East Africa A	Varietal development and multiplication systems.
East Africa B	Tomato cultivar adaptability and nutritional evaluation; design and execute a holistic program to enhance the production and consumption of indigenous vegetables.
East Africa C	Study seed/plant reproduction systems to develop techniques for maintenance, rapid multiplication and distribution of priority horticultural crops.
Southern Africa	Improve the availability of indigenous horticultural crops through documentation, assessment, and conservation.
Sustainable Production Systems and Natural Resources Management	
West Africa/Francophone	Develop strategies to combat the principal pests/diseases of horticultural crops with minimal use of pesticides.
East Africa A	Development of integrated crop management systems.
East Africa B	Develop effective natural methods of pest control (bio-pesticides) for eco-friendly horticulture and health.
East Africa C	Study the application of integrated crop management practices, including the effect of cultural practices and the efficacy of IPM strategies, for an improved yield, quality and sustainability in key horticultural crops.
Southern Africa	Participatory assessment of traditional pest and disease management systems.
Capacity Building and Region Specific Issues	
West Africa/Francophone	Promote the utilization of horticultural crops in the fight against HIV/AIDS.
East Africa A	Strengthen local horticultural support institutions for research, training and development; Capacity building of service providers for continuous market survey and information dissemination; capacity building of market chain participants to access and utilize market information.
East Africa B	Improve information flow, knowledge exchange and organizational arrangements to enhance smallholder livelihoods.
East Africa C	Identify and study capacity of key stakeholders in the horticultural supply chain, and their respective roles.

Latin America and the Caribbean: Zamorano, Honduras, March 24-26, 2005

Table 2

Market Linkages	
Central American Group 1	Analysis of market trends and opportunities of horticultural products.
Central American Group 2	Consolidated and transmissible information regarding local, regional and international markets.
Central American Group 3	Stimulate market research and develop market intelligence of horticultural products in local, regional and international markets.
Andean Group	Develop market access, including capacity to diversify production based on studies of market and consumer preferences.
Caribbean Group	Identify niche market opportunities for expansion and development for fresh and value-added Caribbean horticultural products, including linkages of hotel/tourism markets to local producers.
Postharvest Systems and Food Safety	
Central American Group 1	Identification and implementation of postharvest management strategies.
Andean Group	Develop postharvest system to meet market demands, and develop postharvest pilot projects to teach farmers cold chain technologies.
Caribbean Group	Provide appropriate postharvest handling and safety information to all levels of the postharvest chain, including linkages to transfer of appropriate technologies.
Genetic Resources Development and Conservation	
Central American Group 3	Utilization and conservation of native crops species and appropriate introduced species, including genetic improvements of cultivars.
Andean Group	Identify useful germplasm for use in improved seed production.
Caribbean Group	Identify, develop, manage, and utilize genetic resources for sustainable horticulture.
Sustainable Production Systems and Natural Resources Management	
Central American Group 1	Develop sustainable, market-orientated production systems based on crops and crop clusters.
Central American Group 2	Promotion and innovation of horticultural production technology geared towards small and medium- sized farmers.
Central American Group 3	Establishment of a regional center to study and analyze disease risks of horticultural commodities.
Andean Group	Establish a data base, accessible to producers, on which cultivars grow where, in the hopes of increasing production alternatives and diminishing production risks.
Caribbean Group	IPM systems for disease/pest problems.
Capacity Building and Region Specific Issues	
Central American Group 1	Farmers Field & Postharvest Training School models.
Central American Group 2	Organize small and medium-sized growers into business-orientated entities, which will increase their capacity in production, administration and marketing or products.
Central American Group 3	Specialization of human resources along the agricultural production chain, including organization of small and medium-sized producers to strengthen social capital and business capacity.
Andean Group	Strengthen farmer organization and business capacity.
Caribbean Group	Coordinate the delivery of horticultural services, including information, extension services, technology and research, to growers, processors, handlers and technicians.

Asia and the Near East: Cairo, Egypt, March 12-14, 2005

Table 3

Market Linkages	
North Africa	Institute a database system facilitating greater access to market information.
Near East	Promote market intelligence and transparency through establishment of proper information systems.
South Asia	Assess and develop market infrastructure to address the issues of the value chain for horticulture commodities.
South East Asia	Strengthen market intelligence systems (content and delivery).
Postharvest Systems and Food Safety	
North Africa	Creation of a postharvest market assurance team to assess standards and aid in certification processes.
Near East	Proper practices for postharvest, value-added and processing management at the farmer, packinghouse and market level.
South Asia	Understand and develop appropriate post-harvest technologies for horticulture commodities to ensure quality, safety and value.
South East Asia	Develop participatory training programs to enable farmer groups to implement GAP and GHP to meet the standard required for domestic, supermarkets, and export markets.
Genetic Resources Development and Conservation	
North Africa	Introduce new species of traditional and non-traditional horticultural commodities.
Near East	Collection, conservation and utilization of horticultural genetic resources
South Asia	1) Development of quality seeds and planting materials production and distribution systems. 2) Trait-specific germplasm enhancement using novel crop improvement and biotechnological approaches.
South East Asia	Development of production technologies for valuable local plant species including the transition from wild gathering to domestication.
Sustainable Production Systems and Natural Resources Management	
North Africa	Optimizing production through utilization of protected systems (e.g. greenhouses)
Near East	Application of integrated production & protection management in horticulture production to elevate farmer income.
South Asia	Assessment of peri-urban horticulture production system for sustainable food supply for urban populations.
South East Asia	Research and development of off-season varieties and production systems including protected cultivation (plastic roofs, net houses, etc.)
Capacity Building and Region Specific Issues	
North Africa	Design a database system addressing natural, human, technical, and marketing information.
South Asia	Empowering farmers, especially women, in technology generation, transfer, adoption and capacity building sub-systems through participatory approaches.
Enabling Environment	
South Asia	Empowering farmers, especially women, in technology generation, transfer, adoption and capacity building sub-systems through participatory approaches.
South East Asia	Analyze policies (national/local government, donors, etc.) that affect the horticultural sector (land tenure, human capacity, credit, infrastructure, tariffs, import/export barriers) to determine areas of need for policy change, advocacy, lobbying, and capacity building to promote policy changes.

APPENDIX VIII

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