Title: Identification of Appropriate Postharvest Technologies for Improving Market Access and Incomes for Small Horticultural Farmers in Sub-Saharan Africa and South Asia

Grant Agreement: BMGF Grant Number 52198
Project Dates: Feb 2009 – Jan 2010
Project co-leaders: Dr. Lisa Kitinoja (WFLO), Dr. Marita Cantwell (UC Davis)

Executive Summary

Objectives
The main objective of this planning project on Appropriate Postharvest Technology was to:
Establish a core team of 6 or more partner organizations in the US, Sub-Saharan Africa and South Asia and work together over 12 months to build local capacity in postharvest technology by training at least 30 people in project evaluation, postharvest loss assessment, Commodity Systems Assessment, identification and evaluation of potential small scale postharvest interventions, extension education methods for postharvest technology and/or strategic planning and proposal development.

Activities
- Literature reviews – postharvest losses in developing countries, numbers and topics of past agricultural development projects in Sub-Saharan Africa and South Asia
- Past Project Assessments – 12 projects revisited in 5 countries
- Training workshops – 5 workshops held for 226 trainees in 4 countries
- PostHarvest loss and quality assessments (PHLQA) – 24 crops assessed
- Commodity Systems Assessments (CSA) – 30 crops assessed
- Field trials of postharvest technologies – 50 + potential technologies identified, 19 field tested
- Cost/benefit analyses – 81% of postharvest technologies were cost effective for smallholder farmers
- Planning workshop held at UC Davis – 45 participants from 19 countries

Results
- Literature reviews determine – only 5% of funding for agricultural development has been allocated to postharvest, while losses range from 20 to 80% for perishable crops.
- Lessons learned from 12 past horticultural projects (Egypt, Ghana, Kenya, India, Indonesia)
- Postharvest losses and quality concerns for horticultural crops
    - By country (India, Ghana, Benin and Rwanda) – losses tend to be higher when temperatures are very high
    - By crop – average losses range from 20 to 80% depending upon the crop and types of packages in common use
    - By value chain location (farm, wholesale or retail market) – handling damage occurs at all levels
    - By relative perishability of the crop – highly perishable crops are more susceptible to water loss, bruising
- Identification of research needs, training needs and advocacy issues
- Identification of cost effective, appropriate small scale postharvest technologies

Conclusions

- Appropriate small scale postharvest technologies can reduce fruit and vegetable crops waste, improve incomes by at least 30% for smallholder farmers and marketers
    - Improved containers to reduce mechanical damage of horticultural crops (plastic crates, liners in rough containers, smaller packages)
    - Use of shade to reduce water loss (cloth, woven net or thatch shade structures, market umbrellas)
    - Field packing to improve quality (sorting, trimming, quality grading and packing in the field)
    - Use of low cost cooling practices to maintain quality and extend postharvest life
    - Field curing to extend storage life and maintain quality of root, tuber and bulb crops
    - Low cost cold storage structures for successful longer term storage of potatoes and onions
    - Solar drying to transform perishables into more stable processed food products
    - Village scale canning, bottling and pickling to transform perishables into more stable products

Recommendations for future projects

- Extension/outreach strategies to build local capacity
    - Provide demonstrations of appropriate postharvest technologies in rural markets and villages
    - Target the women who produce, harvest, process and market horticultural crops
    - Improve access to postharvest tools, equipment, packages, supplies
    - Utilize "commodity systems assessment" to build local knowledge of the value chains
    - Promote "integrated postharvest management systems" for reducing losses (in quantity, quality and market value)
    - Use, cost/benefit assessment using local costs, prices, expected benefits
    - Train on business management skill development for improving profits
    - Provide "train the trainers" programs for creating a cadre of local postharvest specialists

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US Partners
- WFLO
- UC Davis

International Partners
- IITA (Benin)
- KNUST (Ghana)
- CSIR-CRI (Ghana)
- Ghana PolyTechnical Institutes (Bolgataga, Ho, Tamale and Wa).
- ISAR (Rwanda)
- KIST (Rwanda)
- Amity University (India)

Four sub-objectives:

1) To review of past international horticultural postharvest development projects and their outcomes and impacts in five countries, in order to characterize their long-term outcomes/impacts compared to their intended outcomes/impacts, to determine which postharvest interventions were successfully adopted and why, which interventions were not adopted and why, and which interventions were initially adopted, then abandoned and why.

2) To systematically assess and characterize the postharvest losses for 10 to 20 key horticultural crops in 4 countries using field based measurements at the farm, wholesale and retail markets, and a modified Commodity Systems Assessment (CSA) process, which includes pre-production, production, postharvest and marketing components of the value chain, in order to increase the knowledge base and to identify priority postharvest problems that currently limit market access for small farmers and rural marketers.

3) Using the results of these reviews, evaluations, measurements and assessments, to adapt and field test specific postharvest technologies that could solve priority postharvest problems, by conducting adaptive laboratory experiments and field trials in Sub-Saharan Africa and South Asia. Cost/benefit analyses were performed and modifications in the technologies were made if necessary to address the major constraints and better fit the varying technical, socio-economic and policy environments in the four target countries.

4) To identify 4 to 6 potential postharvest technology (PHT) and extension interventions that will specifically address the identified priority problems and serve to reduce food and value losses, and that are of appropriate scale, cost effective, easy to use on a trial basis and capable of generating increased incomes by at least 30% for small farmers.

Ghana

Benin

Rwanda

Uttar Pradesh, India

Activity 1: Literature reviews and past horticultural project assessments

Literature reviews: 1990 to the present date, published and unpublished documents, reports, web pages and project evaluations

Background: Reducing postharvest losses for fresh produce, reported to be in the 30 to 50% range, has been demonstrated to be an important part of sustainable agricultural development efforts meant to increase food availability (Kader 2005), but during the past thirty years less than 5% of the funding provided for horticultural development efforts has gone toward postharvest areas of concern, while more than 95% has gone toward trying to increase production (Kader and Rolle, 2004).

Horticultural producers in developing countries are mostly small farmers, and they are rarely organized into a formal cooperative or association. It is estimated that 10 to 20% of all farmers are producers of horticultural crops, sometimes in combination or rotation with field crops, and that horticultural cropping accounts for approximately 7% of the land in SSA and 6% in South Asia was allocated to agriculture in the year 2000 (AVRDC 2005; FAOStats 2004). The vast majority of horticultural crops producers and marketers in Sub-Saharan Africa and many horticultural producers in South Asia are women.

Findings

1) Postharvest losses of horticultural crops in developing countries

Many of the hundreds of published reports include general estimates of postharvest losses by the author(s) and/or refer to loss estimates or measurements published by other authors. We found only 69 published reports that included **primary data** on postharvest losses of fruits and vegetables, including 18 from Africa, 19 from South Asia, and 32 from other parts of Asia and Latin America. These reports are based on interviews or sampling as follows:

Postharvest losses literature review

Published Reports	Africa	South Asia	Other	Total
Interviews	6	7	13	26
Sampling	12	12	19	43

Since physical damage is the top cause of postharvest losses, the extent of losses depends on the relative susceptibility of the commodity to physical damage. As shown in the following table, losses in tomatoes ranged from 18 to 22% while losses in onion, potato, and yam ranged from 9 to 12.4%. Greater postharvest losses of bananas and Chinese cabbage were associated with longer transport distance on poor roads (increased physical damage incidence and severity).

Postharvest Losses of Fruits and Vegetables in Some Developing Countries

Country	Commodity	Method used	Losses (%)	Reference
Ghana	Tomato	Interviews	20	Bani et al, 2006
Benin	Mangoes Tomatoes	Sampling Sampling	17 (early April) 70 (mid June)- due to fruit flies 28 (economic loss = 40)	Vayssieres et al, 2008 IITA, 2008
Kenya	Banana (imported from Uganda)	Sampling	18.2 – 45.8	George & Mwangangi, 1994
Nigeria	Yam	Survey	12.4 (economic loss = 10.5)	Okoh, 1997
India	Onion, citrus , mango Tomato Cabbage	Sampling Sampling Interviews	30, 27, 26 30.3 – 39.6 15-20	Roy, 1993 Pal et al, 2002 Gajbhiye et al, 2008
Pakistan	Tomato Tomato, potato, onion	Survey	20 22, 12, 9	Mujib et al, 2007 Zulfiqar et al, 2005
China	Chinese cabbage	Interviews	22.7 - 61.6	Wang & Bagshaw, 2001
Oman	Fresh produce	Survey	3 - 19	Opara, 2003
Jordan	Tomato, eggplant, pepper, squash	Sampling	18, 19.4, 23, 21.9	El-Assi, 2002

2) Agriculture and horticulture development projects

While thousands of development projects have been launched in Sub-Saharan Africa and South Asia between 1990 and the present time by dozens of donor agencies, we found that few have focused on agriculture (less than 6% according to the AiDA database; 25% according to the World bank), very few have focused upon horticulture (approximately 1% of the agricultural projects) and only 1/3 of these very few horticultural projects included a postharvest component (which was generally some kind of food processing). Most of other horticulture projects appeared to focus upon increasing food production via various means such as improving irrigation systems, infrastructure, developing markets for processed or export products or extension work. Overall, then, only 1 in 5000 international development projects undertaken by various global agencies falls into the category of "postharvest horticulture" targeted for study under this planning project.

Breakdown of the Agricultural Development Projects found in various online databases

	Agriculture (grains, rice, maize, pulses, beans, coffee, cocoa, fruits, vegetables, floriculture, livestock, fisheries, forestry, etc)	Marketing (market research, value chains, market links, market access, market info, etc)	Horticulture (includes production-irrigation, seed improvement, soils/ fertility, pest mgmt, etc, postharvest and marketing of fruits and vegetables)	Postharvest (includes fresh produce handling, drying grains, food processing, transformation)	Fresh produce handling and marketing (sorting, grading, pest mgmt, packing, cooling, cold storage, transport, distribution, markets)
AiDA database 500k projects listed in all aspects of international development	29,000 projects listed (5.8%)		100 (0.3% of the 5.8% that are agriculture projects)	29	4
USAID advanced search	25,409 documents	1954	252	460	35
USAID Final Evaluation Reports (DEXS) 25,409 projects listed	267 (1%)	27	2	4	1
World Bank database 12,810 documents listed	3235 (25%)	402	38 (1.2% of the 25% that are agriculture projects)	1	1
inPHo (UN FAO) postharvest information network library (training manuals)	70	9	5	4	3
Devex (current, pending and forecast projects database)	5730	272	185	106	2 (1 current, 1 forecast)

Note: Data based upon advanced searches using key words and key word combinations.

AiDA http://aida.developmentgateway.org/aida/Search.do

USAID http://dec.usaid.gov/index.cfm?p=search.sqlSearch&CFID=9413138&CFTOKEN=51188616

World Bank http://web.worldbank.org/WBSITE/EXTERNAL/PROJECTS/0,,menuPK:51563~pagePK:95873~piPK:95910~theSitePK:40941,00.html

UN FAO http://www.fao.org/inpho/isma?i=INPhO&p=index.jsp&lang=en

DEVEX http://www.devex.com/

Past projects assessments:

International Horticultural Development Projects included in our original proposal
1) World Bank: Uttar Pradesh Diversified Agricultural Support Project (**UP DASP**)
2) USAID: Egypt Agricultural Technology Utilization and Transfer (**ATUT**) Project
3) USAID: Egypt Agricultural Exports and Rural Incomes – Enhancing the Livelihoods of Smallholder Horticultural Activities Managed Sustainably (**AERI EL SHAMS**) Project
4) USDA: United States-Ghana Consultative Committee on Agriculture and Rural Development (**CCARD**) Training and Analysis Assistance in Building Capacity Project.
5) USDA: **Indonesia Cold Chain Project**

Seven more Past Projects were added after the Literature Review
6) USAID: India Agricultural Commercialization and Enterprise Project (**ACE**)
7) USAID: India Growth and Microenterprise Development Project (**GMED**)
8) MCC: Ghana MiDA Agricultural Productivity Project (**MiDA APC**)
9) USAID: Indonesia AMARTA Project (**AMARTA**)
10) USAID: Kenya Hort Dev Project (**KHDP**)
11) JICA: Kenya HCDA Project (**HCDA**)
12) Rockefeller Foundation: Kenya Technoserve **Banana Program**

Key informants included project Chief of Parties, directors or managers, subject matter specialists and foreign consultants, trainers, evaluators, funders and affiliated local extension workers. Key informants were individuals with intimate knowledge of the project, and we asked each person about their experiences working with farmers or farmer organizations, training efforts, technical assistance efforts, marketing links, any successes, failures, problems/issues, ideas for improvements, “lessons learned”.

Farmer groups were either associated with the projects as a formal target group or were outsiders who could speak about their own local situation and discuss issues both related to the project as well as unrelated issues and outcomes. Farmer associations or informal groups who were considered beneficiaries may have received training or technical assistance, while other groups were local people involved in the horticultural value chain (i.e. traders or marketers) but not directly involved in any development project.

We asked about their involvements with and their reactions to the project activities– for example:

- What technologies did they learn about?
- Did they find the information useful?
- Did they get results? If so, were the outcomes sustained after the end of the project?
- Ideas for improvements?
- Any desires for future training or technical assistance?

The 12 development projects assessed during the project:

	Egypt		Indonesia		India			Ghana		Kenya		
Projects	AERI	ATUT	AMARTA	Cold Chain Project (ICCP)	DASP	ACE	GMED	CCARD	MiDA APC	KHDP	HCDA	Banana Program
Funding agency	USAID	USAID	USAID	USDA	World Bank	USAID	USAID	USDA	MCC	USAID	JICA	Rockefeller Fdn
Years of operation	2003-2007	1996-2002	2006-2009	2000-2004	1998-2004	1996-1998	2001-08	2000-04	2007-2012	2003-2008	2001-2005	2004 - 2008
Total Funds for Project	$66m	$55m	$15m	$11m	$120m	$30.9m	$6.3m		$547m	$10.3m	2,016m Yen	
Project Funds for Horticulture	EL SHAMS $18.5m	$40m			$4m	$5.7m	$6.3m		$241m	all	all	
Estimated %of Hort funds allocated for postharvest tasks	20%	10%			1%		10%					
Target Population	30,000	160,000		11,000	263,000		20,000		230,000	58,000		12,000 to date
Focus on Small farmers	xxx	x	x	x	xx	x	xx	x	x	xx	xxx	xxx
Focus on postharvest	xx	xx	x	xx	x	xx	x	xx	xxx	x	xxx	xx
Developed training and educational materials	xxx	xx	xx	xxx	x	x	x	x	x	xx	x	xx
Focus on Market linkages	xxx	xx	xx	xx	none	xx	xx	xx	xxx	xx	xxx	xxx
Followed up with new horticultural projects	no	Yes (AERI)	On-going (extended to 2010)	Yes (AMARTA)	Yes (DASP II)	no	Yes (Sunhara)	Yes (TIP, TIPCEE, HEII, EMQAP)	On-going	On-going (extended to 2010)	Yes (SHEP)	On-going, extended to 2010 (AGRA funding)

More than 300 persons were interviewed representing 12 horticultural development projects in five countries during March – September 2009. The following tables provide descriptive information and summary statistics related to the implementation of the past project assessments, including numbers of key informants and groups that were interviewed in each country.

	Egypt		India			Ghana		Indonesia		Kenya		
Dates of trip	March 31- April 9, 2009		April 4– 15, 2009			April 9 -18, 2009		April 28- May 9, 2009		Sept 4- 12, 2009		
Projects Assessed	AERI	ATUT	DASP	ACE	GMED	CCARD	MiDA APC	AMARTA	ICCP	KHDP	HCDA	Banana Program
Funding agency	USAID	USAID	World Bank	USAID	USAID	USDA	MCC	USAID	USDA	USAID	JICA	Rockefeller Fdn
Years of operation	2003-2007	1996-2002	1998-2004	1992-1998	2001-2008	2000-2004	2007- 2012	2006-2009	2000-2004	2003-2007	2001-2005	2004 -2008
A. # of key informant interviews	6	7	6	2	2	8	5	3	5	6	6	2
# of group interviews	3		2	1	3			7	6	1	2	
B. # involved in group interviews	22		65	4	14			64	24	9	21	
# of people interviewed (A+B)	28	7	71	6	16	8	5	67	29	15	27	2
# of others interviewed (alternative views, policy issues)	2 individuals		1 individual 1 group of 12			9 individuals		4 individuals		4 individuals 1 group of 15		
TOTAL persons interviewed per country	37 in Egypt (includes 4 females)		106 in India (includes 10 females)			24 in Ghana (includes 4 females)		99 in Indonesia (includes 7 females)		53 in Kenya (includes 16 females)		

Information from the interview process on identification of the many types of postharvest practices and technologies that were promoted during the 12 projects revealed many simple technologies still in use on the farm, at the packinghouse, in the markets and during processing. Of 44 specific postharvest technologies that were described as **short term** successes, 37 are still in use (84%), indicating their sustainability.

Postharvest technologies included: use of harvest indices, improved packages, shade, sorting/grading, field packing, cooling, use of packinghouses, improved storage structures, small scale food processing methods (solar drying).

Three of the completed projects (AERI, CCARD and HDCA), had very few measureable or sustainable **long term** impacts on postharvest handling, either due to the complete pull-out of technical support once the project ended or to a deliberate discontinuation of any follow-up efforts.

Which PHTs were successful and why?
When analyzing the adoption of specific postharvest technologies, we found that the simpler the postharvest technology, the better its chance for being still in use over the long term. If farmers can make more money by adopting a simple practice, then the use of a technology or technology package will be sustainable.

Small scale postharvest practices such as the use of maturity indices to identify proper harvest timing, improved containers to protect from damage during handling and transport, the use of shade, sorting/grading to enhance market value, and use of on-farm storage practices have been generally successful.

- Improved practices were adopted if they fit well into an existing value chain and marketing system (representing small steps of improvement rather than requiring huge changes).
- Encouraging famers to learn more about marketing and take more responsibility for their crops after harvest lead to reduced losses
- Sustainability of the adoption of a technological innovations depended mostly upon their profitability in the local setting
- Subsidies were provided for investing in some technologies (ex: plastic crates, zero-energy cool chambers, ventilated onion storage in India)
- Developing new or improved market links help sustain the use of any technical improvements
- Development of alternative value chains were sometimes appropriate – for example adding value by cooling, temporary storage or processing
- Empowering local institutions through capacity building (i.e.: training extension workers) helped generate continuing local action after the project ended and improved chances of sustainability
- Study tours, where farmers visited the city markets where their crops were sold, or international visits and exchanges for extension workers and young scientists, served to build local capacity and enhance aspirations.
- Forming industry or crop focused trade associations helped increase effectiveness and efficiency of innovation delivery systems (members have a place to come to learn and improve their postharvest handling and marketing practices)

Which PHTs were not adopted and why?
Large scale efforts to provide packinghouses or complex postharvest infrastructure were generally less successful, due to problems with selection of sites (poor location for growers), high cost for energy required for operations, and the lack of trained local personnel needed for successful management.

- Reported numbers of people reached were often very high, but the number of adopters of promoted interventions is generally much lower than the number that attend training programs
- Poverty reduction (access to quality food and incomes for improved livelihood) was largely not addressed, since projects targeted those who were already well along the development path
- Equity and gender issues were not given any strong focus in most projects – women's access to education and resources, and access of the poorest of the poor to information, credit and markets is still limited
- Unintended impacts included "the rich get richer" scenario, where people with access to assistance leaped ahead of those without access and began to try to take advantage of them
- Government did not provide adequate support or incentives (i.e.: providing the right kinds of incentives, improved access to credit, timely provision of required licenses or permits)

Lessons learned:
Six major lessons were learned from the 12 projects that were revisited by our WFLO/UC Davis postharvest teams.

1) **Focus on the Beneficiaries**
Many of our assessments pointed to the need to advocate agri-business skills, attitudes and aspirations.

- Treat farmers as agri-business people rather than just farmers.
- Aim to be not only more productive but more profitable.
- Ask smallholder farmers to consider issues beyond their farm plots – address the entire value chain, understand the needs of their buyers
- Deliver targeted training or agricultural extension services that help improve the quality of produce, postharvest handling and marketing linkages.
- Provide training in local languages, incorporate audio-visual training aids

Examples: DASP, GMED, AMARTA, Banana Program

2) Work through Groups whenever possible
Whether via informal groups, co-operatives or formal associations, it is vital to work with groups to impact policy and reach large numbers of people. It is very challenging work, but groups are the key to:

- Assessing local needs, facilitating targeted training, introducing new crops and technologies
- Strengthening marketing capacity and market linkages
- Managing contracts and sales beyond capacity of individuals.
- Building Privatization efforts (moving from project provided services to community provided services),
- Development of Financing opportunities (micro-credit, creative schemes)
- Designing appropriate, cost effective innovation delivery systems (providing people with the information and skills they need, when and where and in a way they can best understand and use it).
- Women's issues remain important -- access of women to credit, training and extension services remain lower than that of men.

Examples: AERI EL-SHAMS, HCDA, AMARTA, ICCP

3) Postharvest best practices should be incorporated early on in projects.
Identifying appropriate interventions is key, since barriers affecting adoption of postharvest interventions include complexity, availability and perceived costs versus benefits.

- Sorting, grading, packing, cooling, storage topics should be addressed via agricultural extension
- Best practices training should be supported by appropriate infrastructure development and technology improvements
- The case studies revealed that most of the postharvest activities implemented in the assessed projects were too few and too late.

Examples: ATUT, AERI EL-SHAMS, DASP, AMARTA, KHDP

Don't neglect the postharvest components of the value chain—we found too many examples of projects that identify high levels of postharvest losses and poor quality as major weakness when the goal is improving market linkages, but then spend the majority of project time and resources on improving production. Past projects in agricultural development have tended to focus on production and/or marketing, and when the evaluations are completed, admit that if more attention had been given to postharvest handling (sorting, grading, cleaning, packing, cooling, transport, cold storage or processing to more stable products that occurs between production and marketing) then losses would have been lower, market linkages would have been better maintained and profits for farmers and other chain participants would have been higher.

4) **Invest more wisely in postharvest infrastructure**
Training in postharvest horticulture increases readiness and willingness to make changes, but if postharvest infrastructure and marketing support is not there for participants, the results of training can be frustration. Similarly, providing infrastructure without training can be a disaster waiting to happen, since successful postharvest management requires complex knowledge and skills.

- Make investments earlier in the project (on the farms, at packinghouses, for transport or storage, in markets, and market information systems
- Develop the infrastructure to enhance their agri-business activities (consider location, access, costs, etc).
- Match the facilities (cost, size, scope) to local needs and management capabilities.
- Avoid over-building – large facilities are very difficult for smallholders to manage and can be too costly to be profitable
- Develop and enhance horticultural value chains by assisting buyers to meet and interact with farmers (market linkages)
- Deliver training to ensure that infrastructure is utilized, managed and maintained properly.

Examples: ATUT, AERI EL-SHAMS, AMARTA, HCDA

Even the few projects that have had a postharvest focus tried to promote changes in handling or processing practices, but did not link the "technical assistance" to adequate long-term comprehensive support. While potential users were convinced that using improved postharvest practices was a good idea because losses would be reduced, quality would be maintained and more fresh and processed foods would be available to sell and to eat, they had little or no access to the needed supplies, tools or equipment, power for cooling, credit to make investments or follow-up training to help resolve new problems or assist in troubleshooting when local issues arose. And typically when a project ended, all existing support was withdrawn, leaving packinghouses without power, and growers without buyers and marketers without technical assistance.

5) **Build local capacity (strengthen institutions, human resources, community services)**
Training should leave behind a cadre of local trainers and support service businesses to continue the work that is started by a development project. Capacity building includes:

- technical and educational program development
- training of master trainers
- network creation (helping members of the value chain meet and get to know each other)
- resource identification and strengthening of support services (local postharvest suppliers, repair services, engineers, credit)
- Building functional local capacity seems to have a strong relationship to sustainability
- Sending farmers on "study tours" to regional or capital markets helps them to better understand the value chain for their crops
- Designing appropriate innovation delivery systems depends upon first developing this local capacity.

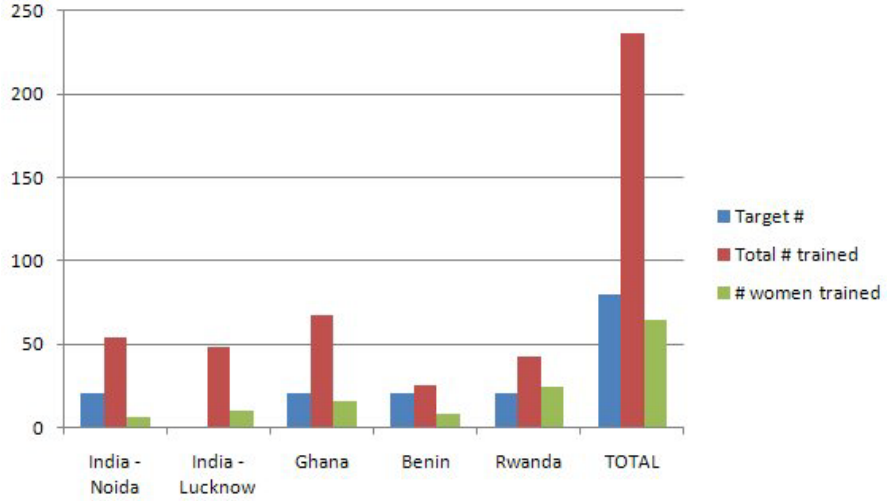
Examples: ATUT, AERI, ICCP, CCARD

6) **Projects should have a longer term focus** (rather than the traditional 2 to 5 years), to increase the likelihood of sustainable results.

- Project cycles cannot be too short (2 to 5 years does not provide enough time to build a solid base that will allow project to work successfully with low resource communities)
- Projects that follow on past projects (and follow up on any evaluation based recommendations) can achieve good results.
- Horticultural development project plans should be flexible enough to allow for adjustments during implementation
- ten years for a full scale project cycle is recommended

Examples: All 12 projects

Activity 2: Postharvest Training Workshops



Two-day long workshops were held in 5 locales during March - July 2009

Instructors were from WFLO, UC Davis and local research centers and universities, plus 4 unplanned volunteers from AVRDC (Christophe Kouame), Punjab Agricultural University (B S Ghuman and BVC Mahajan, India) and ACDI/VOCA (Deo Datt Singh).

Partner organizations:
India – Amity University
Ghana – CSIR, KNUST, Ghana Poly-Technical Institutes
Benin – IITA
Rwanda – ISAR, KIST, Umatara PolyTechnic

Target number of trainees (80) was exceeded by 280%.
Total number trained: 236
% women = 27%

Training topics:

- Postharvest loss assessment methods
- Quality assessment tools
- Postharvest tools for measuring losses
- Data collection protocols, sites, interviewing methods
- Commodity Systems Assessment
- Identification of research, training and advocacy needs

Commodity Systems Assessment methodology–
considers more than 20 steps related to the handling and marketing of horticultural crops
Production planning (based upon market info and consumer preferences)
Production
Food safety (GAPS)
Harvest
On farm storage
Transport from farm
Sorting
Grading
Cleaning
Pest management
Packing/packaging
Food safety
Cooling
Central cold storage
Transport
Agro-Processing (may or may not be part of the commodity system)
Food safety (HACCP)
Transport to market
Marketing (identifying alternative markets for alternative products allow the actors in the commodity system to make decisions regarding production, collection practices and processing methods that are intended to upgrade the component within the system and add value).
Consumption (market demand)

Each step of the commodity system may be under the control of different actors, who can be trained to improve their knowledge and skills, reduce waste and enhance quality, safety and market value, by paying close attention to handling practices, time and temperature management. The more of the steps within the commodity system a farmer or farmers association willingly takes charge of and responsibility for, the more potential value accrues to the horticultural crop producers.

Activity 3: Postharvest Loss and Commodity Systems Assessments in the Field

Crops assessed by the Postharvest Losses and Quality Assessment (PHLQA) process during the project

India	Ghana	Rwanda	Benin
Tomatoes Brinjal (eggplant) Cucurbits Okra Mangoes Litchi	Tomatoes Eggplant Peppers Okra Onions Cabbage Mangoes Pineapples Plantains	Tomatoes Leafy Greens Bananas Pineapples	Tomatoes Peppers Leafy Greens Onions Mangoes Pineapples Oranges

Sampling:
10 random samples of each crop were assessed at each of 3 sites: Farm (F), Wholesale Market (WS) and Retail Market (R)

Postharvest Tool Kits provided to assessment teams:

Refractometer (measures sugar and other soluble solids content)
Effigi Penetrometer pressure tester (measures firmness)
Sling Psychrometer (measures relative humidity)
Digital Scales
Digital temperature probe
Laser-guided Infrared temperature sensor
Color charts for key crops (used to assess maturity)
Sizing rings
Calipers
Quality rating scales and charts for key crops
Chlorine test strips
pH test strips
Water quality testing supplies

Postharvest losses based upon sorting (discarding of produce that is too damaged or decayed to sell)
1) Temperature: The temperatures during harvest, handling, transport and marketing were much higher than those that are recommended for the produce for quality maintenance.
The general lack of the use of shade contributes to high pulp temperatures and high water losses
Weight loss in Rwanda for leafy greens (amaranth in sacks) was measured to be an average of 11% over a time period ranging from 30 to 240 minutes after harvest.

2) Poor quality containers: packages were too big, too rough, too flimsy to provide protection and/or without adequate ventilation
Produce is marketed in sacks, baskets, boxes or cartons with the damaged produce hidden in the bottom and the most attractive produce displayed on the topmost layers (India, Ghana, Benin). When a basket or sack of leafy greens was sorted in the wholesale markets in Benin, the average level of mechanical damage was determined to be 89.5%.

3) Poor field sanitation: promotes the spread of fungal and bacterial diseases and insect pests. For example, pre-sorting losses due to pest damage were very high for okra in India (18.5%) and for leafy greens in Benin (17.3%).

4) Time: The time it takes to reach the retail market varies widely, but damage increases as the hours or days go by. In Benin, the average level of damage measured for produce being sold at the retail market was 76.5% for mangoes and 79% for leafy greens (amaranths and African eggplant leaves).


Student recording pulp temperature in wholesale market


Packed in Cloth bundle


Okra unloaded from gunny bag in wholesale market

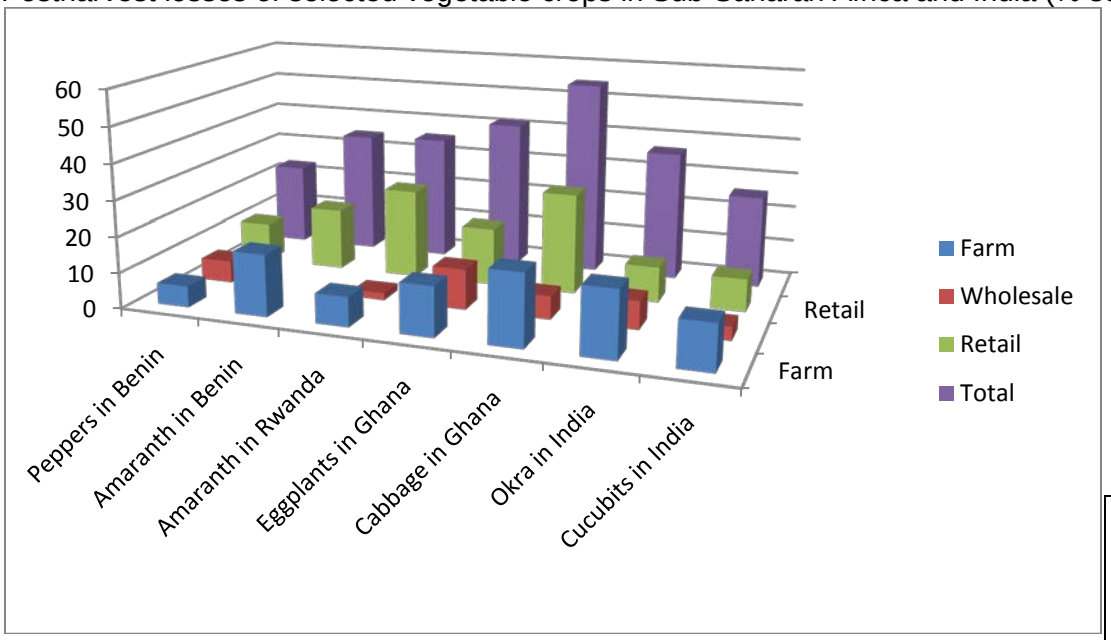

Leafy greens in bundles (Benin) undergo heavy damage during packing and transport


Enormous sacks of cabbage (Ghana)

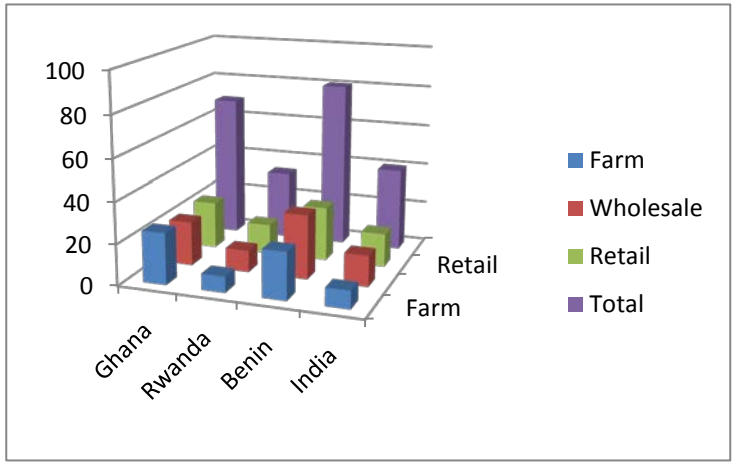
Postharvest losses of Fruits and Vegetables in 4 Countries: selected crops as measured on Farm (F), at Wholesale (WS) and Retail Markets (R)

Country	**Commodity**	**Method used**	**Physical Losses (% sorted out and discarded)**	**Quality Losses (% mechanical damage)**	**Quality Losses (% decay)**	**Economic Losses** (% decline in retail market value/kg)	**Local data collection team**
Ghana	Tomatoes	Sampling	25.1 (F), 21.5 (WS), 23 (R)	33.5(F),21.5(WS),10.5(R)	17 (F), 14 (WS),11.5 (R)		KNUST, CSIR-CRI & Tamale Poly Tech
Ghana	Cabbage	Sampling	20.1 (F), 6.5 (WS), 28.1(R)	54 (F), 32 (WS), 45 (R)	13 (F), 8 (WS), 5 (R)		KNUST
Ghana	Eggplant	Sampling	13.9 (F),11.3(WS),16.2 (R)	22 (F), 19 (WS), 9.5 (R)	2.8 (F), 2 (WS), 0 (R)		CSIR-CRI
Ghana	Mangoes	Sampling	6 (F), 10.4 (WS)	2.3 (F), 5 (WS), 8 (R)	2.5 (F), 0.4 (WS), 1 (R)		Tamale Poly Tech
Ghana	Okra	Sampling	16.6 (F), 2.3 (WS), 6.3 (R)	28 (F), 4.5 (WS), 15 (R)	6 (F), 0 (WS), 8.5 (R)		Tamale Poly Tech
Benin	Tomatoes	Sampling	23 (F), 31.2 (WS), 26.4 (R)	29 (F), 27.5(WS), 31.2(R)	24 (F),21.2(WS),27.5(R)		IITA
Benin	Peppers	Sampling	5.9 (F), 6.2 (WS), 11 (R)	15 (F), 7 (WS), 10 (R)	24 (F), 18 (WS), 8 (R)		IITA
Benin	Amaranths	Sampling	17.3 (F), 17.3 (R)	34.5 (F), 89.5(WS), 79(R)	47 (F)	30%	IITA
Benin	Oranges	Sampling	10 (F), 11.6 (WS), 10.9 (R)	15 (F), 41 (WS), 51 (R)	5 (F), 16.4 (WS), 33 (R)		IITA
Rwanda	Tomatoes	Sampling	7.8 (F),10.7 (WS), 14.7(R)	2 (F), 11 (WS), 12.5 (R)	6 (F), 7 (WS), 6.5 (R)		ISAR/KIST
Rwanda	Amaranths	Sampling	8.3 (F), 2 (WS), 25 (R)	18.5 (F),15 (WS), 32.5(R)	7.5(F),12.5(WS),13.5(R)		ISAR/KIST
Rwanda	Bananas	Sampling	14.8 (F),35.1(WS),30.1 (R)	7.5 (F), 19 (WS), 25 (R)	0 (F), 9.5 (WS), 0 (R)		ISAR/KIST
Rwanda	Pineapples	Sampling	10.4 (F), 17 (WS), 15.9 (R)	11.8 (F), 20 (WS), 21 (R)	0 (F), 2.9 (WS), 2 (R)	30%	ISAR/KIST
India	Tomatoes	Sampling	8.7 (F), 15.1 (WS), 16.4(R)	10.5 (F), 7.5 (WS),16 (R)	5 (F), 7 (WS), 8.5 (R)	1%	Amity University
India	Cucurbits	Sampling	12.7 (F), 3.8 (WS), 9.2 (R)	9 (F), 6 (WS), 5 (R)	4.5 (F), 7(WS), 5 (R)	52%	Amity University
India	Okra	Sampling	18.5 (F), 7.9 (WS), 10 (R)	8.8 (F), 3.8 (WS), 6 (R)	2.6 (F), 2 (WS), 8.8 (R)	31%	Amity University
India	Mangoes	Sampling	6.5 (F), 7.9 (WS), 7.1 (R)	6.5 (F), 6 (WS), 9.5 (R)	5 (F), 7 (WS), 7.5 (R)	20%	Amity University
India	Litchis	Sampling	9.8 (F), 11.4 (WS), 10.1(R)	14 (F), 6 (WS), 10 (R)	8.5 (F), 8 (WS), 8.7 (R)	18%	Amity University

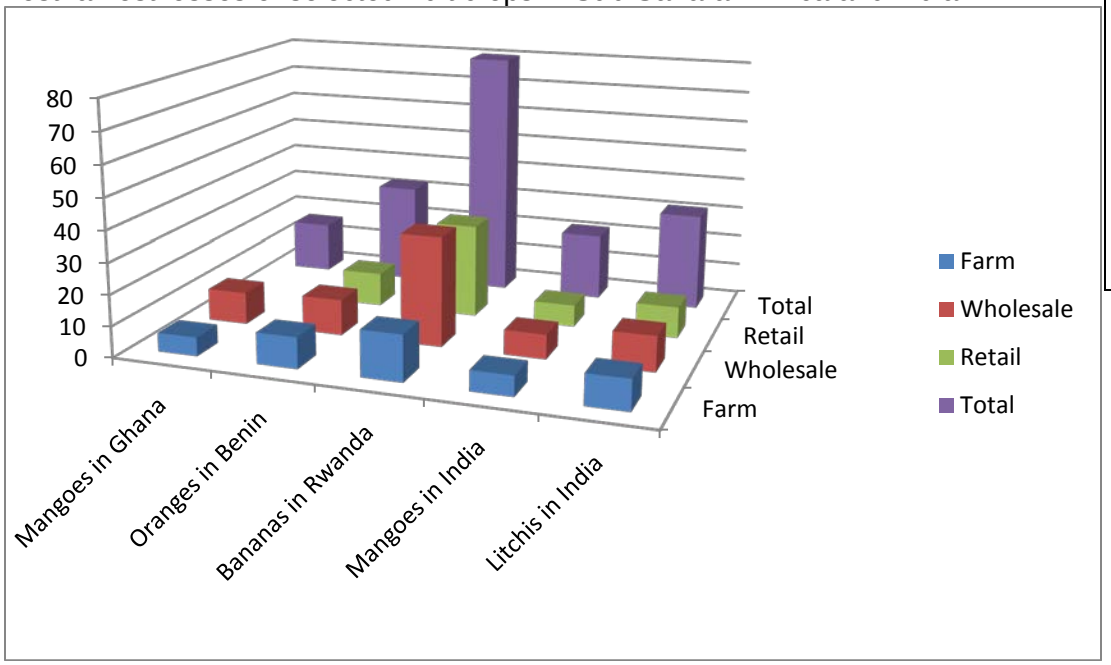
Postharvest losses of selected vegetable crops in Sub-Saharan Africa and India (% sorted out and discarded before sale)



Postharvest losses of Tomatoes in 4 countries



Postharvest losses of selected fruit crops in Sub-Saharan Africa and India



The totals provided are averages of the % sorted out and discarded before sale, and are meant to be illustrative. The totals are useful for comparison purposes, but actual totals will vary since individual lots were not followed from farm to market, and while losses are cumulative over time, percentages must be adjusted as the total volume declines from site to site for specific lots over several days.

Crops assessed by the **Commodity Systems Assessment** (CSA) process during the project

India	Ghana	Rwanda	Benin
Tomatoes Brinjal (eggplant) Sponge gourd Bottle gourd Okra Potatoes Peas Cauliflower Cabbage Onions Mangoes Litchi Bananas Guava	Tomatoes Eggplant Onions Cabbage Mangoes Pineapples	Tomatoes Leafy Greens Bananas Pineapples	Tomatoes Peppers Leafy Greens Mangoes Pineapples Oranges

Identification of Research Needs, Training/Extension Needs and Advocacy Issues

Only one example is provided (for tomatoes in Benin). Our final report contains the full lists of Research Needs, Training/Extension Needs and Advocacy Issues identified during each of the 30 crop assessments.

Commodity Systems Assessment Results

As a group our international teams collected data, analyzed and wrote 30 complete CSA reports on individual crops.

Overall CSA findings can be summarized as follows:

- Production practices are in use that increase quality problems and subsequent losses during marketing
- Postharvest losses (physical damage, decay, market value losses) for horticultural crops are still very high
- Food safety issues abound (especially water quality issues and concerns regarding pesticide residues)
- Postharvest handling is rough, causing bruising, abrasions and cuts
- Packages are generally of poor quality, providing little or no protection
- Packages can be very large, leading to even higher losses when they are dropped or stacked
- Temperature management is very poor—shade and cooling practices are not commonly used
- Processing methods are underutilized due to lack of information and equipment
- Needed postharvest infrastructure is lacking, or if available, is underutilized
- People in SSA and S Asia are clamoring for **information** on improved small scale postharvest practices that they can use on the farm and in the villages to reduce losses
- Small scale farmers lack **access** to training, tools, infrastructure related to use of simple postharvest technologies (shade, ZECCs, plastic crates, solar drying, food processing, etc) that can be used on the farm, in the village or in local markets.

Tomatoes in Benin	Research Needs	Extension or Training Needs	Advocacy Issues
Production	• Research on improve seed quality germination • Irrigation: research how to change from spray and sprinkle to avoid flower drop • Identify ways to reduce cost of production • Find solutions for bacteria galls, caterpillars and fungi • Research topics discussed with farmers in participatory approach including tomato diseases, insects • Identify the main tomato pests • Compare, identify and adapt the best pest control methods	• Establish farmers groups for seed production • Demonstrate benefits of good planning of fertilization, weeding pesticide application and irrigation • Train famers on cost of production • Train labor and in nurseries • Train on best methods for seed storage • Train famers on good use of pesticides	• Encourage production of good local seeds • Control quality of locally produced seed • Need more seed outlets • Quality control on the final product • Statistics on tomato production • Facilitate access to good quality seeds • Advocate securing land for tomato production at the urban fields level. • Advocate to facilitate support services to farmers
Postharvest	• Research for adequate transportation other than motorbikes and taxis • Improve packaging for processed tomato. • Trials and identification of the best containers for harvest. • Adapt tomato drying equipment	• Train famers on time of harvest and maturity indices, stage of harvest • Train intermediaries on PH handling and treatment • Train on storage space, temperature and duration • Reduce delays in handling • Need trained labor for tomato processing. • Train famers on best techniques for tomato harvest and transport • Train processors on the best practices for drying tomatoes	• Need for wholesale market for tomatoes to start a regular tomato processing activity. • Roads inadequate for transportation of the fresh commodity
Marketing	• Research consumer demand concerning processed tomato: market trends research.	• Awareness in rules and regulations on tomato processing and export.	• Open air (wholesale and retail market need to be cleaned as fresh produce are left on the ground during the night. • Advocate to reduce police annoyances • Promote grouping of farmers and facilitate linkages with buyers. • Marketing campaign for locally produced tomato
Over-arching issues			• Solve the illiteracy problems for the information to flow • Incentives for quality improvement would hasten the process. • Need coordination and reactivation of public institutions to improve the sector • Reduce taxes (48%) on certified seeds and biological pesticides • Implement a price policy • Facilitate access to credit

Activity 4: Field trials of potential postharvest technologies
Adaptive studies take a potentially useful technology and modify it if necessary to address the major constraints and better fit the varying technical, socio-economic and policy environments that were found in the target areas.

Field trials on 19 individual postharvest technologies were conducted during September - December 2009. Each of the technologies identified as a solid potential intervention was tested for one or more specific countries, in several versions if possible (low cost, moderate cost, higher cost) and the costs and benefits under local conditions for each version were determined.

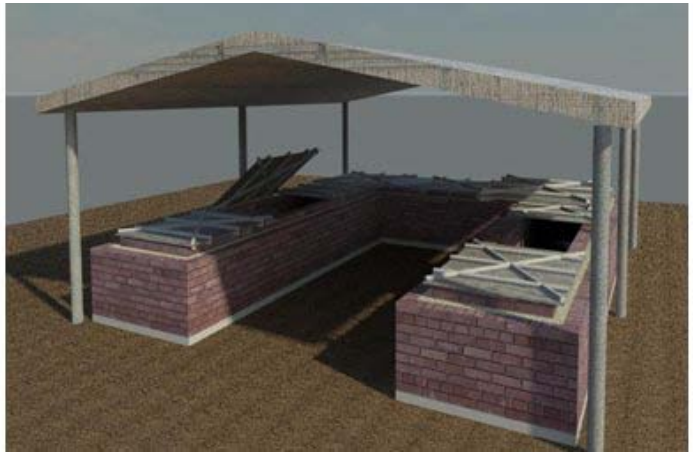
The postharvest technologies we were able to investigate in full detail were field tested in a variety of settings using locally available materials.

- Improved containers (3 technologies: plastic crates, crate liners and smaller packages)
- Field packing (2 technologies: sorting, grading and packing in the field, use of cling film wraps)
- Use of shade (2 technologies: PolyNet shade structure, inexpensive cloth)
- Zero energy cool chambers or ZECCs (2 technologies: large 1MT walk-along unit, smaller 100kg to 200kg sizes)
- CoolBot unit as part of a small-scale cold room
- Improved canning/bottling methods (2 technologies: assorted tomato products, pickled vegetables)

A few of the technologies on our initial list were given lower priority due to being:

- Too small (clay refrigerator)
- Too complex (hot water treatments for pest management, CoolBot unit on an insulated transport cool box; Peltier refrigeration systems, sanitation practices in the field and packinghouse)
- Too expensive (insect proof packages for dried products -- plastic bags with repellent wax coating, use of CO2 flush or dry ice)
- Already too well known (curing of root and tuber crops, ventilated onion storage structures, improved direct and indirect solar drying)

Our core team of scientists at WFLO and UC Davis, and field workers from our partner organizations in SSA and South Asia were joined in these efforts by representatives of **Nepal** (Mahendra Thapa of NARC/NARI), **Sri Lanka** (Arthur Bamunuarachchi of Sri Jayewardenepura University), **Cape Verde** (Lizanne Wheeler and Patrick Brown of Agland Investments, who are working on an MCC Agricultural support project) and **Tanzania** (Bertha Mjawa, a scientific officer with the Ministry of Agriculture and Food Security). We thank them all for their extraordinary voluntary efforts to assist us during this postharvest technology planning project.


Walk-along ZECC: 1MT size for cool storage of vegetables, cost of construction = US$1200

Appropriate Postharvest Technology- Summary of Options and Strategies

Problem Identified	Potential Solutions	Examples of APT field trials
Produce loses value due to weight loss or wilting	Protect produce from the sun, keep it cooler during handling and marketing	Provide shade
Produce loses value due to mechanical damage during the marketing period	Protect produce from damage by using better quality packages and containers	Plastic crates Liners for existing containers Smaller containers
Produce has low market value due to poor appearance, decay or damage during handling	Add value by using proper harvesting, sorting, grading and packing practices	Field packing of tomatoes Cling film for cauliflower
Produce has low market value due to poor appearance, decay or damage during handling	Field cure root, tuber and bulb crops before they leave the farm to better prepare them for storage	Curing onions before packing and use of ventilated storage
Produce loses value due to exposure to high temperature if it cannot be sold right away	Short term storage in inexpensive cool chambers powered by evaporative cooling	Zero energy cool chamber (ZECC) for vegetables in India and Ghana
Market value vary widely between the time of harvest and the time of local shortage	Store produce for a month to several months in low cost self-built cold room	CoolBot equipped cold room on farm for onions in Ghana
Market value of the crop plunges during peak harvest period	Transform produce to a more stable product that can be stored for months, then consumed or sold when market prices recover	Solar drying of vegetables and fruits Canning and bottling of processed tomato products Pickling of vegetables

Costs and Expected Benefits

Overall, of the 21 C/B analyses we performed on six different categories of postharvest technologies, all 21 were found to be profitable for small farmers, and 17 technology/crop combinations (81%) were found to provide an increase in income of 33% or more. Assuming a baseline income of $600 per year or less than $2 per day, potential profits were more than $200 per year. The technologies were each assumed to be under-utilized in order to make sure our C/B calculations did not depend upon optimum usage.

In some cases we may be too conservative in our assumptions, since we have been told that not only would the field tested technologies be fully utilized by the farmers (i.e.: those using plastic crates, shade, ZECCs and improved canning methods), but that they planned to construct more units and/or buy more equipment and supplies on their own as soon as they saved sufficient funds from their improved profits. In India, now that they have seen the results of the field trials undertaken by Amity University in UP, they are not waiting for us to return and offer more assistance, but are ready to proceed on their own.

The 4 technologies that did not meet our criteria are the small scale food processing (solar drying and various types of canning/bottling methods and recipes). While profitable, they did not provide adequate returns, mainly due to the low quantities of produce that were processed by the women during the field trials.

Sample C/B Worksheet

Costs and Benefits of ZECC walk-along cool storage in India
Assumptions: Each harvest = **1000 kg of mixed vegetables** during the hot season
Consider only those variables that are different when comparing handling practices or technologi

	Current Practice	New Practice
Describe postharvest technology and practices:	Vegetables must be sold on the day of harvest regardless of farm gate price or market price	Vegetables can be stored in the ZECC for a week to 10 days if needed before sale
COSTS		
Zero energy cool chamber walk-along model (1MT size ZECC)		$1000
Containers (20 sacks)	$10	
Reusable Plastic crates (50)		$ 250
Relative cost	$10	$1250*
EXPECTED BENEFITS		
% losses	30%	10%
Amount for sale	700 kg	900 kg
Value/kg	$1.00	$1.20
Total market value of one load	$700	$1080
Market value – recurring costs	$700 - $10 = $690	$1080
Relative profit		+ $390
Time required to repay the investment		$1250 / $390 = 3.2 The investment pays for itself in about one month (3.2 uses) if used at full capacity.
Return on Investment (ROI)		Each subsequent 1MT load provides a $390 premium compared to the traditional practice.

Eight Recommended Interventions

Appropriate Postharvest Technology #1: Improved containers
The containers typically in use for handling horticultural crops in Africa and South Asia are baskets, sacks and wooden crates. All of these are a source of damage due to the roughness of the materials, are often over-filled and when stacked provide little or no protection to the produce.
Improved containers include:

- High quality plastic crates, with proper venting, which are stackable, nest-able, easy to clean and reusable
- Fiberboard liners for locally made containers or plastic crates
- Smaller sized packages

Appropriate Postharvest Technology #2: Use of Shade from farm to market
Shade can greatly reduce the temperature of any fresh produce that is being handled outdoors.
Shade can be provided by:

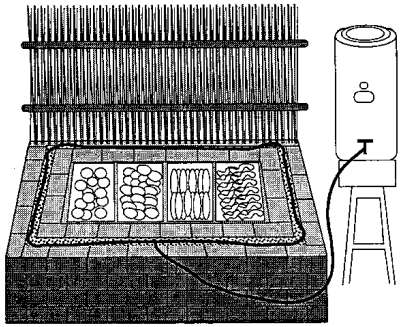
- Net, cloth or thatch structures
- Market umbrellas

Appropriate Postharvest Technology #3: Field packing systems
Field packing can often eliminate the need for a packinghouse, and can greatly improve the speed of postharvest handling, while reducing costs and waste. Field packing can include grading, trimming or wrapping before packing.
Field packing can be done:

- In the row during harvesting
- Under shade at the side of the field

Appropriate Postharvest Technology #4: Curing root and tuber crops
Curing root and tuber crops such as sweet potatoes, potatoes, cassava and yams is an important practice if these crops are to be stored for any length of time. Field curing takes time (5 to 7 days) but costs little or nothing.

Appropriate Postharvest Technology #5: Low energy cool storage methods
Refrigerated storage structures are relatively expensive to build and operate, and most small famers do not have access to these facilities. The low cost evaporative cooling chamber known as the "Zero energy cool chamber" or ZECC illustrated below is constructed from locally made clay bricks and sand in India.



100 kg size ZECC (India)

Plastic crate (India)

Market umbrella (Ghana)

PolyNet shade structure (India)

Field packing station (Rwanda)

Appropriate Postharvest Technology #6: Cold room with CoolBot unit

Recently a US company has developed an easily installed controller that prevents ice build-up but does not require modifying the control system of an inexpensive window style air conditioner (Cool-bot, Store It Cold, LLC, http://storeitcold.com). Assuming US pricing the room air conditioner and Cool-bot control system costs about 90% less than the commercial refrigeration system. The control system is designed so that any moisture condensed on the refrigeration coils is returned to the cold room air and the system will therefore cause less product moisture loss than the commercial refrigeration system.

Storage will be financially feasible if the cost of storage is less than the increased value of the stored crops when sold during the off-season. In Tamale, Ghana, the market prices are reported to increase enough for onions, and in India, market prices increase for potatoes during 3 to 4 months of storage, to make this technology cost effective.

Appropriate Postharvest Technology #7: Improved solar drying

Direct solar drying can result in quality problems and damage when produce overheats, gets wet or is contaminated by insects or other common pests. Simple improvements such as raising the produce up off the ground and putting trays or mats on a platform, and using thin cloth to cover the trays or mats will have positive results at low cost. In Benin the field trial was performed using a simple raised platform.

Raised trays and cloth cover for solar drying (Ghana)

Improved indirect solar dryer (Kenya)

Appropriate Postharvest Technology #8: Improved canning, bottling and pickling methods

There are many local and regional recipes and village level practices used for food processing in Sub-Saharan Africa and South Asia, but information on costs, nutritional value and food safety are often lacking.

Local recipes that include ingredients such as preservatives or that do not include an obvious heat processing step (such as boiling) are of extra concern since the women doing the processing typically estimate their measurements and temperatures, which can create food safety hazards. Hands-on, practical training is a critically important part of any intervention.

Training on Food Processing (India)

Key factors regarding promotion of selected postharvest interventions

Postharvest Technology	Crops that would benefit	Potential to scale up to many farmers?	How many might benefit?	Beneficial for women?	C/B analysis available?	Simple enough to repair; use by the next generation?	Key constraints?
Improved Containers: Plastic crates	All hort crops	yes	unlimited	yes	yes	yes	Need to develop systems for ownership, return, cleaning
Liners for existing crates	All	yes	unlimited	yes	yes	yes	Need designs to match local needs
Smaller packages	All	yes	unlimited	yes	yes	yes	Designs to match local needs
Field packing	Many F & V	yes	unlimited	yes	yes	yes	Training
Use of Shade	All	yes	unlimited	yes	yes	yes	Weather (wind)
Improved Curing	onions, garlic	yes	unlimited	yes	yes	yes	Training
Low energy cool storage: Brick/sand structures	All but onions, garlic	yes	unlimited	yes	yes	yes	Relatively high cost, needs financing, doesn't work well in humid or rainy weather
Small scale cold rooms with CoolBot	All	yes	unlimited	*	yes	requires repair services	Relatively high cost, needs financing, requires electricity, back-up generator
Improved Solar drying	Many F & V	yes	unlimited	yes	yes	yes	Training
Improved packaging for dried products	All	yes	unlimited	yes	yes	yes	Training
Improved canning, bottling or pickling practices	All	yes	unlimited	yes	yes	yes	Training
Notes	Grains and legumes also benefit from shade, improved packages	Easy to try on small scale before investing in larger or more units of the technology	Estimates of hort farmers in SS Africa & South Asia = 10% of all farmers	*Women's groups may be able to get financing for low cost PH investments	ROIs are positive, Pay back periods are quite short, can be weeks or months	Designs have few moving parts, are designed to be constructed locally	All these technologies would require support by local training activities for farmers, women's groups, small scale processors

Looking forward
For promoting adoption of any of these postharvest technologies, each technology would require the development of a local business plan. We recommend that business development efforts must be supported by:

- technical design specifications that can be reproduced locally, listing locally available supplies and estimated costs
- training materials for local extension people to use in order to demonstrate the tools and techniques to farmers and marketers, and especially targeting women farmers
- training materials providing information on key principles, practices and costs/benefits
- ideas for incentives for participation in training programs, including financial (i.e. better compensation for more skilled labor) and non-financial rewards and incentives for women (i.e. books for their children, clothing or festivals with food provided)
- sample business plans and loan/financing guidance
- online mentoring for participants via the internet
- postharvest resource guide of tool sources and supplies for individual countries in Sub-Saharan Africa and South Asia

Training programs should be established to promote these key tools and techniques and to train the trainers. A "best practices" training package targeting key postharvest technologies should be developed and implemented, and may include:

- workshops in different regions of Africa and South Asia for the people responsible for training local clientele in improved postharvest handling techniques (Training the Master Trainers)
- market visits for farmers to see where their fresh produce is being sold (study tours to regional or capital wholesale and retail markets)
- study tours in the USA or appropriate regional sites for selected African extension workers and postharvest training professionals
- workshops in different regions of Africa and South Asia for growers, handlers and marketers

Planning workshop (10-12 November 2009): Proposals for Future Large Scale Postharvest Horticultural Development Projects
Our November planning workshop generated many new ideas for outreach efforts and numerous discussions on planning new projects and dealing with the risks and opportunities. For three days during November 2009, forty of the many people who have been involved in this planning project gathered at UC Davis to review the results to date and spend a few days brainstorming and preparing concept notes and coming to consensus on key objectives for future postharvest development efforts in Sub-Saharan Africa and South Asia. The meeting generated a host of new ideas, a set of ambitious strategies and a successful meeting of the minds among many willing and ready future development partners.

Potential Future Partners for full scale postharvest horticulture projects (proposal drafts to be developed during March – June 2010)

Global	USA	Sub-Saharan Africa	South Asia
DAI Development Associates Int'l Don Humpal, Sacramento, CA HORT-CRSP UC Davis, USA Beth Mitcham AVRDC (WorldVeg) Headquarters Taiwan Jun Acedo WFLO World Food Logistics Organization Symantha Holben Global Horticulture Initiative – Kenya (linked with AVRDC-WorldVeg Center) Fintrac Bob Rabatsky	Agricultural Education Initiative (Cornell Univ) Univ of Florida Univ of Hawaii North Carolina State Univ	IITA - Benin West Africa AVRDC- West Africa Offices (Mali and Cameroon) WARDA c/o ICRISAT, BP 320, Bamako, Mali Liaison Office Cameroon BP 2008 Messa, Yaounde Cameroon Ghana PolyTechnical Institutes (Tamale, Wa Bolgatanga and Ho) Rwanda KIST ISAR Umatara PolyTechnic Tanzania Nat'l Research Institute at Mbeya: Esther Meela Ministry of Ag and Food Security: Bertha Mjawa, postharvest specialist Cameroon RCESDO – Resource Centre for Environment and Sustainable Development Organization Chief Primus F. Nkemnyi, Julius Nkeze, Francis Mbunya Women Development Association (MWDA) Mrs. Evelyne E. Nojang Zambia ZEGA, Luke Mbewe – links with East African Regional Trade Hub	India Amity University Nepal Agricultural Research Institute NARI / NARC Bangladesh M.M. Molla, BARI (research center now doing PH work) Pakistan Farzana Panhwar, Sindh Rural Women´s Up-lift Group in Hyderabad, Sindh Sri Lanka Arthur Bamunuarachchi, Sri Jayewardenepura University India- Maharashtra State Hort Technology Center (HTC) in Pune A.S. Gaikwad, Lead Trainer India –Punjab State Punjab Horticultural Postharvest Technology Center at PAU B.S. Ghuman, Director BVC Mahajan, postharvest specialist

Building on Lessons Learned
Future projects should incorporate the major lessons learned from the 12 projects that were revisited by our WFLO/UC Davis postharvest teams, and the results of our 30 commodity systems assessments, 24 postharvest losses and quality assessments and 19 field trials and 21 cost/benefit analyses.

General Recommendations for future projects

- Utilize Extension/outreach strategies to build local capacity
    - Demonstrations of appropriate postharvest technologies in markets and villages
    - Improved access to postharvest tools, equipment, packages, supplies
    - Commodity systems assessment to build local knowledge of the value chains
    - Integrated postharvest management systems for reducing losses (quantity, quality and market value)
    - Cost/benefit assessment using local costs, prices, expected benefits
    - Business management skill development for improving profits
    - Train the trainers programs for creating a cadre of local postharvest specialists

1) **Focus on the Beneficiaries**
Many of our assessments pointed to the need to advocate agri-business skills, attitudes and aspirations.

- Treat farmers as agri-business people rather than just as farmers. Rural youth are especially interested in developing business and entrepreneurial skills.
- Ask smallholder farmers to consider issues beyond their farm plots – address the entire value chain, take more responsibilities in return for additional opportunities for profit making
- Deliver targeted training or agricultural extension services that help improve the quality of produce, postharvest handling and marketing linkages.
- Provide training in local languages, incorporate audio-visual training aids
- Aim to be not only more productive but more profitable.

Many of the most successful past projects assisted farmers to become active marketers, rather than passively waiting for a trader to arrive at their farm gate and offer a price. When farmers were willing to take on more responsibility for their crops and become direct marketers, by learning how to grade, pack, handle and sell their produce directly to the retailer, they also gained more of the financial rewards.

2) Work through Groups
Whether via informal groups, co-operatives or formal associations, it is vital to work with groups to impact policy and reach large numbers of people. Groups are the key to:

- Assessing local needs, facilitating targeted training, introducing new crops and technologies
- Improving communication in order to strengthen marketing capacity and market linkages
- Managing contracts and sales beyond capacity of individuals.
- Gathering and incorporating farmer feedback to assist in measuring the effectiveness of interventions
- Building privatization efforts (moving from project provided services to community provided services)
- Development of financing opportunities (micro-credit, creative schemes)
- Designing appropriate, cost effective innovation delivery systems (providing people with the information and skills they need, when and where and in a way they can best understand and use it).

The CSA process we used to gather information on commodity systems during this planning project can be inexpensively and effectively applied to reassess the progress of farmer groups as they try out and adopt or reject new postharvest technologies.

Recent grants from the Bill & Melinda Gates Foundation for micro-finance ($38m) will allow 18 institutions to expand their portfolios, and reach more smallholder farmers.

3) **Women's issues remain important**
Access of women to credit, training and extension services remain lower than that of men. Ideas for improvements include:

- Increasing the number and percentage of women hired and trained as extension workers
- Holding training programs and extension meetings close to the homes of women so they can attend more easily
- Holding meetings/trainings in the afternoon since women have a lot of household and farm work to take care of in the mornings
- Offering trainings via video, posters, discussions, role playing, etc (to increase accessibility and relevance for those who are non-literate).

Many of these issues were recently highlighted by a report from the World Food Programme (2009).

4) Postharvest best practices should be incorporated early on in projects.
Identifying appropriate interventions is the first step key, since barriers affecting adoption of postharvest interventions include complexity, availability and perceived costs versus benefits. Having a year round supply of vegetables could improve the nutritional status of rural families, and especially for young children and their mothers.

The World Bank estimates that 20–25% of the global disease burden for children is due to under-nutrition (World Bank, 1993). Postharvest technology is an important part of achieving food security. According to the UN, Food security is typically subdivided into three components: (i) availability, or the existence of an adequate and stable supply of food; (ii) access, or the ability to obtain (physically or economically) appropriate and nutritious food; and (iii) utilization, or the ability to consume and benefit from nutritious foods (UN, 1996).

Postharvest best practices include:

- Clean and efficient sorting, grading, packing, cooling, storage
- These topics should be addressed via agricultural extension and related to infrastructure development and technology improvements
- Past project assessments revealed that most of the postharvest activities implemented in the assessed projects were too few and too late.

Work is on-going by our economic team members to develop an "expert system" for decision making regarding when to use which postharvest technology for what crops. Key decision making inputs include how the technology can affect postharvest losses, shelf life and market value for a specific crop, and what the technology will cost in a specific location.

5) **Invest wisely in postharvest infrastructure**

- Make investments early in the project (on the farms, at packinghouses, for transport or storage, as well as in the markets).
- Develop the infrastructure to enhance their agri-business (consider location, access, costs, etc).
- Match the facilities (cost, size, scope) to local needs and management capabilities.
- Develop and enhance horticultural value chains by improving communication
- Deliver training to ensure that infrastructure is utilized and maintained properly.
- Build in sustainability by using rational business models for providing businesses services (fee for service)

Training in postharvest horticulture increases readiness and willingness to make changes, but if postharvest infrastructure and marketing support is not there for participants, the results of training can be frustration. Similarly, providing infrastructure without training can be a disaster waiting to happen— successful postharvest management requires complex knowledge and skills.

Improving communication regarding pertinent information (i.e. expected weather changes, availability and prices of postharvest supplies, consumer demands, changes in the needs of traders and market prices) will require outreach efforts via accessible methods such as local radio, inexpensive mobile phones, internet kiosks or via visual means (for example daily updated whiteboards posting market prices).

6) **Build local capacity (strengthen institutions, human resources, community services)**
Training should leave behind a cadre of local trainers and support service businesses to continue the work that is started by a development project. Capacity building includes:

- Postharvest technical and educational program development, especially targeting women and rural youths
- combining lab research with adaptive on-farm or market based fieldwork
- training of master trainers
- network creation (helping members of the value chain meet and get to know each other)
- resource identification and strengthening of support services (local postharvest suppliers, repair services, engineers, credit)
- Building functional local capacity seems to have a strong relationship to sustainability
- Designing appropriate innovation delivery systems depends upon first developing this local capacity.

We recommend that future projects include Commodity Systems Assessment (CSA) as a methodology for training extension workers— the CSA process requires them to work as a team, learn by doing, study all the details on the local commodity system, meet key players, decision makers, producers, postharvest handlers, processors, marketers, and understand the value chain from field to fork. The original CSAM manual is available online from the UN FAO inPHo website (LaGra, 1990).

Several of our consultants recommended that future projects include the methodology for mapping and influencing dynamic agrifood markets (includes Value Chain Mapping) as one of the first steps of any new development project. The manual is available online from www.regoverningmarkets.org (Vermeulen et al, 2008).

Hall and Devereau (2000), when studying low cost storage for sweet potatoes in Uganda, found that a combination of lab research centered at modern institutions and a adaptive research fieldwork based approach could be used to improve results and speed the technology validation process.

7) **Projects should have a longer term focus**

- A longer project cycle (7 to 10 years) would increase the likelihood of sustainable results.
- Projects that follow up on evaluation based recommendations (such as those provided in this report) can achieve good results.
- Horticultural development project plans should be flexible enough to allow for adjustments during implementation

8) **Promote an Integrated Postharvest Management System**
Our final recommendation is to promote an integrated postharvest management system beginning with "training of master postharvest trainers".

One of the unplanned side effects of this planning project has been to raise the expectation of potential target groups, since once they learned a little bit about how postharvest technology can help improve their livelihoods they actively have been seeking more information and requesting future training. Direct requests have already been made for:

- Training in the establishment of cool chain management for horticultural crops (Rwanda, India).
- Installation of cool chambers and training of farmers (Rwanda, Ghana).
- Training on simple village level food processing methods (India, Nepal, Benin)
- Training of postharvest trainers (Nigeria, Ghana, Senegal, Cameroon, Kenya, Zimbabwe, India, Rwanda, Sri Lanka, Bangladesh)

The following steps would be required:

- Training of master trainers in each target country – includes training in technical knowledge in horticulture, appropriate postharvest technology, business development skills, cost/benefit analyses, improved teaching/training practices. Master trainers serve to leverage any future training efforts by having a multiplier effect.
- Smallholder farmers could then be locally trained to begin with improving quality on the farm (using maturity indices, gentle handling, pre-sorting, protective packages, and shade)
- Farmers could be encouraged to learn about direct marketing and the many new responsibilities it entails
- Postharvest tools and supplies should be made available for sale at rural postharvest shops (make it easier for farmers to try any new technology)
- Smallholder farmers could be trained to develop decision making skills for utilizing when appropriate, some form of cooling, storage or processing in order to further enhance the market value of their horticultural crops.
- Micro-credit or rent-to own models should be integrated into any outreach efforts.

Initially, the focus of any new development project should be to provide basic information and demonstrations of these simple practices that can reduce postharvest losses. The longer term goal should be to promote the use of cooling and cool or cold storage and transport practices that can protect the investment of the farmers and can further reduce losses. Globally, investments in the cold chain often have been shown to repay themselves in a short period of time —hence the existence of an enormous number of companies around the world that offer services in cooling, cold storage and transport for a fee that is willingly paid by the owner of the produce— and this reduction in waste theoretically allows for three positive outcomes. The grower can receive more for their crops, while the middlemen or marketers lose less during handling and transport, and the consumer gets a better quality product at the same or lower price. By making an investment in appropriate scale postharvest technologies we can therefore achieve a win/win/win situation, where everyone involved in the value chain will benefit. Improved postharvest handling and the use of a cool chain simply protects the food supply as it moves along the value chain—so we can end up with more food, of better quality, safer and more nutritious to eat, and at a lower price because we have reduced the level of waste.

References and citations: See Appendix J of the Final Report

Acknowledgements: Thank you to all our WFLO and UC Davis consultants, and to the BMGF for supporting this unusual effort in which we were given the time and resources to look back at the past, work in the present, and plan for the future.