MEDIUM-TERM PLAN 2014-2016

AVRDC
The World Vegetable Center

2014-2016
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Published by
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AVRDC Publication: 14-776
ISBN 92-9058-204-9
Editor: Maureen Mecozzi
Graphic Design: Amy Chen
Publishing Team: Kathy Chen, Vanna Liu, Lu Shiu-luan
Photos: AVRDC Image Archive

Suggested citation
AVRDC. 2014. *2014-2016 Medium-term Plan*. AVRDC – The World Vegetable Center. Shanhua, Taiwan. Publication 14-776. 123 p.

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Bringing women to the forefront of agricultural research and development

FOREWORD

Achieving genuine food security is no longer a matter of making enough food available, but also making enough of the right kind of wholesome food available. Although hunger persists among 870 million people, the diets of 2 billion people today remain deficient in minerals and vitamins.

The emphasis has thus changed from considering hunger alone to regarding malnutrition as the key constraint to widespread human health. This has profound implications for research. Greater involvement of women in the research process is required if agriculture is to successfully address the problem of malnutrition.

Who decides what we eat?

While staple carbohydrate-rich crops are usually eaten daily, the consumption of fruits and vegetables is certainly not as automatic—the choice to include them in a meal is almost entirely up to women. Presently, consumption of fruit and vegetables in most countries fails to meet the norm of 400 g/person/day established by the World Health Organization. Changing the food preferences of households, particularly of young members, must become a priority if good health is to be attained and maintained. Thus, new challenging research questions emerge in which gender must take center stage. AVRDC has actively taken up the development of new food recipes that match cultural food preferences and employ preparation methods that better preserve the nutritional value of food.

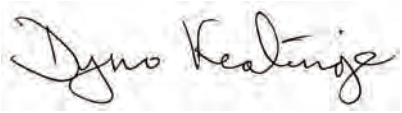
Women dominate vegetable growing, but not the value chain

Women are the chief producers of fruit and vegetables in many countries, particularly where production is mostly small-scale. A common view until recently was that the introduction of vegetables would automatically benefit women more than men. However, it is now better understood that gender equality in access to and control over resources is required if women are actually to benefit from horticultural development, especially since parts of the vegetable value chain such as transport, wholesale markets, storage, agrochemical and seed suppliers, and extension services are still mostly the purview of men.

Nourishing the world: Putting women in charge

Merely feeding the world in 2050 will not be enough; it also must be nourished. Fruits and vegetables must therefore play an increasingly important role in human diets. While all members of the family can actively participate in this change, most likely it will be women who will drive the effort to diversify and improve the family diet.

AVRDC is now well-equipped with capacity among its staff to apply gender research tools to understand the condition of women and leverage their position for accomplishing this goal. The Center's horticultural research will be more consumer- and women-oriented. Mainstreaming gender into any new technological interventions along the vegetable value chain is mandatory. The Center will encourage beneficial social change for women so that they gain better access and control over the resources involved in the full vegetable value chain, from the field to the table, and can make good food choices for the whole family. By this means AVRDC seeks to effectively fulfill its goal of bringing prosperity to the poor and health for all.



J.D.H. Keatinge

Director General

Strategic Organization

OFFICES

The Center's headquarters is located in Shanhua, Taiwan. Four regional offices are located in Bangkok, Thailand (East and Southeast Asia), Arusha, Tanzania (Eastern and Southern Africa), Bamako, Mali (West and Central Africa) and Hyderabad, India (South Asia). Additional offices, staff members and functions are located in Cameroon, Bangladesh, Pakistan, Uzbekistan, Indonesia and Fiji.

The Center's research and development activities are organized under four separate broad themes to encompass the vegetable value chain. The four themes are integrated in a matrix with the regional offices and headquarters. Both research and development components are built into each theme's activities. Results from adapted and applied research are used to formulate the development component of the themes to generate positive outcomes and impacts among target beneficiaries.

The Center's activities are conducted in active partnership with the public and private sectors. Research activities involve national agricultural research systems, international organizations, private institutions and advanced education and research institutes. To ensure sustainability of development activities in targeted sites, the Center collaborates and works within national government and nongovernmental agricultural systems, farmers' groups, women's groups and community-based organizations. All activities are conducted with a strong focus on capacity building, promotion and advocacy for improved production and enhanced consumption of vegetables.

1. AVRDC - The World Vegetable Center, Headquarters - Taiwan
2. East and Southeast Asia (ESEA) - Bangkok, Thailand
3. ESEA Research and Training Station - Kamphaeng Saen, Thailand
4. Project Office - Malang, Indonesia
5. Project Office - Sigatoka, Fiji
6. Project Office - Honiara, Solomon Islands
7. Korean Sub-Center - Suwon, Republic of Korea
8. South Asia (SA) - Hyderabad, India
9. Project Offices - Ranchi, Ludhiana, Bhubaneswar, Chickmagalur, and Raichur, India
10. Project Office - Dhaka, Bangladesh
11. Project Office - Islamabad, Pakistan
12. Sub-regional Office - Central and West Asia and North Africa (CWANA) Tashkent, Uzbekistan
13. Eastern and Southern Africa (ESA) - Arusha, Tanzania
14. West and Central Africa (WCA) - Bamako, Mali
15. Liaison Office - Yaoundé, Cameroon
16. Project Office - Sikasso, Mali
17. Project Office - Maroua, Cameroon

GERMPLASM

Germplasm conservation, evaluation, and gene discovery

GOAL

Biodiversity of vegetable genetic resources is preserved and its utilization for food and nutritional security is enhanced.

PURPOSE

Vegetable germplasm collected, conserved and distributed; the collection evaluated to identify those accessions with desirable traits, and their genes identified, characterized, and introgressed using classical and molecular technologies.

BREEDING

Genetic enhancement and varietal development of vegetables

GOAL

Varieties with potential to expand opportunities in tropical vegetable production.

PURPOSE

Farmers obtain varieties and lines of major vegetables that produce high yields of nutritious and marketable food with less health risk and environmental damage.

FOUR THEMES

PRODUCTION

Safe and sustainable vegetable production systems

GOAL

Substantial contributions to safe and sustainable vegetable production generated.

PURPOSE

Increased supply of safer vegetables through adoption of profitable, environmentally sound practices by farmers leading to knowledge-based farming.

CONSUMPTION

Balanced diets through increased access to, and utilization of, nutritious vegetables

GOAL

Consumer health improved by increased consumption of nutritious vegetables for a balanced diet.

PURPOSE

Increased public awareness, accessibility and utilization of nutritious and diverse vegetables.

Global Action

Breeding cucurbits for the tropics and building capacity of local researchers

East and Southeast Asia

AVRDC's activities in East and Southeast Asia are aligned with the Center's mission and contribute to building a strong and thriving vegetable sector in the region, which is vital for human health and economic development. With continuing population growth and the shift from rural to urban areas in the region, increasing and changing demands for food will have strong but unpredictable effects on rural and urban livelihoods. In the past three decades, East and Southeast Asia has achieved significant economic progress, but this growth has not translated into improved nutrition for the populations of a number of the countries in the region. While these countries continue to deal with the problems of infectious diseases and undernutrition (i.e. deficiencies in carbohydrate, protein, essential vitamins and minerals), they are at the same time experiencing an upsurge in non-communicable disease risk factors such as obesity and overweight, particularly in rapidly growing urban settings. Ensuring ensure safe, nutritious and culturally appropriate food is available, accessible and affordable year-round is one of the most pressing concerns in the region. This concern is aggravated by climate change, which poses a major risk for the region and exacerbates existing development problems such as population growth, rapid urbanization, increasing competition for natural resources, and environmental degradation.

Agriculture, nutrition and health are intrinsically linked with significant implications for the prosperity of people, especially for the poor and other vulnerable groups. Negative health impacts can be minimized by reducing environmental health risks and improving nutrition. This nexus between the different sectors is reflected in the suggested definition of the United Nations Standing Committee for Nutrition for the term 'Food and Nutrition Security', which "exists when all people at all times have physical, social and economic access to food, which is safe and consumed in sufficient quantity and quality to meet their dietary needs and food preferences, and is supported by an environment of adequate sanitation, health services and care, allowing for a healthy and active life."

Vegetable gardens have the potential to improve food and nutrition security in the region, generating additional income, contributing to better health, and promoting gender equity and equality. Home and community gardens can provide a wide variety of fruits and vegetables throughout the year, thus contributing significantly to a nutritious, balanced diet for family members and offering opportunities for income generation through sale of extra produce. School gardens can be used to encourage the production and consumption of a wide diversity of vegetables and fruit, which is particularly important when persuading children to favor a balanced and nutritious diet as part of a healthy lifestyle. School-based health and nutrition programs are considered effective, since the preexisting infrastructure of the educational system can often offer a more cost-effective route for delivery of health and nutrition interventions than national health systems.

In summary, the Center's strategy in East and Southeast Asia focuses on:

- Combating malnutrition: Ensuring a year-round supply of, and access to, affordable nutrient-rich, and safe vegetables for all segments of society;
- Generating income: Raising incomes, creating jobs, and improving the livelihoods of marginalized and vulnerable groups;
- Building capacity: Training scientists, extension specialists and farmers, and creating awareness among consumers and policy makers;
- Developing sustainable solutions: Ensuring responsible use of natural resources.

International Year of Family Farming

A number activities of in the region are dedicated to the 2014 International Year of Family Farming, which was declared by the General Assembly of the United Nations to highlight the significant role of family and smallholder farmers in eradicating hunger and poverty, providing food security and nutrition, improving livelihoods, managing natural resources, protecting the environment, and achieving sustainable development—including "SEAVEG 2014: Families, Farms, Food - Sustaining Small-Scale Vegetable Production and Marketing Systems for Food and Nutrition Security," a regional symposium organized by AVRDC and partners in Bangkok, Thailand on 25-27 February 2014. The symposium brought together experts and representatives from the vegetable sector to discuss regional vegetable value chains. During their interactions at the symposium, staff from agricultural and environmental agencies, universities, policy makers, farmers, consumers, and producer groups were able to develop sound recommendations to improve small-scale horticulture and strengthen the region's vegetable sector amid the challenges of a changing climate.

The member states of Association of South East Asian Nations (ASEAN) are expected

to benefit from a regional approach to improving small-scale farming systems. Supporting small-scale farms will put ASEAN in a much stronger economic position in terms of international trade due to improved quality and quantity of vegetable produce and better adherence to internationally accepted phytosanitary and Codex standards, and quality assurance schemes, such as Good Agricultural Practices. Improved resilience to the negative effects of climate change will enable the ASEAN vegetable industry to lessen the impact of natural calamities and disasters.

Building capacity

The Center's International Vegetable Training Course remains a regional priority. The course, which is organized in three separate but interrelated one-month long modules, aims to enhance technical, scientific and managerial skills of researchers and extension workers from national and international agricultural research institutes, universities, and non-governmental organizations. It enables participants to contribute to the sustainable development of their countries through the increased production and consumption of nutritious and health-promoting vegetables. The training course emphasizes advanced and sustainable vegetable production and postharvest technologies, farmer education, human health and nutrition, and marketing. This training enhances awareness and understanding of emerging global development issues and technologies.

Ten one-week long, in-country training courses will be conducted in four Southeast Asian countries to cover subjects of integrated pest management, vegetable seed production, postharvest handling, and linking farmers to markets (Cambodia); home gardening, postharvest technologies, and integrated pest management (Indonesia); farmer-based participatory seed production and community seed banks, linking farmers to markets and integrated pest management (Lao PDR); and a writeshop on project development and extension methods (Myanmar).

AVRDC East and Southeast Asia's involvement in scaling up agricultural technologies will be more prominent in the coming years. The office will coordinate additional training activities; further dissemination, testing, adaptation and adoption of technologies; and will assure quality data collection and documentation.

Climate resilience and safer vegetable production

Climate change contributes to frequent flooding, prolonged droughts and temperature extremes that are increasingly affecting the agricultural sector in East and Southeast Asia. To enhance the resilience of vegetable growers in the region to these climatic events, AVRDC promotes technologies such as cultivation on raised beds, microirrigation and grafting. This is complemented by breeding of vegetable lines that are tolerant of, or resistant to, abiotic and biotic stresses. AVRDC further promotes integrated crop management strategies to minimize contamination from pesticides and other pollutants as well as improved storage technologies and better postharvest management. These strategies contribute to enhance the year-round accessibility and affordability of safe and nutritious vegetables for consumers and to increase profits for vegetable growers.

Research and development projects being implemented in the region contribute to the evidence base of safe production technologies for vegetable crops, improve the livelihood of farmers, and increase the availability of wholesome vegetables with reduced risk of pesticide contamination through sustainable production systems. Collaborative multi-institutional effort

will increase the availability of health-promoting, nutritious and affordable vegetables to the poor through cost-effective and sustainable integrated disease management systems. This includes the appropriate use of begomovirus-resistant varieties of hot pepper, tomato and mungbean crops and minimizing the risk of infection through whitefly vectors. Simple, economical, and environmentally-sound IPM strategies to control other major pests and plant diseases will be developed and/or validated and promoted to manage major biotic constraints.

Combating malnutrition

Cucurbits, specifically bitter gourd and pumpkin, are an integral component of vegetable gardens in Asia. These vegetables are rich sources of vitamins, other essential micronutrients and dietary fiber. Bitter gourd and pumpkin breeding by the private seed sector has focused on developing hybrids for larger scale commercial production with horticultural attributes that may be unsuitable for home and school gardens. Schools and home gardens need short-vined varieties with early and late maturity to extend the harvest period. These lines should be high yielding; open-pollinated, so that vegetable gardeners can save the seed for successive plantings; nutritionally dense; resistant to prevalent diseases to minimize pesticide use; and able to produce fruit with good shelf life. In 2014 - 2016, the cucurbit breeding team will evaluate the horticultural traits and nutritional content of advanced breeding lines intended for home vegetable garden production.

Generating income

From 2014, the AVRDC East and Southeast Asia will be involved in activities within the CGIAR Research Program on Integrated Systems for the Humid Tropics, which aims to help poor farm families to boost incomes from integrated agricultural system intensification while also preserving their land for future generations. Regional activities will focus on the Greater Mekong Sub-region, which comprises Cambodia, Lao PDR, Myanmar, Thailand, Vietnam and Yunnan Province of the People's Republic of China. The Mekong region is undergoing major social, economic and ecological changes, offering a plethora of economic opportunities yet also posing potential threats to ecosystem sustainability. Initial activities will focus on scoping studies on commercial vegetable production as well as home gardening in the target countries. In early 2014, a project staff member will be based at the World Agroforestry Centre (ICRAF) in Hanoi, Vietnam, to coordinate AVRDC's activities in the region.

Women's groups start seedling nurseries and increase family incomes

South Asia

Over the last two years the number of AVRDC activities in South Asia has expanded significantly. With good coordination between these activities and countries in the region, duplication can be avoided, and all parties will be able to take advantage of synergies and learn from each other. There is a need to extend the financial management system to accommodate expanding regional activities and facilitate management.

India is the only member of the BRICS group of large developing countries (Brazil, Russia, India, China and South Africa) in which AVRDC works extensively. Despite its economic growth, India has a very large proportion of the world's malnourished people and more than 50% of rural women suffer from anemia. AVRDC needs to increase its profile in the country and to connect with a growing number of national initiatives to increase vegetable production. The Indian National Food Security Bill introduced last year is the world's largest attempt to reduce malnutrition through guaranteed supply of subsidized grains for up to 75% of the rural population and 50% of the urban population. Vegetables are not included in this program and vegetable production and supply continues to be well below the minimum required for good health. The supply of vegetables and the nutritional indicators in Pakistan, Bangladesh and Nepal are in many cases worse than for India. There is an

opportunity for AVRDC to link with major initiatives and to support research and development that can have an impact on vegetable production and the nutrition of the population across the region.

While vegetable seed industries in most countries in the region are moribund, in India the seed industry is dynamic. There is a strong demand for training, and AVRDC's past ad hoc training initiatives could be strengthened to improve the supply of vegetable seed across the region. AVRDC's core funding may be best spent to build essential infrastructure that an expanding program needs and to support initiatives to connect to new donors and create new science. The first regional review and planning meeting in May 2013 began the process of identifying these needs.

Major work thrusts

Legume breeding: Although past research and development activities have focused on mungbean and vegetable soybean, the work could be expanded to include cowpea and black gram, and to include more laboratory-based studies. The Center's current legume breeding activities could be expanded to include more international trials.

Tomato and chili testing: Although AVRDC has had a major impact in tomato production in the region, Indian seed companies are the only major users of AVRDC's tomato germplasm. Testing of improved germplasm recently has been driven by short-term projects rather than longer term goals. There is need for a more consistent supply of germplasm for widespread testing in the local market and the appointment of a regional seed production officer means that regional testing of AVRDC germplasm can now be better linked to the Center's global breeding programs.

Home vegetable gardens for improved nutrition: This has been a major area of AVRDC's work in the region for 20 years. Currently, five research and development projects in the region include some home vegetable gardening. Better socioeconomic research is needed to understand the adoption process, and better connections to local health and nutrition services are needed to ensure widespread adoption and impact.

Protected cultivation: AVRDC has good experience in refining practices for smallholder farmers in Punjab, India but protected cultivation is still relatively underdeveloped in the region. There is an opportunity to build on local approaches to frugal innovation for the benefit of smallholder farmers across the region, and this can tie in well with current AVRDC work in Pakistan and proposed work in India.

Capacity building for the seed industry: Lack of quality, affordable vegetable seed is a major limitation to vegetable production in the region. A large unmet demand for training in the seed industry was recently identified in India, and there is a need for capacity building in the seed industries in other countries in the region. A well-designed training program could be financially self-sustaining and build on partners' skills in the region and within AVRDC to improve the regional vegetable seed supply chain.

Expected staffing requirements

Seed production and distribution: A seed production officer has been appointed and will be supported by two or three regional projects. This position will be responsible for importation of seed, production and distribution within India, as well as maintaining the regional seed bank. Equipment and facilities are needed for better seed production, grading and storage.

AVRDC'S home garden designs provide the micronutrients families need for good health

Training design and delivery: There is an opportunity for short, specialized training courses in the region, particularly for the seed industry and among NGOs working with farmers. The Center will support some technical trainers, but more educational expertise and coordination could help make the Center's training activities educationally sound and financially sustainable. The position has been requested with support from Germany.

Postharvest research and development: A postharvest scientist will be posted at the South Asia office with regional responsibility, linked to the Center's postharvest activities in Tanzania. There is a postharvest Center in India with which the Center plans to connect.

Plant pathology: There has been a growing need for plant pathology support due to the Center's expanding activities on developing crop management technologies to complement host plant resistance breeding and deployment of resistant lines. Pest and disease management expertise must be strengthened to support regional projects. There is an opportunity to link with CABI and their work in plant protection within the region to provide some of this support.

Writing and evaluation: We have a growing need for a senior science writer. A lot of time is required for writing proposals and editing. Much of the evaluation work is yet to be published. There are many opportunities for funding in the region and additional support with good English skills would be an asset.

Communications: AVRDC South Asia works in many different local languages and scripts and currently liaises with the Center's Communications team at Headquarters but uses local designers. Additional support is needed to create a range of local publications, help with communication across the region and to work with reliable developers of video materials.

Expected infrastructure requirements

Extra building space: The current office space in Hyderabad will soon be full with the arrival of new staff. There is a need for well-ventilated indoor space to clean seed, for expanded laboratory space, and to provide laboratories for postharvest activities. The current building was designed to make it easy to add a second floor and this space would be used for a laboratory including a freeze drier, oven, and facilities for disease identification, for seed processing and cleaning, for postharvest testing and as a specialized training area.

Seed processing and cleaning equipment: We currently clean, sort and pack seed by hand using unskilled staff. Better quality seed could be provided to our project partners through the purchase of proper seed cleaning, sorting and grading equipment.

Higher quality protected cultivation facilities: Our current nethouse facilities are simple and need upgrading to poly-net houses using microirrigation and plastic mulching for year-round cultivation to improve quality and to be consistent with farmer practices.

Regional transport facilities

Staff in projects in rural India hire transport on a daily basis, use buses or their own motorbikes. This is often expensive and can be unreliable. Most vehicles owned by the AVRDC South Asia are based in Hyderabad. Development projects in Karnataka and Odisha could be more effective with additional vehicles.

Expected sources of funding

In addition to core funding, the region currently has two projects with Indian funding, and seven other donor-funded projects. Three of these are regionally led, and four are led from Headquarters. The number of Indian donors is expected to increase in future years due to increasing government commitments to improving vegetable production and the mandated requirement for corporations to have Corporate Social Responsibility projects. AVRDC South Asia already has been approached by some companies with an interest in vegetable-related activities. There are opportunities to expand our connections with the regional offices of international donors in South Asia.

Better integration of projects with others in the region, and a better regional coordination mechanism could improve shared services and increase synergies between projects. This will avoid duplication and contribute as much as possible to developing common support services.

AVRDC in Africa

Institutionally, Africa has witnessed a substantial move towards policy and program harmonization across countries, notably via the development of a West Africa Agricultural Productivity Program (WAAPP) under the auspices of the Economic Community of West African States (ECOWAS) and an unfolding Central Africa Agricultural Productivity Program (CAAPP) under the auspices of the Economic Community of Central African States (ECCAS). Both WAAPP and CAAPP are linked to the continent-wide Comprehensive African Agricultural Development Program (CAADP) coordinated by the African Union Commission. All these programs recognize cooperation in agricultural research and development as essential and have entrusted the Forum for Agricultural Research in Africa (FARA) to coordinate such at the continent level, and the West and Central African Council for Agricultural Research and Development (WECARD), also known as Conseil Ouest et Centre Africain pour la Recherche et le Développement Agricoles (CORAF), to do the same for West and Central Africa.

It is in this context that AVRDC, in April 2011, began a reflection on aligning operations with these geopolitical configurations, similar to what other international agricultural research centers had done. The discussions and strategic thinking resulted in a split of the Regional Center for Africa into two regional offices on 1 January 2014. It is anticipated that proximity to the target operational zone would make it possible to better capture and respond to challenges posed by the specific socioeconomic, agroecological and geopolitical realities of the region, as well as funding opportunities with proposals that better fit the needs of clients.

Nursery techniques to improve onion production

West and Central Africa

West and Central Africa is home to about 300 million people, many of whom are smallholder farmers growing a variety of staple food crops within complex farming systems where livestock, tree crops and vegetables co-habit in various spatial and temporal configurations. The region experiences extreme heat during most of the year as well as low and erratic rainfall that results in drought; crop failures occur in two out of five years. The past decade has seen an increased frequency of floods in the lowlands of this otherwise water-scarce region, which also contributes to crop failures. The overall coping strategy of the population has been to grow a combination of perennial species and shorter season crop varieties under rain-fed conditions or residual moisture conditions offered by lowlands (inland valleys) or river banks during the off-season.

Horticultural crops, in particular vegetables, have become conspicuous features of off-season production and account for an estimated 40% of the market sales of products in the region. These crops are mainly grown and traded by women in domestic markets with substantial regional market linkages. Increased and sustained growth in this sector will translate into more income for women and associated benefits for household nutrition and food security, health, and educational status of children; these changes will occur concurrently in many countries.

Most vegetable crops are produced for fresh market sale, which make them vulnerable to spoilage if delays in reaching markets occur. These losses add to those occurring before or during harvest due to unsuited genetics of the crops, inadequate protection of the crops against pests and diseases, and poor agronomic characteristics.

Developing options for reducing spoilage would thus appear as an essential companion to research to increase production, and a precursor to interventions that increase and diversify processing capacities. Only in this way would additional gains and stability in income along the vegetable value chain be secured.

AVRDC - The World Vegetable Center formally established outreach operations in West and Central Africa in 2003 with staff briefly posted in Côte d'Ivoire and subsequently in Mali under the umbrella of the Africa Rice Center (AfricaRice, previously known as WARDA, the West Africa Rice Development Association). AfricaRice relocated to Benin in 2004 and the AVRDC team remained in Mali to form the sub-regional office for West and Central Africa, operating under a hosting arrangement with the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT).

The sub-regional office focused on variety introductions and adaptive testing supported by seed production and integrated pest management using a networking approach to reach out to national agricultural research systems in the region. At the same time, AVRDC sought joint appointments with other international centers to further expand its ability to respond to the needs of the region. This was exemplified with the posting of one breeder under joint arrangement with ICRISAT in Niger in 2007 to support a crop diversification program. This program succeeded in developing and promoting, through training of women, a model for combining water harvesting techniques, land reclamation and performing varieties that formed the backbone of the African Market Garden initiative. In March 2010, the Consultative Group on International Agricultural Research (CGIAR) presented AVRDC and ICRISAT the 2009 CGIAR Science Award for Outstanding Partnership at the First Global Conference on Agricultural Research for Development (GCARD).

Building on inter-center cooperation, AVRDC set up a liaison office for Central Africa in Cameroon in 2007, as part of the sub-regional office. The liaison office was initially hosted by the World Agroforestry Center before it co-located with the International Institute of Tropical Agriculture (IITA) under hosting arrangements reciprocated by AVRDC for IITA in Tanzania. To consolidate the Center's legal status in the region, a host country agreement was signed with the Government of Mali in January 2009 and the Government of Cameroon in August 2009. Both agreements provided substantial privileges with respect to tax exemptions and immunities. This led to restructuring of Center's operations, whereby the sub-regional office became AVRDC West and Central Africa from 1 January 2014, with two full-time internationally recruited staff.

Deliberate efforts to invigorate human resources at AVRDC West and Central Africa will be the topmost priority in 2014, in view of assembling an increased competency pool of experienced professionals in plant breeding, cropping systems agronomy, food science and nutrition, socioeconomics and project management. This will enable the Center to meet existing commitments and respond to emerging opportunities in the region. As it aims to attain its own critical mass, the regional office will concurrently seek to

contribute to NARS capacity building. In this regard, we will consolidate relationships with the Ghana-based West Africa Centre for Crop Improvement (WACCI, an initiative of AGRA, the Alliance for a Green Revolution in Africa) and support graduate training, with possible placement of students at AVRDC. This would aim to help tackle the shortage of trained breeders, and indeed of agricultural scientists, in a region where the average age of NARS scientists is often above 50 years according to an assessment by FARA. There is a strategic need for the Center to invest in WACCI and similar initiatives, given that only with qualified counterparts in NARS would AVRDC be able to develop and benefit from effective partnerships to fulfill its mission.

In 2014, the regional office will have concluded a three-year assessment of the feasibility of carrying out the Center's global onion breeding from Mali, following the transfer of the program from Taiwan. Substantial investments have been made to develop ambient and cold storage facilities for bulbs and seeds. Obtaining seed had been the main challenge faced in Taiwan but the transfer to the region did not overcome this constraint, particularly for lines that had not been developed in the region. Thus, additional efforts will be directed at developing vernalization protocols to enhance seed set (with the anticipated addition of a new breeder to the team) while focusing on deployment of adapted lines through a network of NARS partners across the region. In particular, the program will continue to support an outscaling initiative sponsored by the International Fund for Agriculture Development through PADFA in northern Cameroon that is entering the second year of its four-year lifetime ending in 2016. Another crop of major focus for the region is okra, which the Center is seeking to establish breeding capacity for in Cameroon, starting in 2014.

In 2014, AVRDC West and Central Africa will continue to nurture partnerships with NARS and non-governmental organizations in addressing issues surrounding mass supply of vegetables based on efficient seed production and delivery systems, and promoting the diet-diversifying and nutrition-enhancing use of vegetables. For example, the Center will move into the implementation phase of a three-year project for increased production and marketing of traditional leafy vegetables, with expertise from Burkina Faso, Cameroon and Ghana and support from CORAF's multi-donor trust fund led by the World Bank. The project will adopt the best practices hub model developed by the Center and tested in southern Mali for tackling the disconnect between research and practice. Testing and deployment of varieties and associated technologies to increase the availability of vegetables as well as links to education on postharvest strategies and food preparation can boost market access and consumption while building the capacity of producers as part of project exit strategy and legacy.

Meanwhile, the best practices hub model and the technologies it tested are now mature for large-scale deployment within southern Mali and across other regions, which will be initiated in 2014 with substantial funding from USAID-Mali under the Feed the Future (FtF) Initiative. It is anticipated that some 30 vegetable technology immersion clusters will have been established by 2016 to avail 50,000 or more seed kits and facilitate community access to new varieties. It is projected that increased demand for quality seed will emerge as a result of the project. To sustain this, AVRDC will demonstrate, starting in 2015, protocols for efficient seed production to potential seed entrepreneurs and facilitate access to low cost seed drying equipment that can be easily constructed locally. The seed dryers also can be used for drying leafy vegetables or cut pieces of fruit

vegetables, which facilitates preservation and future use after rapid rehydration. Also from 2015, the regional office will help to establish low cost storage facilities at each vegetable technology immersion cluster and at the best practices hub sites. These low cost storage facilities will be based on zero energy cool chamber (ZECC) evaporative coolers to extend shelf-life of harvested produce. The construction of the cool chambers and seed dryers will provide temporary employment to local artisans and likely stimulate small businesses around postharvest handling of vegetable seed or produce, and possibly applications to other commodities. Recruitment of a food and nutrition specialist is expected to be completed in 2014 and will provide expertise to support the postharvest research and training needs of the scale-up.

Experience has shown that growers coming into contact with the testing and demonstration scheme rapidly adopt the locally adapted improved varieties and grow them in sole or mixed cropping regimes with the major staples, predominantly maize and groundnuts. This provides an important linkage with USAID Africa RISING, a five-year project for sustainable intensification of food-crops based systems started in 2012 that both regional offices in Africa have been involved in alongside commodity centers (ICRISAT and IITA). Focal domains for this project in the region encompass northern Ghana and southern Mali, both of which significantly contribute to food production with cereal-dominated crop systems and have an untapped potential for the production of vegetables as sole crops or in association with cereals to contribute to food security and diet diversity. The addition of a cropping systems agronomist to the regional team in 2014 will enhance the center's contribution to the initiative with expected commensurate benefits. In 2016, the region will have implemented several projects focusing on downstream dissemination and adaptation of tested vegetable technologies. In so doing, it will have generated knowledge, transferred know-how, and strengthened research-to-delivery capacity and linkages to enhance the contribution of vegetable research for development outputs to livelihood and nutrition impacts. To verify this postulate, the region will need to have carried out scientific evaluation in terms of the performance of the technologies as well as that of the dissemination process. Thus, critical project interventions will have been monitored to generate new knowledge that could support future policy formulation on issues such as:

Deployment of new varieties: It is generally agreed that profitable production depends on the cultivation of varieties most suited to the biophysical context but also to market demand (the same variety might not behave in the same way depending on where and when it is grown).

Pesticide use: As climate fluctuations cause unknown shifts in pathogen and pest profile, farmers often resort to solutions inspired from field crops practices. Such solutions may not have been thoroughly tested for vegetables. Learning about pest profiles and crop management and protection options that work would be to the credit of the Center's projects.

Barriers and incentives to adoption of new technologies and consumption of new/improved vegetables: It is suspected that growers adapt their choices and

practices to consumer attitudes, but there has been no deliberate research on understanding the main drivers of adoption.

Effectiveness of the mechanism for testing, adapting and delivering research outcomes: Continue to build capacity to turn research outcomes into profitable business as dictated by local conditions.

The anticipated addition in 2014 of a socioeconomist and a project development officer to the regional team will be a bonus. Several of these research issues are also pertinent for the Center's work in Eastern and Southern Africa and will provide learning opportunities across sub-Saharan Africa.

Promoting well-adapted global and traditional vegetable crops

Eastern and Southern Africa

Genetic resources

AVRDC Eastern and Southern Africa holds the largest seed repository of traditional and global vegetables on the continent. The seed repository is unique because of its focus on traditional vegetables. Traditional vegetables, partly because of their relative higher pest- and disease resistance, adaptation to biotic stress, nutritious content and local adaptation, play an increasingly important role in diversifying local diets and improving nutrition, particularly for resource-poor smallholder households. The regional office realizes it occupies a niche position and possesses an underutilized asset (e.g. compared to the private sector, which focuses on global vegetables), and will leverage its unique seed repository with a continued focus on traditional African vegetables.

During 2014-2016, the seed repository needs (a) safeguarding, (b) characterization, (c) increased accessibility and (d) expansion:

- Genetic resources held at the seed repository will be secured by upgrading the physical facilities (e.g. temperature control) and improving seed drying procedures to bring moisture content to international standards for longer term conservation.
- Many of the accessions are ill-described, and therefore a major activity will be their morphological and agronomic characterization in the screenhouse

and the field, using well-defined and harmonized standards.

- The seed repository will continue to respond to requests for seed kits from local and regional entities for programs emphasizing the provision of income and nutritional benefits for poor and vulnerable communities, as well as large-scale requests as components of disaster relief or post-conflict recovery programs. It is paramount that, for medium- and large-scale seed requests, seed kit distribution be combined with practical and comprehensive training-of-trainers programs at the regional office (community seed production, agronomy, harvest, postharvest, marketing and utilization) and follow-up visits in the field. This will allow the regional office to ensure quality, and implement effective monitoring and evaluation. A large seed kit distribution program (10,000 seed kits) will be rolled out in 2014-2015 targeting Northwestern Tanzania through Helen Keller International's homestead food production program. Several new seed kit distribution initiatives targeting South Sudan will be launched in 2014 through the Food and Agriculture Organization of the United Nations, with the aim to distribute more than 20,000 seed kits. Both initiatives, as well as future ones, will be complemented with training programs, but follow-up visits for conflict or disaster zones will be outsourced.
- Currently, the seed repository holds 2,450 accessions, but in the longer term, the repository hopes to add new collections, while ensuring that the collecting activities follow all international and national guidelines and legal requirements.

The seed repository forms the basis for germplasm development at the regional office. Selection from within the vast existing accessions of traditional vegetables will continue in the office's breeding program, prior to evaluation, testing and release by national programs and private companies in target environments of various countries in the region. Global vegetables such as tomato are very important in sub-Saharan Africa, but in the short term, their improvement will focus mainly on introduction of target populations from Center headquarters or mandated regional centers.

Linkages with staple crop systems

The potential for enhancing staple crop and food systems through vegetable-based interventions has not been sufficiently exploited. In Eastern Africa, great potential exists in linking vegetable cowpea and pigeon pea, and amaranth with maize (e.g. through the International Institute of Tropical Agriculture [IITA] and the International Wheat and Maize Improvement Center [CIMMYT]); and in linking tomato, sweet pepper, onion, amaranth and African eggplant as follow-up crops to irrigated rice, using residual water (e.g. through the Africa Rice Center [AfricaRice]), which will be explored in the long term. In the short term, the regional office hosts an expanding banana breeding team from the International Institute of Tropical Agriculture (IITA), and joint research on banana-vegetable (e.g. amaranth) intercropping systems will be explored.

Postharvest research

The regional office for Eastern and Southern Africa will continue to be part of AVRDC's global research and development initiatives on postharvest handling and processing, particularly for women, with emphasis on completing physical and economic postharvest loss assessments and testing options for prolonging shelf-life and adding value. Planned work for 2014 and onwards includes (a) undertaking needs assessments of postharvest handling and storage for vegetable crops in Ethiopia, Mali and

Malawi; (b) evaluating shelf-life performance of newly introduced vegetable varieties in Malawi; (c) assessing pesticide application practices by smallholder vegetable producers in Tanzania; and (d) testing zero energy cool chamber (ZECC) evaporative coolers for short-term storage of vegetables in Malawi. These field activities will be complemented with (e) on-station research in Tanzania on options for reducing deterioration of vegetables during storage, transportation and marketing (e.g. through use of ice packs, low cost hydro-coolers and improved packing crates); and (f) capacity-building interventions in Kenya and Tanzania to ensure better understanding of the postharvest opportunities to add value, minimize losses and improve nutrition.

Focus on market research

Three socioeconomists are based at AVRDC Eastern and Southern Africa, including the Center's Global Theme Leader - Consumption. One of the region's largest projects, "Improving income and nutrition in Eastern and Southern Africa by enhancing vegetable-based farming and food systems in peri-urban corridors' (VINESA)" has just started. A disconnect frequently exists between vegetable production and smallholder farmers and consumers on the other. Opportunities exist to generate income for farmers, especially youth and women, and increase nutrition for consumers. In sub-Saharan Africa, the availability and consumption of vegetables is far from reaching recommended rates in this region, partly due to deficient supply systems, insufficient public education, and inadequate policies.

Using its solid socioeconomic expertise, AVRDC Eastern and Southern Africa will actively pursue opportunities (e.g. proposals, public-private or other partnerships) that tackle this disconnect. In some countries (e.g. Kenya, Tanzania and Uganda) traditional vegetables are well-vested among smallholder farmers and local consumers, whereas in others (e.g. Mozambique) efforts will need to introduce traditional vegetables into the marketplace. A cross-cutting effort will be needed to increase public awareness of the nutritional benefits of traditional vegetables. The regional office will continue working on global vegetables. Reaching the end-user remains a challenge, essentially because of the lack of efficient channels for the adaptation and dissemination of research-based technologies and knowledge. To overcome this constraint, AVRDC developed a model for bridging research practice by focusing interventions in targeted geographical areas or "best practice hubs" that are embedded within vegetable farming communities to maximize impact by linking smallholder farmers to high value markets.

Regional expansion

Current activities led from AVRDC Eastern and Southern Africa are biased towards Tanzania, with project-based activities in Ethiopia, Kenya, Malawi and Mozambique. In 2015, efforts will be made to expand activities to other countries (e.g. Madagascar, Uganda and Zambia).

Linkages and partnerships

Linkages and partnerships will be crucial to consolidate our research impact, and expand geographically as well as thematically.

- The most important and direct linkage will be with AVRDC West and Central Africa. Many similarities exist in the problems facing vegetable research and development across sub-Saharan Africa, and many synergies will be seized by working closely together. Collaboration will occur on transfer of germplasm and breeding lines, co-writing of continent-wide proposals, exchanging knowledge, and sharing of staff and expertise.

- The regional office for Eastern and Southern Africa will actively explore opportunities with members of the Association of International Research and Development Centers for Agriculture (AIRCA), of which AVRDC is a founding member.
- Linkages and partnerships with sub-regional bodies such as the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA); and with continental bodies such as the African Union, the Forum for Agricultural Research in Africa (FARA) and the Alliance for a Green Revolution in Africa (AGRA) will be essential to advance Africa-wide and policy issues, and raise the profile of vegetables on the continent.
- Vegetables share a lot of aspects with fruits and fruit trees: they are both nutritious, gender-empowering and income-generating. Surprisingly, this synergy has not yet been exploited. The regional office will actively explore linkages with institutions researching fruits, such as the World Agroforestry Center (ICRAF).
- The regional office will continue to strengthen its linkages and partnerships with national agricultural research and extension services, non-governmental organizations, seed companies, public seed enterprises, farmer-based organizations, processing industries, and relief and rehabilitation organizations to ensure dissemination, adoption and ultimately impact.

Infrastructure

At the beginning of 2014, AVRDC Eastern and Southern Africa will undergo a thorough facelift. The refurbishment, combined with a concurrent sensitization campaign, will attract partners to use our fields, training and laboratory facilities, creating synergy during 2015 and 2016. In 2015, the office will have reached a fully project-ready status, with functional laboratories and a diversified research team in all major disciplines, cutting across the global research themes. The office will use the laboratory to introduce relatively simple molecular tools as a valuable asset to the breeding program. The office will have further established itself as a center of excellence for postharvest research and development in the region.

Human resources capacity

AVRDC Eastern and Southern Africa will need to expand capacity to address plant health research issues both in terms of research (especially breeding-related activities) and development. Because of a gradual shift towards enhanced nutritional quality and consumer health, resulting in a concurrent shift of donor emphasis, the regional office will attract resources to recruit a nutritionist. Support will also be needed to help with writing proposals and publications. Molecular markers are important tools to expand our understanding of genetic variability and to speed up the pace of germplasm development. Because the Center has a well-equipped molecular laboratory, efforts will be made to recruit a molecular marker specialist in the medium term.

Training

AVRDC Eastern and Southern Africa has excellent training facilities, including an auditorium, a postharvest center, and ample laboratory and field space. Coupled with easy access to the region, proximity to national programs involved in vegetable research and development, and a booming private sector, its training capacities will be actively leveraged from 2014 onwards. Short courses will be promoted, targeting trainer-of-trainers or farm group leaders. Linkages will be built with local, regional and global universities to house a larger number of interns, MSc and PhD students.

Impact and outreach

AVRDC Eastern and Southern Africa will put itself more on the forefront using a three-pronged approach: (a) increasing high-quality publications, both scientific as well as practical; b) increasing communication and promotion; and (c) ensuring rigorous monitoring and evaluation of its research and development interventions, as well as impact assessment incorporated into all activities and projects from start to finish.

Slippery cabbage (*Abelmoschus manihot*), a popular and nutritious traditional vegetable

Oceania

The Center's activities in Oceania remain largely project-based. Despite the recent recruitment of a Project Coordinator for the region, the Center's operations are run by a small team. The Center continues to seek a proper hosting arrangement with local governments, particularly in Fiji, or with the Secretariat of the Pacific Community (SPC) to facilitate activities and possible further expansion of its operations in Oceania.

In 2014, research and development activities in Oceania will continue to improve the livelihoods of smallholders and their communities by increasing incomes from vegetable production. Special effort will be made to address key production constraints including insect pests and diseases, low soil fertility, and poor seed and seedling quality and lack of quality supply. Introduction and evaluation of elite high-value vegetable cultivars and lines will continue. A set of AVRDC tomato lines will enter their third year of local evaluation; official release of selected tomato lines will be sought in 2014 in Fiji, and the Center will engage in discussion with ministries in the Solomon Islands and Samoa for the same purpose. Evaluation of AVRDC sweet pepper lines will be continued in Fiji, Samoa, and the Solomon Islands in the next two to three years. Chili pepper is one of the key vegetable export commodities in Fiji. However, an outbreak of chili anthracnose since 2010 has caused severe yield losses; AVRDC chili lines will

be evaluated to identify lines with field resistance. Chili cultivar 'Akabare' is in high demand from the tuna canning industry in the Solomon Islands; however, quality and quantity of locally produced chili is uneven. AVRDC chili accessions and lines with similar characteristics have been selected for evaluation.

A series of integrated crop management activities will be conducted in 2014 and the following two years for improving year-round production of high-value vegetables, especially tomato, cabbage and sweet pepper. Pests on tomato crops will be monitored across locations and seasons in Fiji and integrated pest management on the crop will be evaluated. Protocols for diagnosis of tomato diseases will be developed from Headquarters. The efficacy of control of cabbage insect pests using exclusion net and biopesticides will continue to be assessed in collaboration with SPC. Practices on improving soil fertility will be evaluated including application of starter solution and rotation with legumes. High-value vegetables, like tomato, are in high demand during the rainy season from November to April. The potential for using flood-tolerant eggplant rootstocks for off-season tomato production will be determined and the feasibility of using protected structures for off-season vegetable evaluated.

The Center will continue mentoring and supporting farmer groups taking part in the participatory guarantee system (PGS) in the Solomon Islands and Fiji. AVRDC expects farmer groups in Fiji will be able to conduct business with resorts via registered companies; that contracts will be established between buyers and growers; and that there will be timely delivery of produce according to contracts. Regular visits to advise PGS farmer groups on vegetable production and business practices will be made and special training sessions on production and business skills will be provided based on specific needs. The Center will transfer healthy seedling production practices to the Ministry of Primary Industries, local nurseries, and lead farmers to improve seedling supply.

In collaboration with the Secretariat of the Pacific Community and local ministries, the Center will facilitate discussions among key stakeholders to improve quality seed supply in the region. Assistance to local private seed sector companies will be made through capacity building in seed production and processing, especially for open-pollinated varieties. This would be an effective and sustainable mechanism to deliver seed of elite AVRDC lines to local communities. As vegetable cultivars developed in Southeast Asia have a good chance of performing well in the region due to the similar climatic conditions, the Center will facilitate improved communication and interaction between the local seed sectors in Oceania and seed companies in Southeast Asia.

The non-communicable disease rate in Oceania is very high. Strengthening research and development efforts on traditional vegetables would help contribute to improved nutrition that might reduce the risk of non-communicable diseases. The International Horticulture Congress in Brisbane, Australia in August 2014 is a good opportunity to raise awareness of non-communicable diseases and the role of traditional vegetables as part of a balanced diet to reduce the risks. AVRDC is organizing an international symposium on traditional vegetables at the Congress which, in addition to discussing new technologies and latest results, will provide opportunities to collaborate with scientists from the region and to build regional capacity in traditional vegetable research.

New vegetable varieties create new markets

Central Asia and the Caucasus

AVRDC conducts activities in Central Asia and the Caucasus under the umbrella of the CGIAR - Program Facilitation Unit in Tashkent, Uzbekistan, and works within the CGIAR Collaborative Research Program for Sustainable Agricultural Development in Central Asia and the Caucasus in close collaboration with National Agricultural Research Systems (NARS).

Under the Central Asia and the Caucasus Regional Network for Vegetable Systems Research and Development, AVRDC will continue to foster collaborative research partnerships in areas of common interest in Armenia, Azerbaijan, Georgia, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan to attain better, more efficient use of the expertise, technologies, germplasm and scarce resources available in these countries.

Most of the former Soviet Union countries lack improved germplasm—the building blocks for successful breeding programs. AVRDC has a very important role in supplying the eight countries countries with well-adapted vegetable germplasm. In 2014-2016 introduction and evaluation of AVRDC improved germplasm will continue through Regional Varietal Trials. AVRDC germplasm has been successfully involved in State Programs on Breeding and in seed production activities, and will continue to be used in the region.

Climate uncertainty requires that more attention be paid to agricultural diversification in dry conditions with limited water resources through the introduction of drought-, heat- and salt-tolerant lines of vegetable crops, including tomato, pepper and eggplant as well as new varieties of legumes, leafy greens and cabbages, which are important for crop diversification. Development of new varieties based on AVRDC germplasm with valuable commercial traits such as early maturity, resistance to diseases, high yielding and other quality traits will be continued. Testing of around 40 varieties of 14 crop species including tomato, sweet and chili pepper, eggplant, cucumber, vegetable soybean, mungbean, snap bean, pea, custard squash, marrow, lettuce, basil and celery under the State Variety Trials will be continued throughout the region, and new varieties are expected to be submitted for release between 2014 and 2016. Previously released vegetable varieties will be introduced in various regional agroecologies for adoption to diversify and improve diets and to increase farmers' income. Seed multiplication of promising new varieties will be emphasized to enable farmers to be supplied with adequate amounts of quality seed to increase the area under vegetable production.

The cotton- and winter wheat-based cropping system in Central Asia decreases soil fertility. The effect of AVRDC vegetable legumes (vegetable soybean, mungbean) on improving soil fertility will be investigated with research institutes and universities. Adoption of these crops on a larger scale for crop diversification will be encouraged through partnership with government agencies, farmers associations, farmers and local communities.

Vegetable crops in the region are affected by soil-borne diseases, especially those caused by Fusarium spp. Tomato is a very popular crop in the region, but Fusarium disease has significantly decreased tomato yields. AVRDC's promising tomato rootstocks and grafting technology will be evaluated to address soil-borne diseases in selected countries. Grafting with Fusarium disease-tolerant tomato rootstocks will allow farmers to have tomato seedlings that withstand biotic and abiotic stresses, resulting in higher yields.

Consumption of vegetables will provide essential micronutrients. AVRDC's vegetable seed kits will be distributed to home and school gardens, and participatory demonstration vegetable gardens in selected locations of the region will be established to promote vegetable consumption. Vegetable recipes will be developed and promoted in school and community garden programs.

Starting in 2014, AVRDC hopes to conduct activities within the CGIAR Research Program "Integrated Agricultural Production Systems for the Poor and Vulnerable in Dry Areas" at three trans-border action sites (Aral Sea Region, Fergana Valley, and Rasht/Kyzyl-Suv Valley) in Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan in collaboration with, among others, the International Center for Agricultural Research in the Dry Areas, the International Center for Biosaline Agriculture and the International Water Management Institute. The research program aims to address a number of stresses that adversely affect food production and livelihoods in Central Asia. Within the program, AVRDC intends to evaluate improved varieties and advanced lines of food legumes and vegetable crops. Men and women, primarily young researchers and farmers, will be trained to conduct standard field experiments, and carry out crop management and evaluation. Field days will be organized for farmers, researchers,

extension workers, seed producers and policy makers to demonstrate the crops and to permit participatory evaluation of the introduced and local varieties. A seed system platform will be established based on public/private partnerships to tap the knowledge accumulated during years of public sector research and the planning, managerial and organizational capacities of the private sector. The platform will help to make the seed system sustainable, profitable and capable of ensuring timely availability of quality seed. In addition to public-private partnerships, seed multiplication of improved varieties will be addressed through community-based "seed villages" and by promoting farmer-to-farmer seed exchange. Women farmers will be trained and encouraged to take the lead in this activity. Further activities may include innovation platforms for sustainable year-round and market-oriented vegetable production; policy recommendations; dissemination of improved varieties and production technologies; and training activities.

A series of activities will be conducted for capacity building, including training courses and workshops for young specialists and farmers; and training for women to be introduced to modern production technologies and vegetable preparation methods to retain nutrients, especially in the piedmont and mountain areas. Farmer field days will be conducted annually in the eight countries to demonstrate new varieties and technologies and to distribute seeds to increase vegetable production.

AVRDC will continue building capacity to strengthen the scientific and technical proficiency of vegetable professionals to respond to national and regional needs. This will include review and planning with partners to promote adoption of new, innovative technologies to promote sustainable production of quality and safe vegetables for consumption and postharvest processing. Interaction with partners will encourage development of joint projects, collaborative research, information exchange and scientific consultation to facilitate the generation and adoption of improved technologies for vegetable production systems. Strengthening of linkages for acquisition and exchange of relevant information and technologies between and outside the region will be continued. Publications including brochures, articles, posters, booklets and leaflets will be published on vegetable production technologies and the capacity of extension staff and vegetable farmers in the region will be strengthened through training of trainers, farmer training and field days. Meetings with policy makers, decision-makers, donors and NARS leaders will strengthen vegetable research and development to improve the livelihoods of people in the region.

The Center's Projects

Project Title	Donor Name	Duration
Integrated omics on exploring bruchid resistance and improvement of sprouts quality in mungbean (*Vigna radiata* (L.) Wilczek)	Academia Sinica, Taiwan	2013-2016
Vegetable Strategy for AGRA	Alliance for a Green Revolution in Africa	2013-2014
Multilocation evaluation of tomato lines carrying different combinations of Ty genes for resistance against begomovirus infection	Asia and Pacific Seed Association	2013-2014
Improving income and nutrition in Eastern and Southern Africa by enhancing vegetable-based farming and food systems in peri-urban corridors (VINESA)	Australian Centre for International Agricultural Research, Australia	2013-2016
Improving livelihoods with innovative cropping system in the East Indian Plateau	Australian Centre for International Agricultural Research, Australia	2012-2015
Developing an integrated participatory guarantee scheme in the Pacific Islands in support of sustainable production of high-value vegetable crops.	Australian Centre for International Agricultural Research, Australia	2012-2014
Strengthening integrated crop management research in the Pacific Islands in support of sustainable intensification of high value-crop production	Australian Centre for International Agricultural Research, Australia	2011-2016
Improving productivity of allium and solanaceaous vegetable crops in Indonesia and subtropical Australia	Australian Centre for International Agricultural Research, Australia	2013-2015
Strengthening the cooperation between AVRDC – The World Vegetable Center and Taiwan on vegetable research and development	Council of Agriculture, Taiwan	2014
Increased resiliency of vulnerable communities in Puri district, Odisha to recurrent floods	COFRA Foundation, Switzerland	2012-2014
Attraction in Action: Using pheromones and other safe and sustainable management strategies to reduce losses from insect pests and plant diseases on vegetable legumes and leafy brassicas in Southeast Asia	Deutsche Gesellschaft für Internationale Zusammenarbeit, Germany	2013-2016
Beating Begomoviruses: Better livelihoods for farmers in tropical Asia with begomovirus-resistant tomato, hot pepper and mungbean and integrated disease management	Deutsche Gesellschaft für Internationale Zusammenarbeit, Germany	2012-2015
Better bittergourd: Exploiting bittergourd (*Momordica charantia* L.) to increase incomes, manage type 2 diabetes, and promote health in developing countries	Deutsche Gesellschaft für Internationale Zusammenarbeit, Germany	2011-2014

Project Title	Donor Name	Duration
Enhancing horticultural productivity, incomes and livelihoods through integrated management of aphid pests on vegetables in sub-Saharan Africa	Deutsche Gesellschaft für Internationale Zusammenarbeit, Germany	2011-2014
Enhancing the Livelihood Opportunities of Smallholder African Indigenous Vegetable (AIV) Producers through the Development and Implementation of IPM Measures for Arthropod and Nematode pests	Deutsche Gesellschaft für Internationale Zusammenarbeit, Germany	2013-2016
Overcoming conservation and germination problems of selected indigenous vegetables	Deutsche Gesellschaft für Internationale Zusammenarbeit, Germany	2012-2014
Vegetable cucurbits for nutrition-sensitive home and school gardens in Southeast Asia	Deutsche Gesellschaft für Internationale Zusammenarbeit, Germany	2013-2014
Network for knowledge transfer on sustainable agriculture technologies and improved market linkages in South and Southeast Asia (SATNET Asia)	EuropeAid	2011-2014
Implementation of integrated thrips and tospovirus management Strategies in smallholder vegetable cropping systems of Eastern Africa	Federal Ministry for Economic Cooperation and Development, Germany	2012-2015
Safe and effective pest and crop management strategies to strengthen the vegetable value chain in the humid tropicse	Federal Ministry for Economic Cooperation and Development, Germany	2012-2015
African-German partnership to enhance resource use efficiency in urban and peri-urban agriculture for improved food security in West African cities	Federal Ministry for Education and Research, Germany	2012-2015
Diversifying food systems: Learning and innovation in horticultural value chains to improve the livelihood situation of rural and urban poor in Kenya, Ethiopia and Tanzania	Federal Ministry for Education and Research, Germany	2012-2015
RegenIntro: Introduction of accessions from the regeneration initiative into the international collections held by AVRDC	Global Crop Diversity Trust	2013-2015
Vegetable seed kits for flood-affected households in Fiji	Government of Fiji	2012-2014
Bhoochetana Plus	Government of Karnataka, India	2013-2017
Enhancing productivity, competitiveness and marketing of onion in the Sudano-Sahelian region of Cameroon	International Fund for Agricultural Development	2014-2015
Case Study: Enhanced nutritional outcomes of populations through nutrition-sensitive agricultural promotion by a vegetable seed company in Bangladesh	International Fund for Agricultural Development	2013-2014

Project Title	Donor Name	Duration
Good seed initiative	Irish Aid, Ireland	2013-2014
Screening for development of begomovirus-resistant processing tomato hybrid	Kagome Ltd., Taiwan	2013-2015
Lal Teer seconded scientists to AVRDC for breeding program	Lal Teer Seed Ltd., India	2013-2014
Networking to Enhance International Cooperation in Vegetable Research and Development	Ministry of Foreign Affairs, Taiwan	2013-2014
Identification of virus resistance genes in pumpkin and development of the associated marker-assisted selection tools	National Science Council, Taiwan	2012-2014
Training Induced Local Lesions IN Genome of Tomato for Multiple Virus Resistance	National Science Council, Taiwan	2010-2014
Development of Breeding Techniques and Selection of Disease Resistant Germplasm in Cucurbits	Rural Development Administration, Korea	2013-2016
Development of Breeding Techniques and Selection of Virus Resistant Germplasm in Pepper and Tomato	Rural Development Administration, Korea	2013-2015
Vegetables Go to School: Promoting food security and nutrition through school-based approaches	Swiss Agency for Development and Cooperation, Switzerland	2013-2015
Tomato heat tolerance trials in Taiwan	Takii & Co. Ltd., Japan	2013-2014
Value addition of indigenous food crops by low cost sustainable processing: towards poverty reduction, food and nutrition security in sub-Saharan Africa	The Africa Australia Food Security Initiative, Australia	2011-2014
Mobilizing vegetable genetic resources and technologies to enhance household nutrition, income and livelihoods in Indonesia	US Agency for International Development, Indonesia Mission	2010-2014
Improving vegetable production and consumption in Mali	US Agency for International Development, Mali Mission	2013-2014
Postharvest program in Asia and sub-Saharan Africa	US Agency for International Development, USA	2012-2014
Africa RISING: Dietary diversification: integration of vegetables into maize based systems of Babati	US Agency for International Development, USA	2013-2014
Africa RISING: Sustainable intensification of cereal-based farming systems in the Sudano-Sahelian zone	US Agency for International Development, USA	2013-2014
Agricultural Innovation Project: Scientific research and capacity strengthening to promote agricultural growth, poverty reduction, and food security in Pakistan	US Agency for International Development, USA	2013-2014

Project Title	Donor Name	Duration
Urbanization and its impacts on the use of the natural resources in Africa	Volkswagen Foundation	2013-2014
Enhancing productivity, competitiveness and marketing of traditional African (leafy) vegetables for improved income and nutrition in West and Central Africa	West and Central Africa Council for Agricultural Research and Development	2012-2014

Research and Development

Training the next generation of agricultural researchers

Theme outlooks and output targets 2014-2016

AVRDC – The World Vegetable Center aims to generate positive impacts that contribute to reducing poverty and malnutrition among our beneficiaries. The Center's rigorous research contributes to new knowledge development and delivers applicable technologies. Appropriate technologies are developed, adapted and tested with partners and adopted by end users. While opportunities and needs sometimes constrain the balancing act between research and development activities, the Center nevertheless retains flexibility in its diverse project portfolio to ensure effective technology development, dissemination, and uptake.

The Center does not have a defined crop species mandate, and its target crop portfolio has changed over the years. The constant criterion is that the crops are nutritious and health-promoting vegetables. The shift of focus on our target crops may be driven by global needs, our comparative advantages and competencies, economics and/or donor priorities. Disciplinary focus and diversity of the Center's research and development work also need to be shifted and readjusted from time to time.

AVRDC – The World Vegetable Center organizes its research and development work under four global themes: Germplasm,

Breeding, Production and Consumption, to address all aspects of the vegetable value chain. Currently, the Center's crop portfolio comprises tomato, sweet and chili pepper, onion, cucumber, pumpkin, some crucifers, mungbean and traditional vegetables (bitter gourd, African eggplant and nightshade, slippery cabbage, okra, amaranth, roselle, Malabar spinach and moringa, among others).

Competent teams of scientists and support staff members implement the Center's work in various parts of the world, taking into account local stakeholders' needs, resources and concerns. A diversity of disciplines, skills and ethnicity within each of the Center's geographic locations lends to flexibility, perceptiveness and innovative strength to the research and development teams. They respond effectively to changing constraints and opportunities of vegetable production, marketing and consumption—issues that are globally important and which directly influence local circumstances, or conversely, local problems with global pertinence.

The disciplines represented in the Center's scientific teams are: Plant Breeding (Bulb Allium, Cucurbits, Traditional Vegetables, Legumes, Pepper and Tomato), Plant Pathology (Bacteriology, Mycology, and Virology), Entomology, Biotechnology/Molecular Breeding, Nutrition, Socioeconomics, Genetic Resources and Seed Systems, and Global Technology Dissemination. These are supported by Biometrics, Communications and Information, Intellectual Property Management, Information Technology, Grants and Partnership Development, Human Resources, Financial Services, Administration Services, Technical Services and Food and Dormitory Services.

The following thematic outlooks and logical frameworks provide a detailed yet concise workplan for each theme's activities, outputs, and expected outcomes for 2014-2016, and serve as a benchmark for monitoring and evaluation.

Biodiversity is the backbone of plant breeding

Theme Germplasm

2014 and Beyond

The AVRDC genebank is the fifth largest international public genebank in the world and the largest public sector collection of vegetable genetic resources, with 67,817 accessions and sub-accessions (60,899 original accessions) presently in the collection. AVRDC maintains the genebank and its diverse germplasm representing more than 170 genera and 430 species in perpetuity for the benefit of current and future generations. Preservation and full characterization of vegetable biodiversity fulfills the Center's responsibilities to the world's plant breeding community and to the generations ahead, and will help to meet future challenges in the face of global climate change.

Agricultural production must increase by 70% by 2050 to cope with an estimated 40% increase in world population. The world must strive for sustainable food production and reduce the negative externalities of current food production systems. The time is ripe to harness the full power of existing yet underutilized agricultural biodiversity. There is significant potential to domesticate new crops and enhance the productivity and sustainability of current food production systems.

The biodiversity conserved in genebanks is the backbone of advances in plant breeding. Since the mid-1990s, progress in conventional plant breeding has been slowing down, partly due to the limited use that has been made of the existing biodiversity. Landraces, crop wild relatives and undomesticated wild species are valuable sources of new variation to sustain productive agriculture. Those under-used plants have excellent local adaptation and have survived extreme environmental challenges, but their resilience and adaptive capacity is poorly understood and remains largely untapped.

Characterization of AVRDC's genebank entries is an ongoing task. Apart from morphological characterization and agronomic evaluation, molecular characterization at the DNA level is an excellent tool to accomplish this task. In the past, simple sequence repeat markers have been used for genebank accession characterization and trait mapping. For many under-researched species these markers were scarce. AVRDC has started to apply genotyping by sequencing methods on vegetables, both for a model crop, tomato, and a non-model crop, mungbean. The initial results indicate that this method yields large numbers of polymorphic markers for applications such as genetic diversity analysis, linkage mapping or genome-wide association mapping. While microsatellite markers have very low polymorphism levels in mungbean mapping populations, genotyping by sequencing made it possible to produce more than 1500 polymorphic markers for such populations. Open source bioinformatics programs can process huge amounts of sequence data and extract useful markers for downstream applications. In addition to the provision of sequence data, genebank accessions must also be phenotyped to evaluate their traits and overall performance. This is a very challenging, complex and costly task. Using sequence data in combination with phenotypic, geographical and ecological information will enable researchers to develop strategic field experiments and models that can predict plant performance. This will make vegetable breeding more efficient and cost-effective.

Preservation of vegetable genetic resources for global crop improvement

AVRDC strives to fill gaps in its collections and hopes to expand its diverse collection of traditional vegetables, which are key to diversifying diets and reducing malnutrition. These traditional vegetables are under severe threat of genetic erosion.

Only about half of all AVRDC germplasm is currently available for worldwide distribution due to lack of sufficient, highly viable seed stock. Particularly for the genera *Cucurbita* and *Vigna*, there is a regeneration backlog of more than 70% of the accessions held. Nearly 27,000 accessions are overdue for regeneration and characterization. The Center works to reduce the backlog to make most of the germplasm available. Different vegetable species require different cultural management practices, isolation systems, seed processing procedures and descriptors for detailed characterization of morphological and agronomic traits. Regeneration and characterization are resource-intensive activities, and the specialized and varied requirements for different species constrain timely regeneration of germplasm.

Seed distribution to external as well as internal users is a major function of AVRDC's Genetic Resources and Seed Unit (GRSU). All seed samples that leave the Center pass through GRSU for monitoring and quarantine purposes. In 2013, for the first time since the introduction of germplasm processing and handling fees, more than

10,000 germplasm samples (5292 genebank accessions and 4767 breeding lines) were distributed, and we hope to maintain or exceed this level of distribution in the coming years.

Safety duplication of valuable AVRDC germplasm outside of Taiwan is a major safeguard measure to protect the germplasm against unforeseeable events such as earthquakes, flooding and fire. AVRDC collaborates with two major deposit sites: the Svalbard Global Seed Vault currently conserving 12,769 AVRDC accessions (21.3% of our holdings) and the National Agrobiodiversity Center of the Rural Development Administration in South Korea, conserving a similar number of AVRDC accessions. Sub-samples of freshly regenerated accessions will be set aside every year for safety duplication at the two sites.

Conserving and safeguarding germplasm is of little value for users if related information is not available or not accessible. AVGRIS, a software program developed and used by AVRDC, links and documents all genebank operations associated with germplasm conservation and management. This information system assists the GRSU staff in routine genebank activities, facilitates the recording, storage, and maintenance of germplasm data, and provides direct access to information pertaining to accessions for AVRDC staff as well as potential users of AVRDC germplasm worldwide through the AVGRIS link on the AVRDC website. AVGRIS allows data searches at three levels: passport, characterization, and evaluation.

Characterization of germplasm to enhance understanding and utilization of biodiversity

Morphological characterization of accessions during the regeneration process is a major task of the genebank curators; data is validated and then uploaded to AVGRIS. GRSU staff strive to complement morphological with molecular characterization of germplasm accessions. Curators and breeders require information on the genetic diversity present in their collections or populations to make decisions on conservation and breeding strategies. For this purpose, a diversity analysis of selected *Momordica* accessions will be made. Methods for mapping agronomical traits, such as association genetics studies, require insight into the genetic diversity and population structure of the germplasm panel under investigation. Molecular characterization of the wild tomato *Solanum pimpinellifolium* collection is a first step towards mapping agronomical traits in this gene pool.

Genebank accessions of outcrossing plants generally are not pure lines; breeders usually require pure lines for their crop improvement programs. Pure lines of some crops are scarce, especially for under-researched crops such as traditional African vegetable species. AVRDC plans to use molecular tools to monitor the purification of heterogeneous genebank accessions for breeding purposes.

Core collections increase access to the biodiversity stored in genebanks. Core collections typically comprise 10 – 20% of the total germplasm collection of a species, and aim to maintain 80% of the genetic diversity present in the whole collection. Core collections are designed to contain maximal genetic variation and minimal repetitiveness. The first step in establishing a core collection is the stratification of the whole collection into groups with maximal variation between and minimal variation within the groups. Cluster analysis using a combination of morphological and molecular characteristics is appropriate for this purpose.

AVRDC plans to develop core collections for okra, mungbean and pumpkin to facilitate breeders' access to the biodiversity of these crops. Characterization of the genetic diversity of the okra and mungbean genebank accessions is in progress, and first insights into the diversity of the collection and the genetic relationships between the accessions are available. A large core collection for mungbean already has been produced; it will be refined into a mini-core collection by 2015. A core collection of about 200 genotypes of okra representing the whole collection will be accomplished in 2014, and for pumpkin the creation of a core collection will be initiated.

Trait-based characterization and screening to enhance germplasm for effective use of important horticultural traits in the development of new cultivars

Insect pest and disease resistance genes, often originating from wild relatives of cultivated species, are required for vegetable breeding. Trait-based screening of vegetable crops is a major effort at AVRDC to identify resistant candidate genotypes for subsequent use in breeding.

Virus diseases pose a major threat to vegetable production in the tropics and subtropics. AVRDC is currently trying to identify and characterize sources of resistance to locally important begomoviruses infecting mungbean and chili pepper in India, Thailand and Vietnam. *Capsicum* germplasm will be screened for resistance to *Pepper mottle virus*, a potyvirus, and the inheritance mechanism will be studied. Cucurbit accessions will be screened for resistance to *Squash leaf curl Philippines virus*, a begomovirus, and the underlying inheritance mechanism will be elucidated. Screening methods will be developed and optimized to assess leguminous germplasm for resistance to *Bean common mosaic virus*, a potyvirus. Screening of yard-long bean germplasm for resistance to *Bean common mosaic virus* is envisioned for 2015.

Resistance against anthracnose, a pepper disease caused by various *Colletotrichum* species, is an important breeding target. The diversity of the pathogen and environmental influences such as humidity and temperature make the interaction of the anthracnose pathogens with the pepper plant highly complex. Identification of germplasm resistant against multiple pathogen strains and across various environments, as well as improving screening protocols for anthracnose resistance, is planned for 2014 and subsequent years. Bacterial wilt is a threat to tomato production in many regions. The variability of the pathogen (*Ralstonia solanacearum*) and environmental influences complicate the identification of stable resistance to this pathogen. Fine-mapping of previously identified resistance genes in near-isogenic lines is planned to help produce breeding lines with improved disease resistance phenotypes.

The identification and characterization of sources of resistance to insect and mite pests is another major effort at AVRDC. Okra accessions with resistance to aphids and leafhoppers already have already been identified; the mechanism of this resistance must now be understood. Amaranth accessions will be screened for resistance to leaf webber and stem weevil, and the resistance of onion accessions to thrips will be confirmed and the mechanism of resistance elucidated. Resistance of pepper accessions to thrips and broad mite will be confirmed in Bangladesh. Due to monocropping and partial resistance to pesticides, red spider mite (*Tetranychus* sp.) is becoming a major threat for the production of African eggplant and African nightshade. AVRDC germplasm of these

two crops will be screened for resistance to red spider mite to support breeders in the development of resistant cultivars.

The whitefly (*Bemisia tabaci*) is highly polyphagous, and is known to feed on several vegetables including tomato, eggplant and okra. *B. tabaci* also acts as vector for several viral diseases including Tomato yellow leaf curl virus. Biological control and pesticides are not effective enough in open field cultivation to prevent whitefly outbreaks. Recently, whitefly resistance was detected in *S. galapagense*, a close relative of cultivated tomato. In contrast to other wild tomato resistance sources, whitefly resistance in *S. galapagense* is either conditioned by a single gene or at least simply inherited, offering great prospects for resistance breeding. For this reason, *S. galapagense* accessions conserved in AVRDC's Genebank will be screened for resistance to *B. tabaci.*

The evaluation of vegetable germplasm for selected nutrition-related compounds is another important area of trait-based screening. Nutrient databases will be initiated in Mali, Burkina Faso, Cameroon, Nepal and Bhutan. Information on vegetables at species and cultivar level of popular and underutilized crops will be collected. Reported phytonutrient data will be searched and documented. For those vegetables with unavailable nutrient data, a list will be prepared and proposed for planting and subsequent nutritional evaluation. Laboratory analyses of selected macronutrients, micronutrients and bioactive phytochemicals will be conducted based on funded collaborative projects. The nutrient database will be web-based, interactive, user-friendly and open access.

Development of specialized genetic materials, molecular tools, and methods to enhance the development of new varieties

Once a source of resistance genes has been identified, methods for efficient and cost-effective selection of resistant genotypes in segregating populations are critical for breeding. In the past, breeders relied on natural epidemics in the field, or greenhouse screening protocols, to identify resistant plants. Today, selection is increasingly based on molecular markers linked to resistance genes. Tomato is a model crop; advances in molecular marker technology and genome sequencing have resulted in the development of a large number of DNA markers in tomato. These are routinely used to develop linkage maps and identify quantitative trait loci associated with disease resistance traits to facilitate molecular breeding. Advances in genomics technologies provide better access to markers for non-model species, opening up possibilities for marker-assisted selection technologies for a range of crops. Marker-assisted breeding allows genotypic selection for resistance traits, reduces dependence on tedious phenotypic selection, and facilitates the combination of multiple disease resistance genes in breeding lines. During the coming years, molecular markers for resistance genes against devastating bacterial, oomycete, fungal and viral diseases of tomato, pepper, mungbean and pumpkin, as well as resistance genes in mungbean against insects will be identified in populations segregating for the resistance trait. These molecular markers and resistant germplasm will be used by breeders to speed up the breeding process.

Parallel to the efforts to identify disease resistance genes in wild species for conventional breeding, genetic engineering methods are being explored to induce virus resistance in tomato. RNA interference has been applied successfully to produce transgenic tomato lines resistant to multiple begomovirus strains. The transgenic plants will most likely not be used for

variety development, but access to RNA interference technology might become important in the future to combat diseases for which no resistance genes are available in the germplasm pool.

Environmental stresses such as heat, high salinity and flooding are major constraints for vegetable production. Saline soils or salty irrigation water increasingly limit agricultural production in many regions of the world. Improving salt tolerance of vegetable crops can help farmers in regions threatened by soil and water salinization to maintain productivity. Breeding salt tolerant crops is complex due to the large number of genes that contribute to this trait. Tomato is an excellent model for studying salt tolerance in crops. A number of salt tolerance candidate genes have been identified in wild relatives of tomato that could be used in breeding. *S. pimpinellifolium* is the closest wild relative to tomato and can be readily crossed with *S. lycopersicum*. It has been used as a donor for many important horticultural traits of cultivated tomato, but except for one tolerance gene improving fruit weight under salinity, none of the salinity tolerance genes present in this species have been used in tomato breeding. AVRDC plans to apply a combination of different trait mapping methods to identify salt tolerance genes in wild tomato and transfer these genes into cultivated tomato.

Flooding is another major environmental stress to agricultural productivity, especially in tropical regions. Up to now, flood tolerant vegetable varieties have been scarce, but periodic flooding of field trials during the summer months in Taiwan has pinpointed some flood tolerant tomato lines in the AVRDC germplasm collection. During the coming years, systematic screening of genebank accessions will identify any flood tolerant lines that can be channeled into breeding programs.

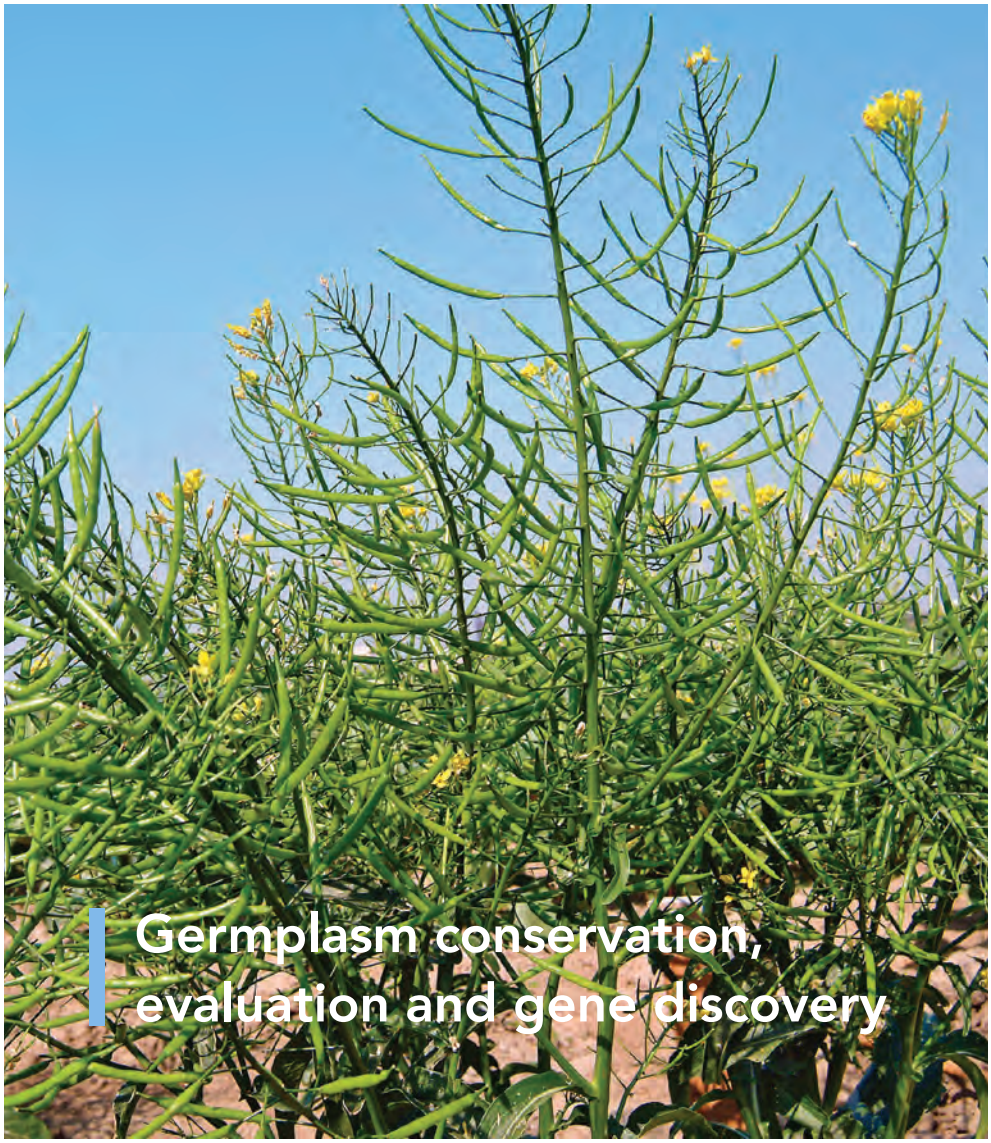
Heat stress tolerance research will be continued. Over recent years, genomic regions containing heat stress tolerance genes in tomato were identified. The tolerance traits will be fine-mapped and new heat tolerant material will be explored for improved heat tolerance traits.

Recent developments in genome sequencing technologies and bioinformatics provide unprecedented access to molecular markers. Technologies such as restriction enzyme associated DNA (RAD) sequencing have been successfully applied to AVRDC's breeding populations and have resulted in broad availability of molecular markers for crops; until recently, few such tools have been available. Over the next few years, implementation of next generation sequencing methods will be continued to speed up the generation of significant marker resources and improve the quality of markers available for AVRDC mandate crops, and to map biotic and abiotic stress tolerance genes.

Developing capacity in germplasm conservation, characterization, evaluation, and gene discovery

Training of human resources—either individually or in groups, on the job or in specialized training activities—in vegetable genetic resources conservation, management, and evaluation using conventional and advanced techniques continues to be a major focus.

Bruinsma J. 2009. The Resource Outlook to 2050: By How Much do Land, Water and Crop Yields Need to Increase by 2050? In Proceedings of the Technical Meeting of Experts on How to Feed the World in 2050, Rome, Italy, 24–26 June 2009. Food and Agriculture Organization (FAO): Rome, Italy, 2009; pp. 1–33.



Germplasm conservation, evaluation and gene discovery

GOAL

Biodiversity of vegetable genetic resources is preserved and its utilization for food and nutritional security is enhanced

PURPOSE

Vegetable germplasm collected, conserved and distributed; the collection evaluated to identify those accessions with desirable traits, and their genes identified, characterized, and introgressed using classical and molecular technologies

Output 1: Vegetable genetic resources (including wild relatives, breeding materials, genetic stocks and populations) collected, conserved and distributed

Outcome: Vegetable genetic resources preserved and made available globally for crop improvement

ACTIVITY 1.1

Collect/acquire and conserve vegetable and legume germplasm

Output Targets 2014

- 150 accessions collected/acquired at the Center's headquarters
- Effect of storage conditions on the germination rate of bitter gourd determined
- Effect of seed priming techniques on germination rate and field establishment of stored seed of bitter gourd, okra, and water spinach determined
- 100 accessions/breeding lines collected/acquired from countries in sub-Saharan Africa (SSA) for safety duplication in Eastern and Southern Africa office

Output Targets 2015

- 150 accessions collected/acquired at the Center's headquarters
- 100 accessions/breeding lines collected/acquired from countries in SSA for safety duplication in Eastern and Southern Africa office

Output Targets 2016

- 150 accessions collected/acquired at the Center's headquarters
- 100 accessions/breeding lines collected/acquired from hubs in SSA for safety duplication in Eastern and Southern Africa office

ACTIVITY 1.2

Maintain effective regeneration of priority vegetable germplasm

Output Targets 2014

- 1400 accessions regenerated at the Center's headquarters
- 250 accessions regenerated at Eastern and Southern Africa office
- Good quality seeds produced and increased: 10 crops for nutritional seed kits; advanced lines for multilocation and on-farm trials; maintenance of breeder seed materials
- Seeds of recommended eggplant, chili pepper, tomato and fig-leaf gourd rootstocks produced for training and/or distribution

Output Targets 2015

- 1400 accessions regenerated at the Center's headquarters

ACTIVITY 1.2	• 250 accessions regenerated at Eastern and Southern Africa office • Good quality seeds produced and increased: 10 crops for nutritional seed kits; advanced lines for multilocation and on-farm trials; maintenance of breeder seed materials • Seeds of recommended eggplant, chili pepper, tomato and fig-leaf gourd rootstocks produced for training and/or distribution *Output Targets 2016* • 1400 accessions regenerated at the Center's headquarters • 250 accessions regenerated at Eastern and Southern Africa office • Good quality seeds produced and increased: 10 crops for nutritional seed kits; advanced lines for multilocation and on-farm trials; maintenance of breeder seed materials • Seeds of recommended eggplant, chili pepper, tomato and fig-leaf gourd rootstocks produced for training and/or distribution
ACTIVITY 1.3 Distribute vegetable germplasm accessions and improved lines worldwide	*Output Targets 2014* • 80% of vegetable germplasm requests served • 5,000 accessions/breeding lines distributed worldwide from headquarters • 700 accessions/breeding lines distributed by Eastern and Southern Africa office to public and private partners *Output Targets 2015* • 80% of vegetable germplasm requests served • 5,000 accessions/breeding lines distributed worldwide from headquarters • 700 accessions/breeding lines distributed by Eastern and Southern Africa office to public and private partners *Output Targets 2016* • 80% of vegetable germplasm requests served • 5,000 accessions/breeding lines distributed worldwide from headquarters • 700 accessions/breeding lines distributed by Eastern and Southern Africa office to public and private partners
ACTIVITY 1.4 Safety duplicate AVRDC - The World Vegetable Center's germplasm in other genebanks	*Output Targets 2014* • 750 accessions from the Center's headquarters duplicated at National Agrobiodiversity Center, Korea and Svalbard Global Seed Vault, Norway

ACTIVITY 1.4

- 150 accessions from Eastern and Southern Africa office duplicated at the Center's headquarters and Svalbard Global Seed Vault, Norway

Output Targets 2015

- 750 accessions from the Center's headquarters duplicated at National Agrobiodiversity Center, Korea and Svalbard Global Seed Vault, Norway
- 150 accessions from Eastern and Southern Africa office duplicated at the Center's headquarters and Svalbard Global Seed Vault, Norway

Output Targets 2016

- 750 accessions from the Center's headquarters duplicated at National Agrobiodiversity Center, Korea and Svalbard Global Seed Vault, Norway
- 150 accessions from Eastern and Southern Africa office duplicated at the Center's headquarters and Svalbard Global Seed Vault, Norway

ACTIVITY 1.5

Systematically store information on conservation and distribution of vegetable germplasm in AVRDC - The World Vegetable Center's electronic databases

Output Targets 2014

- 100% of acquisition and distribution data generated in 2013 entered into the Center's Vegetable Genetic Resources Information System (AVGRIS), Seed Distribution Database and Eastern and Southern Africa office's database
- Characterization and evaluation data of the 2011/12 regeneration cycle made available in AVGRIS and Eastern and Southern Africa office's database

Output Targets 2015

- 100% of acquisition and distribution data generated in 2014entered into the Center's Vegetable Genetic Resources Information System (AVGRIS), Seed Distribution Database and Eastern and Southern Africa office's database
- Characterization and evaluation data of the 2012/13 regeneration cycle made available in AVGRIS and Eastern and Southern Africa office's database

Output Targets 2016

- 100% of acquisition and distribution data generated in 2015 entered into the Center's Vegetable Genetic Resources Information System (AVGRIS), Seed Distribution Database and Eastern and Southern Africa office's database
- Characterization and evaluation data of the 2013/14 regeneration cycle made available in AVGRIS and Eastern and Southern Africa office's database

Output 2: Germplasm characterized to enhance understanding and utilization of biodiversity in the vegetable germplasm collections

Outcome: Genetic diversity of AVRDC – The World Vegetable Center germplasm collections determined and core collections established and validated

ACTIVITY 2.1

Characterize morphological traits of vegetable germplasm maintained at AVRDC and its Regional Centers

Output Targets 2014

- 1400 accessions at the Center's headquarters and 250 accessions at Eastern and Southern Africa office characterized, based on standard morphological descriptors
- Seed of 50 GRSU *C. moschata* accessions multiplied and preliminary evaluation completed
- Characterization of selected genebank accessions in Central Asia and the Caucasus region

Output Targets 2015

- 1400 accessions at the Center's headquarters and 250 accessions at Eastern and Southern Africa office characterized, based on standard morphological descriptors
- Seed of 50 GRSU *C. moschata* accessions multiplied and preliminary evaluation completed
- Characterization of selected genebank accessions in Central Asia and the Caucasus region

Output Targets 2016

- 1400 accessions at the Center's headquarters and 250 accessions at Eastern and Southern Africa office characterized, based on standard morphological descriptors
- Seed of 50 GRSU *C. moschata* accessions multiplied and preliminary evaluation completed
- Characterization of selected genebank accessions in Central Asia and the Caucasus region

ACTIVITY 2.2

Conduct molecular characterization, genetic relationship and diversity analysis of germplasm collection

Output Targets 2014

- Information on begomovirus resistance traits in pepper made available
- Molecular characterization of the *Abelmoschus* germplasm collection accomplished (800 accessions)
- Genetic diversity among 100 important *Momordica* lines and germplasm accessions determined

Output Targets 2015

- Diversity and population structure of wild tomato species *Solanum pimpinellifolium* established using genome-wide single nucleotide polymorphic markers

ACTIVITY 2.2

Output Targets 2016

- Molecular tools for purity analysis for major African traditional vegetable accessions made available and in use

ACTIVITY 2.3

Develop, characterize, and validate AVRDC germplasm core collections

Output Targets 2014

- *Abelmoschus* core collection accomplished
- Mungbean core collection accomplished

Output Targets 2015

- Pumpkin core collection accomplished

Output 3: Trait-based characterization and screening to enhance vegetable germplasm for effective use of important horticultural traits in the development of new vegetable cultivars

Outcome: Superior sources of genes for important horticultural traits identified

ACTIVITY 3.1

Identify and characterize sources of resistance to viral diseases

Output Targets 2014

- Mungbean and hot pepper germplasm of F_3 families screened for resistance to local begomoviruses in the field in India, Thailand and Vietnam
- Cucurbits screened for resistance to *Squash leaf curl Philippines virus* (SLCuPV; *Begomovirus*), and study of inheritance of virus resistance in *C. moschata* continued
- Method for screening leguminous germplasm for resistance to *Bean common mosaic virus* (BCMV; *Potyvirus*) developed/optimized and host range of Taiwan strain assessed

Output Targets 2015

- Yard-long-bean germplasm screened for resistance to *Bean common mosaic virus* (BCMV; *Potyvirus*)
- Cucurbits screened for resistance to *Squash leaf curl Philippines virus* (SLCuPV; *Begomovirus*), and study of inheritance of virus resistance in *C. moschata* continued
- *Capsicum* germplasm screened for resistance to *Pepper mottle virus* (PepMoV; *Potyvirus*)

Output Targets 2016

- Yard-long-bean germplasm screened for resistance to *Bean common mosaic virus* (BCMV; *Potyvirus*)
- *Capsicum* germplasm screened for resistance to *Pepper mottle virus* (PepMoV; *Potyvirus*), and inheritance study of potyvirus resistance in *Capsicum* spp. started

ACTIVITY 3.2

Identify and characterize sources of resistance to fungal and bacterial diseases

Output Targets 2014

- Resistance to anthracnose in pepper characterized on detached fruits with different screening protocols and against field pathogen populations in Southeast and East Asia (Taiwan, Korea and Thailand)
- Germplasm accessions with resistance to multiple diseases to be used as potential rootstocks for tomato and sweet pepper production identified

Output Targets 2015

- Resistance to anthracnose in pepper characterized against field pathogen populations in Southeast Asia (Indonesia) and South Asia (India)
- Germplasm accessions with resistance to multiple diseases to be used as potential rootstocks for tomato and sweet pepper production identified

Output Targets 2016

- Germplasm accessions with resistance to multiple diseases to be used as potential rootstocks for tomato and sweet pepper production identified

ACTIVITY 3.3

Identify and characterize sources of resistance to insect and mite pests

Output Targets 2014

- Mechanisms and bases of resistance to aphid and leafhopper in selected okra accessions characterized
- Onion accessions confirmed for resistance to thrips
- Pepper accessions confirmed for resistance to thrips and broad mite in Bangladesh
- *Solanum galapagense* accessions confirmed for resistance to whitefly and red spider mite

Output Targets 2015

- Mechanisms and bases of resistance to thrips in selected onion accessions characterized
- Mechanisms and bases of resistance to whitefly and red spider mite in *S. galapagense* accessions characterized
- Amaranth accessions screened for resistance to leaf webber and stem weevil

Output Targets 2016

- African eggplant and African nightshade accessions screened for resistance to red spider mite
- Mechanisms and bases of resistance to leaf webber and stem weevil in amaranth accessions characterized

ACTIVITY 3.4

Identify and characterize sources of tolerance to drought, heat, flooding and salinity stress

Output Targets 2014

- Germplasm sources of tomato for salt tolerance identified

Output Targets 2015

- Flooding tolerance screening method for tomato established

Output Targets 2016

- Flooding and salt tolerant source materials for selected vegetable crops (other than tomato) identified

ACTIVITY 3.5

Evaluate vegetable germplasm for selected nutrition-related compounds

Output Targets 2014

- Measured nutritional and functional values of vegetable species/accessions which have not been evaluated and included in the nutrient database, targeting women to consume vegetables with nutrients required during pregnancy

Output Targets 2015

- Nutrient database of vegetables in Mali, Burkina Faso, Cameroon, Nepal, and Bhutan initiated

Output Targets 2016

- Nutrient database of vegetables in Mali, Burkina Faso, Cameroon, Nepal, and Bhutan continued

Output 4: Specialized genetic materials, molecular tools, and methods developed to enhance the creation of new varieties

Outcome: Genes conferring improved horticultural traits introgressed, genetically mapped, and DNA markers developed for marker-assisted selection

ACTIVITY 4.1

Develop mapping populations and identify QTLs for resistance to biotic stresses

Output Targets 2014

- Tomato gene Ph4t associated with resistance to late blight mapped
- Begomovirus resistance loci in pepper identified and mapped
- Candidate resistance loci against *Zucchini yellow mosaic virus* (ZYMV) in pumpkin populations identified
- Mungbean mapping populations segregating for bruchid resistance produced

ACTIVITY 4.1

Output Targets 2015

- Markers for begomovirus resistance in mungbean and pepper validated for breeding purposes

Output Targets 2016

- Validated markers for anthracnose resistance in pepper available
- Quantitative trait loci (QTLs) for bruchid resistance in mungbean available

ACTIVITY 4.2

Develop mapping populations and identify QTLs for tolerance to abiotic stresses

Output Targets 2014

- Mapping populations for salt tolerance developed
- Combined gene expression and QTL analysis in bi-parental populations of *S. lycopersicum* conducted to identify genes involved in heat tolerance

Output Targets 2015

- Mapping populations derived from new resistance sources established to mobilize new heat stress tolerance traits in tomato
- QTLs for heat tolerance elucidated

Output Targets 2016

- Populations derived from multiple parents combining heat stress tolerance and good fruit traits developed
- Combined QTL analysis in bi-parental populations and in a germplasm sample conducted to identify QTLs for salt tolerance in tomato

ACTIVITY 4.3

Conduct fine mapping of QTLs and develop markers for marker-assisted selection (MAS)

Output Targets 2014

- Dissect the major QTLs of gene *Bwr-6* for bacterial wilt resistance in tomato by developing near-isogenic lines
- Fine-map and evaluate the efficiency of marker-assisted selection of potential markers using segregating populations of LA3920
- Effect of different subsections of the *Bwr-6* gene conferring resistance to bacterial wilt in tomato assessed by fine-mapping using near isogenic lines

Output Targets 2015

- Durability of *Bwr* QTLs evaluated

Output Targets 2016

- Gene-based marker for bruchid resistance available for use in molecular assisted selection (MAS) of breeding programs

ACTIVITY 4.4

Assemble and develop molecular marker sets for priority vegetable crops

Output Targets 2014

- A set of suitable markers developed for Bulked Segregant Analysis in *C. moschata*
- Molecular markers for selection for tomato-infecting begomovirus, nematode and late blight resistance in tomato validated in a breeding population
- Restriction site associated DNA (RAD) sequencing for pepper established to obtain and map a large number of molecular markers in populations

Output Targets 2015

- Methods of genotyping by sequencing available for vegetable crops

Output Targets 2016

- Gene-based markers have largely replaced markers linked to traits in MAS

Output 5: Genes affecting important horticultural traits isolated, validated, and functionally analyzed using genomics and molecular technologies

Outcome: Gene markers associated with important horticultural traits developed and pathogen-derived resistance to tomato yellow leaf curl viruses based on RNA interference explored

ACTIVITY 5.1

Allele mining to identify variation conferring superior traits

Output Targets 2014

- At least 200 M2 families of a tomato mutant population screened for putative loss of susceptibility to *Cucumber mosaic virus* in five candidate genes through next generation sequencing and Targeting Induced Local Lesions IN Genomes (TILLING)

Output Targets 2015

- Begomovirus resistance alleles of at least one resistance gene in mungbean identified

Output Targets 2016

- Salt tolerance genes and tolerance alleles in tomato identified
- Bruchid resistance alleles in mungbean identified
- Alleles conferring beneficial nutritive traits in mungbean (sulfur amino acid content) identified

ACTIVITY 5.2 Characterize and validate candidate genes for heat and salt tolerance	*Output Targets 2015* • Heat tolerance genes validated in tomato *Output Targets 2016* • Salt tolerance genes identified in tomato
ACTIVITY 5.3 Evaluate gene function and efficacy through genetic engineering	*Output Targets 2014* • Screening of R3 lines and transformation of shorter bi-RNAi constructs (TY_{12} and TY_{13}) to develop a potential alternative strategy for resistance to tomato yellow leaf curl viruses *Output Targets 2015* • Transformation of TY_{12} and TY_{13}, virus screening and advancement of potential resistance lines *Output Targets 2016* • Evaluation of best RNAi strategy for resistance to tomato yellow leaf curl viruses in tomato

Output 6: Capacity in germplasm conservation, evaluation, characterization, and gene discovery developed

Outcome: Skills of national agricultural research and extension systems' scientists in germplasm conservation, utilization and gene discovery enhanced

ACTIVITY 6.1 Train human resources, ensuring women enrollment, in vegetable genetic resources conservation, management, and evaluation using conventional and advanced techniques	*Output Targets 2014* • Training courses conducted for men and women on germplasm conservation and management, and use of molecular tools for biodiversity analysis and germplasm evaluation • Various vegetable accessions/lines, production technologies and nutritional information displayed in the demonstration garden for information dissemination to at least 500 visitors, and shared through community education for men and women • AVRDC's germplasm and technologies showcased in Taiwan's annual Seeds and Seedling Festival and other events

ACTIVITY 6.1

Output Targets 2015

- Training courses conducted for men and women on germplasm conservation and management. Various vegetable accessions/lines, production technologies and nutritional information displayed in the demonstration garden for information dissemination to at least 500 visitors, and shared through community education for men and women
- AVRDC's germplasm and technologies showcased in Taiwan's annual Seeds and Seedling Festival and other events

Output Targets 2016

- Training courses conducted for men and women on germplasm conservation and management
- Various vegetable accessions/lines, production technologies and nutritional information displayed in the demonstration garden for information dissemination to at least 500 visitors, and shared through community education for men and women
- AVRDC's germplasm and technologies showcased in Taiwan's annual Seeds and Seedling Festival and other events

Vegetables adapted to the heat and humidity of the tropics benefit farmers

Theme Breeding

2014 and Beyond

Since its founding, AVRDC – The World Vegetable Center has understood the importance and potential contributions that superior, tropically adapted vegetable cultivars could make to better the lives of farmers and their families. Improved cultivars are one of the cheapest, simplest and most effective technologies for farmers to improve their vegetable production; they do not require specialist knowledge to deploy. Development of tropical vegetable cultivars poses great challenges because of the many desired traits for a tropical vegetable variety: tolerance to heat, too much or too little rainfall and to other environmental stresses; resistance to the many pests and diseases present in the tropics; capacity to withstand rough postharvest handling and superior quality; nutritional content of the produce.

AVRDC vegetable breeding has built a solid global reputation for tropically adapted breeding lines and stands out as one of a handful of vegetable breeding programs developing new inbred lines. The Center is able to use its genetic resources, including many wild species, to improve traits important in tropical agriculture, including nutritional content of the vegetables.

AVRDC has invested heavily in vegetable breeding and reflection on AVRDC's future direction in breeding should consider the vegetable breeding history, bottlenecks, opportunities, drivers of change and their implications.

Tomato, chili, and sweet pepper: These breeding programs are the largest and most continuous at AVRDC. Breeding strategies for these crops have been "tropicalizing" tomato and sweet pepper by incorporation of heat tolerance and multiple disease resistance, and stabilizing chili yield through multiple disease resistance. Major tomato breeding activities currently include development of lines combining virus and vector resistances for stable resistance to tomato yellow leaf curl disease, lines with high beta-carotene/high carotenoid content, mapping heat tolerance, and introgression of late blight resistance from wild tomato. Pepper breeding activities include identification and introgression of anthracnose and begomovirus resistance, studies on mechanisms of heat tolerance in sweet pepper, and incorporation of cytoplasmic male sterility.

Legumes: The mungbean breeding program was revived after its transfer to the Center's South Asia office in Hyderabad, India and recruitment of a legume breeder. Breeding priorities include resistance to bruchids and *Mungbean yellow mosaic virus*, incorporation of high methionine content into mungbean from black gram, and the use of mungbean for sprouts. Vegetable soybean is popular in parts of East Asia, has high protein content, and the plants can be used as green manure. Research objectives included incorporation of photoperiod insensitivity, basmati flavor, and super-nodulating soybean.

Allium: Onion breeding was transferred to Mali because of the regional importance of onion, a suitable environment for seed production, and presence of a full-time onion breeder. The program currently evaluates Taiwan-developed onion lines for yield, early maturity, bulb qualities, and shelf life, and also selects lines within local landraces such as Violet de Galmi.

Cucurbits: AVRDC cucurbit breeding began in 2007, based at AVRDC's East and Southeast Asia office in Thailand. Bitter gourd breeding objectives include strong gynoecy, earliness, fungal disease resistance, fruit quality, and high nutrient content including compounds associated with antidiabetic properties. Pumpkin breeding objectives include multiple virus resistance, fruit quality, early maturity, and high carotene content.

Okra: Breeding will resume in Cameroon in 2014 with a new vegetable breeder. Okra is important in West Africa and South Asia and breeding objectives will likely give priority to yield, resistance to Okra yellow vein mosaic virus and other diseases.

Traditional vegetables: Breeding of traditional vegetables has been based on mass selection within landraces/accessions (no crossing) and farmer participatory selection. AVRDC's Eastern and Southern Africa office works to improve, among others, African nightshade (*S. villosum*), African eggplant (*S. aethiopicum*), vegetable cowpea (*Vigna unguiculata*), amaranth (*Amaranth* spp.), spider plant (*Cleome gynandra*), and Ethiopian kale (*Brassica carinata*). At headquarters, there are activities on seed production of elite traditional cultivars of roselle (*Hisbiscus sabdariffa*) and okra; Malabar spinach (*Basella* spp.) has been targeted for research and improvement as it is nutritious and flood-tolerant.

Traits

AVRDC's breeding programs historically emphasized traits required in vegetable

cultivars targeted for off-season production in the lowland tropics: heat tolerance (necessary for high yield potential), multiple disease resistance, quality, and nutrition content. New drivers of change such as climate change, urbanization, the rise of an urban middle class and increasing incomes will change market requirements and affect all stakeholders in the value chain. Higher temperatures and altered rainfall patterns will increase the need for cultivars tolerant to abiotic stress, particularly heat. We can expect greater consumer demand for nutrient-rich produce with little or zero pesticide residues, visually attractive, and diverse in types, shapes and colors. New requirements will translate into new breeding objectives and additional traits that should be combined into future AVRDC cultivars.

Heat and drought tolerance: There is a need to raise the levels of heat tolerance in our best heat tolerant vegetable lines. This requires a deeper understanding of the mechanisms underlying heat tolerance, such as pollen viability, discovering new sources (including wild species) and new alleles to increase heat tolerance, and designing appropriate breeding strategies. Breeding progress will depend on the design of screening protocols (mostly lab methods) that permit genetic dissection and molecular mapping of heat tolerance components. Breeding for drought tolerance has been proposed for some vegetables such as tomato; initial investigations suggest it may be more cost effective to investigate management practices such as drip irrigation or replacing drought sensitive with drought tolerant vegetable crops.

Disease resistance: Availability of molecular markers linked to major disease resistance genes allows breeders to pyramid resistance genes, increasing the chances of stable and durable resistance to, for instance, tomato yellow leaf curl disease in tomato. DNA markers also facilitate stacking of many kinds of disease resistance genes in the same line. AVRDC must continue to invest effort in mapping resistance genes and develop marker systems for all its crops.

Insect resistance: Inheritance of insect resistance is often polygenic, such as the acyl sugar-based insect resistance which complicates breeding. AVRDC has designed many sound insect screening protocols that pave the way for identification of resistance sources and mapping of resistance genes. Insect resistance breeding is ongoing for bruchid resistance in mungbean, whitefly resistance in tomato, mites and aphid resistance in pepper.

Nutrition and quality: AVRDC's breeding groups actively collaborate with the nutrition team to breed for increased provitamin A content in pepper and tomato, increased methionine content in mungbean, and identification of antidiabetic properties in bitter gourd. The nutrient content of many traditional vegetables has been characterized by the Center; breeding for enhanced nutrient content will continue to receive high priority.

Postharvest and long shelf life: Cultivars differ in shelf life and capacity to withstand rough postharvest handling. Fruit firmness or other proxy indicators have been used as a measure of shelf life, but improved high throughput protocols are needed for shelf life testing to become a routine part of line evaluation. The Center's strengthened postharvest team will provide the support breeders require to ensure the needs of the value chain and consumers are taken into account as breeding goals.

Cultivar types

Inbred lines have been the main output of

AVRDC breeding programs, although some successful hybrids have been developed. Inbred lines can be directly commercialized or used in hybrids. However, scaling up and commercialization of inbred line cultivars of global vegetables in some countries is hampered by low government priority given to vegetable seed production, as well as insufficient equipment, infrastructure, and public-sector funding. Although there is some limited interest by local seed companies, seed of traditional vegetable cultivars will probably be dominated by the informal seed sector in the near future, and inbred line or open-pollinated cultivars will dominate.

Production systems

AVRDC breeding targets open field vegetable production. While protected vegetable cultivation is important in some regions, AVRDC currently lacks comparative advantage and resources to breed cultivars for protected cultivation. Selection within the current populations for specific targets such as protected cultivation or home garden production is a possibility.

Partnerships

AVRDC breeding programs build relationships with public and private sector institutions to distribute and exchange breeding lines, share information, research and discovery on genetics of important traits and the design of screening protocols, and ensure AVRDC's improved lines, or derivatives of them, are distributed, tested, released, and scaled up. Vegetable farmers tend to prosper in countries that nurture a strong and competitive vegetable seed sector that produces and markets high quality seed of improved cultivars. Direct release of AVRDC breeding lines usually happens through public institutions, which usually recognize AVRDC in cultivar release documents. Public institutions often lack the staff and resources to produce sufficient foundation seed; AVRDC sometimes has to continue to provide seed to ensure enough foundation seed for commercialization.

Expected outputs: likely AVRDC breeding products in the next two to three years

New and improved bacterial wilt-resistant tomato: Bacterial wilt has been a recalcitrant tomato production problem in the humid tropics, with AVRDC tomato bacterial wilt resistant tomato lines holding up in some regions/locations but not in others. Mapping studies revealed that AVRDC lines possessed only one of two major quantitative trait loci (QTL) critical for resistance. Through marker-assisted selection, AVRDC has developed advanced lines possessing both of the bacterial wilt resistance QTLs, tomato yellow leaf curl disease resistance, early maturity and heat tolerance. Expected outcomes are higher yields in tomato production areas and expanded tomato production into new areas.

Bruchid resistant mungbean: Bruchids are a major postharvest problem that makes the mungbean seed unfit for human consumption and forces farmers to sell their grain shortly after harvest when prices are low. AVRDC has identified resistant mungbean accessions, genetically mapped the resistance genes, and will soon develop lines combining bruchid resistance, early maturity, high yield and good grain qualities. An expected outcome is increased farmer income from grain sales during later, higher price periods.

Heat tolerant sweet pepper: Sweet pepper is a high value, nutrient rich crop but production in the tropics is mainly confined to highlands due to lack of tropical adaptation. AVRDC has used two strategies to obtain heat tolerance: intraspecific crosses with tropically adapted chili pepper

and extensive screening for lines with complementary heat tolerance components (pollen viability, root growth, etc.). This work has resulted in lines and hybrids combining heat tolerance and high yield, excellent fruit qualities, and resistance to diseases.

Virus-resistant pumpkin: Pumpkin is a popular, heat tolerant crop in the tropics, and is rich in carotenes and other nutrients. Viral diseases can drastically reduce pumpkin yields. Using the virus resistant landrace Nigerian Local, AVRDC has incorporated a gene for resistance to *Zucchini yellow mosaic virus* into elite pumpkin lines. These lines will enter multilocation trials in 2014 and international distribution is expected in 2016.

Conclusion

AVRDC has achieved much in 40 years, but vegetable production must quickly adjust to challenges imposed by a changing climate. Producers need cultivars with even higher levels of heat tolerance, disease and insect resistance; consumers increasingly demand better quality vegetables with higher nutrient content. AVRDC continues its commitment to vegetable breeding as new tools and methods are adopted to improve efficiency.

Genetic enhancement and varietal development of vegetables

GOAL

Varieties with potential to expand opportunities in tropical vegetable production

PURPOSE

Farmers obtain varieties and lines of major vegetables that produce high yields of nutritious and marketable food with less health risk and environmental damage

Output 1: Cultivars and lines of vegetables with improved disease resistance, stress tolerance, quality and nutritional traits developed
Outcome: Lines adopted directly as cultivars or used in public/private sector breeding programs

ACTIVITY 1.1

Develop heat tolerant and disease-resistant tropical tomato with desirable horticultural and quality traits

Output Targets 2014

- 2-3 F_7 lines combining *Tomato yellow leaf curl virus* (TYLCV) (*Ty-3*) and bacterial wilt (*Bwr-12* +*Bwr-6*) resistances and 2-3 F_7 lines with TYLCV resistance and high carotenoid content developed and evaluated in replicated yield trials
- 3-4 advanced lines combining TYLCV, late blight and bacterial wilt resistances evaluated at RCA

Output Targets 2015

- F_3 or BC_1F_1 entries designed to combine acyl sugar insect resistance and TYLCV resistance subjected to marker-assisted selection, field selection for horticultural traits, and advanced to F_4 or BC_1F_2

Output Targets 2016

- 3-5 late blight resistant lines in cultivar 'Tanya' background developed and evaluated for horticultural traits
- Tolerance traits of wild tomato prioritized for breeding salt-stress tolerant tomato cultivars

ACTIVITY 1.2

Develop and distribute disease-resistant chili cultivars (targeting anthracnose, Phytophthora, bacterial wilt, *Cucumber mosaic virus, Chili veinal mottle virus*, and/or begomoviruses)

Output Targets 2014

- Inheritance of anthracnose in new sources of resistance studied and selection and generation advance made in segregating populations
- Aphid/mite resistance inheritance study completed and 2-3 resistant/tolerant progeny identified for use in breeding

Output Targets 2015

- Inheritance of begomovirus resistance studied and segregating populations advanced for further selection
- Seeds of 8-10 pepper lines increased and made available for international distribution in the International Chili Pepper Nursery
- Seeds of aphid/mite resistance/tolerant lines increased for international distribution

Output Targets 2016

- 15-20 new multiple disease resistant lines evaluated, seeds of better performing 7-8 lines increased
- Molecular markers tightly linked to resistance genes against two *Colletotrichum* species validated

ACTIVITY 1.3

Develop heat tolerant tropical sweet pepper

Output Targets 2014

- Populations segregating for heat tolerance and disease resistance developed and progenies selected and advanced
- Seeds of 4-5 heat tolerant inbred lines and their hybrids increased and made available for on-farm testing

Output Targets 2015

- 5-8 sweet pepper hybrids and inbred lines released to collaborators
- 3-4 lines combining heat tolerance and multiple disease resistances developed

Output Targets 2016

- Seeds of 3-4 lines combining heat tolerance and multiple disease resistances increased
- Functional assessment of pollen viability and heat related traits in sweet pepper

ACTIVITY 1.4

Develop short-day red onions and yellow onions for improved yield and extended shelf-life

Output Targets 2014

- Multilocation trials in West Africa conducted of 5-10 best local populations and 3-5 AVRDC open pollinated lines
- Mother bulbs of 11 local purified selections, 17 AVRDC elite lines and seeds of 2 onion released lines and 10 advanced lines produced for multilocation regional trials in West, Central and East Africa

Output Targets 2015

- Breeder seed of at least 3 AVRDC elite lines and 5 local purified selections produced
- Bulk crosses developed for recombination of major horticultural traits (high yielding, high dry matter content, early maturity, storability) of the best local purified selections
- Seeds of 10 local purified selections and 15 AVRDC elite lines produced for multilocation regional trials in West, Central and East Africa

Output Targets 2016

- Selection among bulk crosses for major horticultural traits conducted
- Local purified selections and AVRDC elite lines screened for resistance to pests and diseases in West, Central and East Africa
- Multilocation regional trials in West Africa conducted of the best local populations and AVRDC open pollinated lines

ACTIVITY 1.5

Develop and distribute heat-tolerant broccoli and Chinese cabbage varieties

Output Targets 2014

- Seed of 2-5 broccoli hybrids, and 1-3 inbred lines increased for international distribution
- Seed of 5-10 Chinese cabbage lines and 1-3 Chinese cabbage hybrids for international distribution

ACTIVITY 1.6

Develop improved vegetable soybean and mungbean with improved stress tolerance and nutritional and flavor qualities

Output Targets 2014

- Vegetable soybean lines promoted in South Asia and sub-Saharan Africa through regional testing
- Bruchid resistant mungbean lines developed using resistant mungbean accessions V2709 and V2802
- Methionine content of back cross derived mungbean lines confirmed by HPLC

Output Targets 2015

- Vegetable soybean lines promoted in South Asia and sub-Saharan Africa through regional testing
- Mungbean lines resistant to *Mungbean yellow mosaic virus*, Cercospora leaf spot or powdery mildew developed

Output Targets 2016

- New bruchid resistance genes characterized in mungbean
- Mungbean lines with multiple resistances to *Mungbean yellow mosaic virus*, Cercospora leaf spot and powdery mildew developed

ACTIVITY 1.7

Develop cucumber lines for improved horticultural traits, disease resistance, good fruit quality, and high gynoecy

Output Target 2014

- 6 entries evaluated in advanced yield trials and characterized for key horticultural traits and seed increased
- 8-10 hybrid combinations of South and Southeast Asian types evaluated for key horticultural traits

Output Target 2015

- Multilocation testing of selected lines conducted

ACTIVITY 1.8

Develop disease resistant and high quality pumpkins (*Cucurbita moschata*)

Output Targets 2014

- 6 open pollinated lines (small fruit type) assessed in an advanced yield trial and assessed for key horticultural and nutritional traits
- Preliminary yield trial of *Zucchini yellow mosaic virus* resistant lines BC4S4 and 15 inbred lines for South and Southeast Asia market segment conducted

ACTIVITY 1.8

Output Targets 2015

- Seed increase and international distribution of 4-6 small fruit type inbred lines completed
- Advanced yield trial of 2-4 *Zucchini yellow mosaic virus* resistant lines and 5-7 inbred lines for South and Southeast Asiamarket segment conducted
- 4-6 hybrid combinations evaluated for horticultural traits and virus resistance

Output Targets 2016

- Screening of BC4S4 lines for multiple virus diseases resistance (*Zucchini yellow mosaic virus, Cucumber mosaic virus, Papaya ringspot virus*) completed
- Multilocation trial of 5-8 F_8 lines conducted and seed increased for international distribution

ACTIVITY 1.9

Develop bitter gourds possessing improved yield, earliness, good fruit quality and resistance to diseases/insects

Output Targets 2014

- Multilocation trial of 10-15 advanced bitter gourd lines conducted
- Multilocation evaluation of bitter gourd powdery mildew resistant lines conducted
- Intermating of selected bitter gourd varieties and accessions to create populations for recurrent selection (first cycle) completed

Output Targets 2015

- 10-15 advanced breeding lines evaluated for key horticultural and nutritional traits
- Recurrent selection cycle 2 completed

Output Targets 2016

- Recurrent selection cycle 3 completed for various market segments

ACTIVITY 1.10

Develop indigenous vegetables with superior horticultural traits

Output Targets 2014

- 10-20 Malabar spinach accessions assessed in a replicated trial in Taiwan
- 3-5 lines each of African eggplant, African night shade, spider plant and cowpea developed at Eastern and Southern Africa

Output Targets 2015

- 2014 Malabar spinach assessment repeated and 3-5 superior Malabar spinach accessions selected for international distribution and promotion

ACTIVITY 1.10	• 3-5 lines each of African eggplant, African night shade, spider plant and cowpea developed at Eastern and Southern Africa • Parental lines developed and crossing program initiated in African eggplant *Output Targets 2016* • African eggplant segregating populations evaluated for yield, quality, and stress resistance
Output 2: Vegetable variety testing networks and improved seed systems developed **Outcome:** Improved distribution, evaluation, release, and seed production of AVRDC-bred varieties leading to (1) better understanding of genotype-environment interactions, (2) trait priorities for particular agroecosystems and markets (3) streamlined variety release procedures, and (4) more efficient vegetable seed production	
ACTIVITY 2.1 Assemble and internationally distribute elite vegetable lines	*Output Targets 2014-2016* • Global distribution and testing conducted of AVRDC chili pepper, sweet pepper, tomato, vegetable soybean, mungbean, African nightshade spider plant and vegetable cowpea and other AVRDC-developed lines
ACTIVITY 2.2 Analyze and review of multi-environment testing of AVRDC-improved germplasm	*Output Targets 2014-2016* • Vegetable variety trials and implications for breeding and variety release analyzed and summarized
ACTIVITY 2.3 Develop on-line seed catalog to facilitate seed requests for AVRDC-improved vegetables	*Output Targets 2014-2016* • On-line seed catalogs developed or updated for tomato, pepper, soybean, leafy brassica, Chinese cabbage, shallot, root stocks, African indigenous vegetables, cucumber, pumpkin and bitter gourd

ACTIVITY 2.4

Monitor and assess variety release, commercialization and adoption of AVRDC-bred lines

Output Targets 2014-2016

- Release and commercialization of AVRDC varieties by national agricultural research and extension system, and seed companies in Africa, Asia, and Central America monitored
- Breeder seed produced of released AVRDC lines at various AVRDC locations

ACTIVITY 2.5

Use male sterility to improve the efficiency of hybrid vegetable seed production

Output Targets 2014

- Impact assessment designed and implemented of AVRDC cytoplasmic male sterile (CMS) pepper lines in improving access to improved varieties
- Sweet pepper CMS-based crosses raised and evaluated for fertility restoration and potential sweet pepper restorer lines identified
- Seeds of chili pepper CMS line made available for cooperators

Output Targets 2015

- Seeds of potential sweet pepper restorer lines increased for international distribution
- Initial cross to isolate alloplasmic cytoplasm developed or feasible use of nuclear male sterility in hybrid seed production examined

Output Targets 2016

- Seeds of 3-5 sweet pepper restorer lines made available for international distribution, testing and utilization
- Molecular mechanism of CMS in *Capsicum* understood and markers validated/developed
- Initial crosses created to transfer nuclear male sterile ms gene in good combiner sweet and hot pepper genotypes

ACTIVITY 2.6

Efficiency and effectiveness of national seed supply systems improved for production of high quality seed of improved varieties.

Output Targets 2014

- Major constraints on vegetable seed production identified, seed production sites identified and partnerships created to overcome the constraints
- 20 tons of good quality mungbean seed produced in Pakistan

Output Targets 2015-2016

- Good quality mungbean seed regularly produced to expand mungbean production

Output 3: Enhanced seed company capacity in vegetable breeding research, design and application of efficient seed systems, and delivering development outcomes

Outcome: Seed companies improved for capacity in vegetable breeding, seed production, or delivering technical advice and promotional messages

ACTIVITY 3.1

Train seed companies (ensuring participation of men and women participants) in design and application of molecular markers in breeding

Output Targets 2014

- Markers for hybrid testing of seven vegetable species developed

Output Targets 2015

- Improved high throughput DNA extraction and genotyping methods for hybrid testing made available

Output Targets 2016

- Improved high throughput DNA extraction and marker-assisted selection methods for important disease resistance genes made available

ACTIVITY 3.2

Collaboration with seed companies to understand key traits for design of improved breeding strategies

Output Targets 2014

- A set of AVRDC tomato lines carrying different combinations of *Ty* genes assessed for resistance against the locally prevalent leaf curl viruses in seed-company-managed field sites in India and Thailand.

Output Targets 2015

- A set of AVRDC tomato lines carrying different combinations of *Ty* genes assessed for resistance against the locally prevalent leaf curl viruses in seed-company-managed field sites in India, Thailand, the Philippines and Indonesia

ACTIVITY 3.2	*Output Targets 2016* • Statistical analysis, journal article prepared including implications for breeding
ACTIVITY 3.3 Equipping seed companies to promote nutrition and other development messages to men and women farmers through farmer field days	*Output Targets 2014* • Effectiveness of Lal Teer's nutrition promotion in Bangladesh evaluated • Interventions to improve Lal Teer nutrition messages determined *Output Targets 2015-2016* • Statistical analysis, journal article prepared, and implications for scaling out strategies for other seed companies in Asia and Africa determined

Biocontrol agents strengthen integrated pest management strategies

Theme Production

2014 and Beyond

A secure supply of safer and affordable vegetables is a prerequisite for achieving nutritional security in developing countries. Such security should be sustainable and not result in increased health risks to farmers, their families and consumers, nor contribute to the deterioration of agroecosystems.

Vegetables can be grown under a diverse range of agroecosystems, and with different input levels. The constraints vary between ecosystems and locations. Use of inputs is generally high for peri-urban, intensive systems that produce vegetables for high year-round consumer demand.

Indiscriminate use of synthetic pesticides and overuse of fertilizers are among the challenges of intensive production systems. Vegetables also can be grown in rotation with cereals or other staple crops. This diversifies the production system, increases income for farmers, and can contribute to better crop management practices. Home gardens have the potential to provide sufficient food for nutritional security, particularly for rural households. Women are usually involved in home garden production, yet often lack knowledge on the choice of crops and production skills. Due to lack of access to inputs for

rural households, especially to chemical fertilizers, low amounts or no fertilizer may be applied in home gardens. This may decrease soil fertility on marginal land.

Despite international and regional efforts, adoption levels of integrated pest management and good agriculture practices are still far from ideal in developing countries. Innovation processes linking research and development should be established to increase adoption while balancing sustainability, productivity and profitability.

The way forward

Theme Production's long-term goal is "Prosperity for smallholder vegetable farmers and health for consumers in a healthy ecosystem." Research and development activities aim to generate three development outcomes: 1) smallholders consider vegetable farming as a profession and that the profession leads to higher incomes and better health; 2) consumers have access to affordable and safer vegetables year-round; 3) society benefits from healthier ecosystems due to the adoption of good agricultural practices. Theme Production proposes that smallholder vegetable farmers adopt sustainable integrated production practices that are profitable, productive, and safer for the environment, farmers and vegetable consumers. Theme Production uses the concept of the research-for-development continuum; achieving a balance between productivity, profitability and sustainability is the key consideration.

Generation of novel information for sustainable vegetable production

Novel information for managing key production constraints will be generated in collaboration with advanced research institutes, national agricultural research and extension systems (NARES) and international agricultural research centers. The information generated will be used to develop effective and sustainable production methods. Information and methods will be developed for the detection and characterization of important insect and mite pests, and diseases, of global and traditional vegetables. For example, a protocol using a paper-based system designed to fix and store nucleic acids directly from fresh tissues for the diagnosis of vegetable diseases sampled from locations remote from laboratory facilities will be developed further in 2014. Monitoring globally important pests is a routine activity for better deployment of resistant cultivars and for preparing communities for changes in pest profiles. Currently targeted pests and diseases include whitefly-transmitted begomoviruses, *Ralstonia solanacearum*, and key insect pests and pathogens of leafy brassicas.

Exploring novel integrated management strategies for major insect pests and diseases is a continuing research focus. Use of host plant resistance, natural enemies, sex pheromone and kairomone blends, biopesticides and cultural practices will be integrated after the mechanisms and potential contribution to overall control efficacy are better understood. In 2014, principles for developing an integrated pest management (IPM) strategy for whitefly virus vectors will be explored. Effective components of IPM for managing insect pests on leafy brassicas will be determined over the next three years. Several biochemical compounds capable of triggering plant basal defenses have been identified; research will be conducted to understand how to use these compounds in managing plant diseases. First studies will be conducted in 2014 on tomato and pepper, followed by leafy brassicas and yard-long bean in subsequent years.

Soil fertility management will contribute to sustainable soil health. Understanding

current soil properties in target areas, followed by developing appropriate soil management practices, will focus on Eastern and Southern Africa and Oceania.

Development of sustainable production practices for targeted agroecosystems

Sustainable vegetable production practices must be adapted to local environmental, social and economic situations. Working with NARES, as well as supply and service industries, is essential for developing and validating adoptable technologies. Validated technologies and related information will be shared with the public and private sectors, nongovernment organizations (NGOs) and farmers.

Two broad production systems are targeted: 1) intensive systems that use more inputs (labor, capital, pesticides, fertilizers, etc.) relative to the land area; and 2) less intensive production systems requiring fewer inputs. The main activities addressing the intensive system in the coming three years include increasing productivity of high value vegetables (Solanaceous crops, leafy brassicas and vegetable legumes) in Southeast Asia, the South Pacific, and Central Asia by selecting suitable cultivars and validating IPM practices; and evaluating specific practices and developing integrated packages for producing high value vegetables under unfavorable climatic conditions, such as production under rain shelters or other protective structures and grafting with appropriate rootstocks for tomato production during the hot-wet season in Southeast and South Asia.

Vegetables can be grown with relatively small amounts of inputs under open field conditions, particularly in rural areas. This has the potential not only to increase the supply of nutritious food and improve incomes, but also to diversify production systems, thus spreading risk and increasing the sustainability of the production system. Agroecosystems targeted for this approach in South Asia include upland rice farming systems, rice-wheat farming systems, and home gardens in flood-prone areas. Suitable crops, cultivars, IPM practices, and crop and soil management practices will be evaluated to determine the best combinations to increase productivity and sustainability.

Innovative dissemination of interventions in vegetable production

Research results can be translated into outcomes and impacts only if the technologies are adopted by smallholders, often with the support of input suppliers, marketing agents and policy makers. Innovative and gender-sensitive dissemination processes will be designed, in collaboration with the most appropriate partners, to assure out-scaling.

Situation analyses will be conducted in new target regions to characterize production systems and identify key stakeholders along the impact pathways. In 2014, such analyses will be conducted in highland areas of Southeast Asia and in peri-urban areas of Eastern and Southern Africa. Farmers' perceptions of, and current management practices for, virus diseases of vegetables in some Southeast Asian countries will be documented. Innovative dissemination processes will be designed, initiated and facilitated. For example, because tomato farmers are not willing to purchase more costly grafted seedlings before experiencing the actual benefits, the Center collaborates with nurseries and NARES to subsidize grafted seedlings for the initial purchase; this helps to introduce the grafting technology to farmers, creates demand, and enhances adoption of the technology.

Capacity building among local partners and farmers to facilitate and conduct innovative processes to permit adoption of good agriculture practices is a continuous focus in our global operations in Southeast Asia, South Asia, Central Asia and the Caucasus, Oceania, and sub-Saharan Africa. Extension and training materials will be prepared and translated into different languages. Effective training methods, such as Training of Trainers, field days, farmer field schools and farmer training courses will be used, targeting different stakeholders. Men are typically regarded as the household head and usually represent their families at meetings and in interactions with extension services. However, as both women and men participate in vegetable production, extension efforts will be designed to target both.

Information on the constraints and opportunities for successful adoption of interventions is vital for scaling-out and scaling-up strategies. The challenges and opportunities for the adoption of sustainable pest management on-farm and at policy levels will be documented in India and Southeast Asian countries. Results of socioeconomic studies and policy dialogues will be used to stimulate policy makers to support the promotion and adoption of IPM techniques at the national level and throughout the region.

Documenting the effect of vegetable production interventions on development outcomes, such as income, gender relations and sustainability will provide useful information for policy makers and other stakeholders. Studies will be conducted on the outcomes of off-season tomato production in South Asia. Data will be collected on the effect of tomato grafting and utilization of AVRDC germplasm for future assessment of outcomes and impacts.

Conclusion

Theme Production has a strong role in linking AVRDC's other research and development themes along the vegetable value chain. With Themes Germplasm and Breeding, priority targets for germplasm characterization, selection and genetic improvement are identified. Pest profiles are monitored for better deployment of resistant germplasm and breeding lines. Selected germplasm accessions and breeding lines are deployed to enhance local productivity. Theme Production feeds into Theme Consumption by developing and promoting the adoption of sustainable production systems that are safer for the growers and the environment, while being profitable and securing a supply of safer and more affordable vegetables for consumers. Successful delivery of these research and development outcomes and impact depends on effective teamwork within AVRDC, and on forging strong partnerships and collaborations with national and international public sector institutions and private sector entities.

Safer and sustainable vegetable production systems

GOAL

Sustainable livelihoods of smallholder vegetable growers and a secure supply of safer and affordable vegetables

PURPOSE

Smallholder vegetable growers (in target regions) adopt sustainable integrated production practices that are profitable and safer for the environment, growers and vegetable consumers

Output 1: Novel information generated for integrated crop managing, including pest, disease, and soil fertility management for sustainable vegetable production

Outcome: Information used by national agricultural research systems and other organizations to develop effective methods to manage major vegetable production constraints

ACTIVITY 1.1

Detect, characterize and explore integrated management strategies for major insect and mite pests

Output Targets 2014

- Major whitefly and thrips species/cryptic species associated with major vegetables in Bangladesh, India and Tanzania characterized
- Principles for developing an integrated pest management strategy (healthy seedling production, biopesticides and sticky traps) for virus vector whiteflies determined for India, Thailand, Taiwan and Vietnam

Output Targets 2015

- Most common insect pests of leafy brassicas and yard-long bean in Cambodia, Lao PDR and Vietnam catalogued
- Major natural enemies of key insect pests (e.g. *Spoladea recurvalis, Pieris rapae* and *Aphis craccivora*) on amaranth, brassicas and legume vegetables identified in Southeast Asia and parasitism of major parasitoids on target pests assessed
- Efficacy of biopesticides against *P. rapae, Phyllotreta striolata, A. craccivora* and thrips determined in Southeast Asia

Output Targets 2016

- Association of molecular variations in *Spoladea, Pieris* and *Phyllotreta* populations with host plants and geographical origins in Southeast Asia and sub-Saharan Africa determined
- Most effective sex pheromone blends against *P. rapae* and S. recurvalis, aggregation pheromone blends against *P. striolata* and kairomone blends against thrips in Southeast Asia and sub-Saharan Africa identified
- Integrated pest management strategy based on sex/aggregation pheromones, kairomones, biopesticides and parasitoids for *P. rapae, P. striolata, S. recurvalis, A. craccivora* and thrips validated in Southeast Asia and sub-Saharan Africa

ACTIVITY 1.2

Detect, characterize and explore integrated management strategies for major fungal and bacterial diseases

Output Targets 2014

- Protocol using FTA™ cards for distant diagnostic of vegetable diseases developed
- Variables affecting the growth and survival of phylotype IIB-1 strains of *Ralstonia solanacearum* determined
- Phylogenetic relationships of *R. solanacearum* genotypes present in Southeast Asia (Vietnam) and Eastern Africa (Kenya and Tanzania) determined
- Potential efficacy of disease control methods that induce plant basal defense for managing tomato and pepper diseases determined

Output Targets 2015

- Protocol using FTA™ cards for distant diagnostic of vegetable diseases validated and applied
- Potential efficacy of disease control methods that induce plant basal defense for managing tomato and pepper diseases determined
- Major fungal and bacterial diseases on yard-long bean and leafy brassicas, including seed-borne diseases, identified and their genetic diversity assessed in Cambodia, Lao PDR and Vietnam

Output Targets 2016

- Major fungal and bacterial diseases on yard-long bean and leafy brassicas, including seed-borne diseases, identified and their genetic diversity assessed in Cambodia, Lao PDR and Vietnam
- Potential efficacy of disease control methods that induce plant basal defense for managing yard-long bean and leafy brassica diseases determined

ACTIVITY 1.3

Detect, characterize and explore integrated management strategies for major viral diseases

Output Targets 2014

- The important viruses, especially begomoviruses, infecting or emerging in vegetable crops in Asia and Africa identified and monitored
- Genetic diversity of begomoviruses infecting tomato, chili and/or mungbean in India, Thailand and/or Vietnam assessed
- The effect of root knot nematode infection on *Ty* gene resistance to tomato leaf curl viruses assessed

Output Targets 2015

- The important viruses, especially begomoviruses, infecting or emerging in vegetable crops in Asia and Africa identified and monitored

ACTIVITY 1.3

- Genetic diversity of important viral diseases affecting Solanaceae, Cucurbitaceae and/or Leguminosea crops in South or Southeast Asia assessed
- The effect of root knot nematode infection on *Ty* gene resistance to tomato leaf curl viruses assessed

Output Targets 2016

- The important viruses, especially begomoviruses, infecting or emerging in vegetable crops in Asia and Africa identified and monitored
- Genetic diversity of important viral diseases affecting Solanaceae, Cucurbitaceae and/or Leguminosea crops in South or Southeast Asia assessed
- Integrated Pest Management (IPM) components for controlling viral diseases of legumes in Southeast Asia investigated

ACTIVITY 1.4

Develop technologies to improve soil nutrient use efficiency and soil sustainability

Output Targets 2014

- Effect of starter solution and legume rotation on tomato production and soil health evaluated in Fiji

Output Targets 2015

- Effect of starter solution and legume rotation on tomato production and soil health confirmed in Fiji
- Soil properties assessed and soil management programs developed for sustainable quality vegetable cropping systems in Eastern and Southern Africa

Output 2: Sustainable vegetable production practices developed/validated for targeted agro-ecosystems

Outcome: Integrated production technologies and related information to enhance and sustain vegetable productivity ready to be disseminated to NARES, NGOs, input suppliers, and small-scale farmers

ACTIVITY 2.1

Develop and adapt integrated production technologies for intensive production system (system of cultivation using large amount of inputs, e.g. labor, capital, pesticides, fertilizers etc., relative to land area)

Output Targets 2014

- Integrated crop management technologies for tomato, pepper, and eggplant validated in open field and adapted in Southeast Asia, South Pacific and Central Asia
- Integrated pest management packages for eggplant, summer tomato, vegetable brassicas and country bean (*Lablab purpureus)* validated in Bangladesh
- Effects of rootstock and/or rain shelter for tomato production during hot and wet seasons determined in Bangladesh and Indonesia and potential of rootstock for tomato production determined in Tanzania

ACTIVITY 2.1

- Vegetable production under protective structures in Pakistan improved through adapting IPM practices, new crops, and other integrated crop management practices

Output Targets 2015

- Integrated crop management technologies for tomato, pepper, and eggplant validated in open field and adapted in South Pacific (Fiji, Solomon Islands) and Central Asia (Uzbekistan and Armenia)
- Integrated pest management packages for eggplant, summer tomato, vegetable brassicas, vegetable legumes and other crops validated and adapted in Southeast Asia (Vietnam, Cambodia and Lao PDR) and South Asia (Bangladesh) and Eastern and Southern Africa
- Vegetable production under protective structures in Pakistan improved through adapting IPM practices, new crops, and other integrated crop management practices

Output Targets 2016

- Integrated crop management technologies for tomato, pepper, and eggplant validated in open field and adapted in South Pacific (Fiji, Solomon Islands) and Central Asia (Uzbekistan and Armenia)
- Integrated pest management packages for eggplant, summer tomato, vegetable brassicas, country bean and yard-long bean (*Vigna unguiculata* subsp. *sesquipedalis)* validated and adapted in Southeast Asia (Vietnam, Cambodia, and Lao PDR) and South Asia (Bangladesh), and costs and returns documented for farmers adopting IPM methods
- Vegetable production under protective structures in Pakistan improved through adapting IPM practices, new crops, and other integrated crop management practices

ACTIVITY 2.2

Develop and adapt integrated production technologies for extensive production system (system of cultivation using small amount of inputs relative to land area)

Output Targets 2014

- Appropriate vegetable crops, varieties and production practices following direct seeded rice cropping system in Jharkhand and for flood-prone areas of Odisha, India identified
- Mungbean production as part of the rice-wheat cropping system and double cropping in wheat-fallow areas improved in Pakistan, including adapting IPM practices

Output Targets 2015

- Vegetable production options following direct seeded rice in Jharkhand, India developed
- Home vegetable garden options for the flood prone target area of Odisha, India developed

ACTIVITY 2.2	• Mungbean production as part of the rice-wheat cropping system and double cropping in wheat-fallow areas improved in Pakistan, including adapting IPM practices

Output 3: Innovative dissemination processes in vegetable production initiated and outcomes assessed

Outcome: Smallholder vegetable farmers adopt new innovations with the support of input supplies, marketing agents, and policy makers and this improves farm productivity and sustainability, strengthens the role of women and enhances livelihoods

ACTIVITY 3.1 Identify and establish gender-sensitive and effective knowledge and innovation systems	*Output Targets 2014* • Farmers' perceptions and management of plant viruses in vegetables and legumes documented in Tamil Nadu, Thailand and Vietnam • Situational analysis conducted to characterize developments, production systems, markets and institutions (including the role of women), natural resource management and environment in northern Thailand and coordinated for Myanmar and Laos • Subsidized grafted tomato seedlings distributed to men and women farmers to introduce grafting technology and enhance adoption in Bali and East Java, Indonesia • Peri-urban vegetable production systems in eastern and southern Africa countries characterized to identify production constraints *Output Targets 2015* • Data collected from men and women farmer respondents and analyzed on farm-level constraints and opportunities to IPM adoption for vegetable legumes and leafy brassicas in at least two of three countries (Cambodia, Lao PDR or Vietnam) • Needs for mungbean IPM practices and opportunities for their introduction or promotion in Pakistan identified
ACTIVITY 3.2 Strengthen the capacity of local partners and farmers to facilitate and conduct innovation processes	*Output Targets 2014* • Extension and training materials published on various vegetable production technologies, distributed to men and women farmers • Capacity of extension staff, nursery operators and vegetable farmers (men and women) in Indonesia, Bangladesh, India, Pakistan, Oceania, Central Asia and the Caucasus, Cameroon and Tanzania strengthened through Training of Trainers, farmer training, Farmer Field Schools or field days

ACTIVITY 3.2

- R4D (Research for development) platforms identified and/or initiated for northern Thailand and their functioning studied and documented

Output Targets 2015

- Extension and training materials published on various vegetable production technologies, distributed to men and women farmers
- Capacity of extension staff, nursery operators and vegetable farmers (men and women) in Bangladesh, India, Oceania, Central Asia and the Caucasus, and Eastern and Southern Africa strengthened through Training of Trainers, farmer training, Farmer Field Schools or field days

Output Targets 2016

- Extension and training materials published on various vegetable production technologies, distributed to men and women farmers
- Capacity of extension staff, nursery operators and vegetable farmers (men and women) in India, Oceania, Central Asia and the Caucasus, and Eastern and Southern Africa strengthened through Training of Trainers, farmer training, Farmer Field Schools or field days

ACTIVITY 3.3

Identify challenges and opportunities to innovation adoption and evaluate outcome generated

Output Targets 2014

- Farm-level constraints and opportunities to IPM adoption for vegetable legumes and leafy brassicas studied, and policy-level constraints and opportunities to a sustainable pest management documented in Cambodia, Laos, Thailand and Vietnam
- Effect of off-season tomato production on income, gender equality and sustainability evaluated and documented for Bangladesh (Barisal and Jessore districts)
- Data collected from men and women respondents for future evaluation of the outcomes of tomato grafting in Indonesia and the impact of AVRDC germplasm on vegetable production in Thailand

Output Targets 2015

- Data analyzed and published on the impact of AVRDC germplasm on vegetable production in Thailand

Output Targets 2016

- Outcomes evaluated of sustainable vegetable production based on the principles of ecological intensification in Northwest Vietnam

Assessing vegetable value chains and improving diets

Theme Consumption

2014 and Beyond

Theme Consumption stands towards the end of the chain to deliver the final outputs of the Center's research and development efforts in terms of creating outcomes and impacts. This poses a special challenge, given the growing recognition from several systematic reviews and circumstantial evidence on the disconnect between agriculture, nutrition and health—despite emerging knowledge of the links between farm production, diets and some nutrition outcomes. There is also increasing recognition of the centrality of gender dimensions, while nascent discussions are beginning on learning from other disciplines to conduct integrative research on food and nutritional security research and development interventions. Non-communicable diseases, especially cardiovascular diseases, cancer, obesity and type 2 diabetes, currently kill more people every year than any other cause of death. Poor and imbalanced diets are widely known as one of the major factors in the epidemiology of these diseases that are of overwhelming importance to public health. The World Health Organization has, over the past decade, responded to the global rise in these diseases by giving increasing attention to their prevention and control

through several programs including its Global Strategy on Diet, Physical Activity and Health. Consequently, there is a growing need to develop a Center-wide framework to guide the development of cost-efficient and effective interventions to promote adequate consumption of vegetables in AVRDC's target regions.

Adding vegetables (and other micronutrient-dense natural foods such as fruit) to diets increases the opportunity for access to micronutrients, but it is also necessary to consider how people prepare and consume food to ensure that the micronutrients are biologically available. Vegetables must to replace some quantity of high energy foods in the diet to effectively increase overall nutrient composition for a more balance diet. There is a need to increase consumption of vegetables (and fruit) in general and also increase variety to ensure the best possible benefits.

An arduous task for Theme Consumption has been the need to provide evidence, particularly on the impact of AVRDC's home and school garden interventions on nutritional outcomes. This will become a major focus of theme activities in the coming year and beyond. There is a need to look at the total diet and different dietary components, not just to consider consumption of vegetables on their own, hence the need to emphasize dietary strategies and recipe development as part of the theme's short-term and long-term plans.

Cross-cutting research and development activities and strategies

While the factors on the supply side of vegetable consumption outcomes seem to be quite well understood, the psychological and sociocultural constructs for the demand side require further evidence. Literature reviews are needed on physiological, cultural, social and psychological determinants as well as the broader environmental determinants of vegetable consumption. This will require closer linkages and coordination between Themes Production and Consumption.

Efforts for increased awareness of the nutritional importance of vegetables will be achieved by expanding and diversifying activities through targeted, region-specific value chain upgrading strategies that address both supply and, particularly, demand factors. The reasons consumers frequently give for not eating more fruit and vegetables include traditional and individual indifference or disdain toward certain foods; high prices and variable availability of many fruit and vegetables; taste; inconvenience of preparation; and concerns about quality and safety. Consumers want foods that are tasty, readily available, affordable, convenient to acquire and prepare, socioculturally appropriate, safe and healthy. Strategies to increase awareness and the amount of vegetables (and fruit) consumed must address a number of sociocultural, economic, commercial, educational and technical challenges, such as:

- Increasing consumer awareness of the benefits of a balanced diet and building the motivation and skills needed to expand vegetable (and fruit) intakes;
- Optimizing postharvest supply chains to ensure that adequate amounts of a variety of produce and products are available to consumers;
- Understanding consumer expectations in terms of taste, texture, form, price, convenience, and quality and safety attributes;
- Developing new and improved vegetable-based food products that meet consumer expectations and lead to increased vegetable consumption;

- Implementing and evaluating promotional campaigns and education programs with efforts to increase the availability of, and access to, vegetables; and
- Providing clear messages and guidelines with regard to quality and safety of vegetables.

Vegetables are easily contaminated with a range of microbial and chemical contaminants. Fruit and vegetables eaten raw have long been known to serve as the means for transmission of infectious disease-causing microorganisms in developing countries. In contrast, the number of confirmed cases of illness associated with consumption of raw vegetables in industrialized countries has been relatively low. Given the growing need to assure consumer health when eating vegetables and fruit, it is necessary to use integrated approaches including the impact of sociocultural factors, and water, sanitation and hygiene (WASH). Factors thought to influence the occurrence and epidemiology of these diseases include the quality of irrigation water and other agronomic practices such as the inappropriate use of manures and biosolids. Measures to avoid such contamination have been encouraged. The general level of hygiene in handling fruit and vegetables is also a major problem contributing to cross-contamination from animal products as well as direct contamination from the food handler. Prevention of contamination is the most efficient way to ensure food safety and prevent food-borne illness. Collaboration with institutions that have core competence in food safety issues such as the current partnership with Swiss Tropical and Public Health institute (Swiss-TPH) in Asia and Africa under the Vegetables Go to School project and the International Institute of Tropical Agriculture in Eastern and Southern Africa under the Research in Sustainable Intensification for the Next Generation (Africa RISING) program in will be explored. Systems-oriented and landscape-focused research and development efforts are a more viable approach to resource mobilization and to ensure integrated rural transformation. Strategic partnerships will be forged with organizations that have core competence in specific complementary disciplines.

Monitoring and evaluation

The Center has introduced and disseminates several technologies. Although there has been modest progress in the last couple of years to streamline activities, efforts must continue to be made to improve AVRDC's monitoring and evaluation activities and processes. AVRDC needs to continue to find options and an institutional framework that will help us document our program intervention outcomes and impacts in a better and more useful way.

The current institutional research and development orientation, where monitoring and evaluation is linked to the Theme Consumption is understandable, as the theme houses the majority of the key staff (mainly socioeconomists) that are involved in impact evaluation studies. As the Center expands its activities into various regions, it will be more appropriate if monitoring and evaluation is taken out of the themes and provides service as an independent group to increase the scientific rigor of research intervention designs while ensuring that activities are driven by target client demand. This is particularly critical for the development-oriented projects for which considerable monitoring and evaluation is required, and can best be handled by personnel with professional qualifications and hands-on experience. An independent monitoring and evaluation group at the Center will also serve to address the need for more robust monitoring and evaluation designs in the Center's research

and development interventions, and documentation of the Center's outcomes and impact while integrating reporting requirements into project monitoring and evaluation deliverables.

Staffing needs and collaboration

Key disciplinary expertise currently supporting activities in Theme Consumption include socioeconomists, agribusiness and marketing experts, postharvest specialists and nutritionists. Given the interdisciplinary nature of the theme's deliverables, the Center would benefit from support from other disciplines such as anthropology, gender experts, community nutritionists, seed marketing and produce specialists.

The long-term vision for implementing monitoring and evaluation at the Center should include a team of individuals with diverse disciplines including biosciences, nutrition, socioeconomists, anthropologists, and gender specialists with a regional balance, particularly for Eastern and Southern Africa, West and Central Africa, Oceania, East and Southeast Asia and South Asia as the Center continues with its research and development decentralization efforts. In addition to the proposed staffing gaps to be filled in the future, current staff will require professional development in new and emerging topics of interdisciplinary research such as gender mainstreaming, qualitative research tools (e.g. social network analysis, vignettes) for assessing nutritional outcomes of increased vegetable consumption. More strategic partnerships between development and research communities will be explored.

Opportunities and outlook

To focus on global needs and to assure funding for its activities in the agriculture-nutrition-health nexus focusing on nutrition-related outcomes, the future direction of Theme Consumption will emphasize:

- Opportunities abound for exploring strategic partnerships with institutions to expand interventions in dietary diversity to address the problems of hidden hunger. Scaling up dietary diversity interventions could include measuring nutritional outcomes, and possible diversification of the Center's portfolio of research and development activities (complementing vegetable research with research on fruit to collectively address micronutrient malnutrition). Dietary diversity would be viewed from two perspectives: diversity of foods on the plate, and diversity of nutrients on the plate.
- Preliminary discussions are underway with the World Agroforestry Center, which has strong activities with fruit trees, as a precursor to proposed collaboration between the two centers. It is important to focus on fruit and vegetable species and cultivars that have a comparatively high nutrient density or market value.
- Integration of staple-vegetable production system interventions similar to those under the CGIAR Research Program on Humidtropics and Africa RISING programs.
- Organization of farmers into groups and linking them to high value markets, particularly in sub-Saharan Africa.

Resource mobilization activities will particularly emphasize:

- Conducting adaptive research on best-bet simple postharvest handling and storage practices to increase produce shelf-life and year-round availability of produce in non-USAID Feed the Future target countries to complement current funding from USAID, and promoting best-bet practices among beneficiaries in target impact communities.
- Developing market linkages and strengthen farmer associations and the farmer's voice through platforms for

discussing vegetable sector development issues. Emphasis would be placed on improving existing market information systems and building collaborative networks (e.g. with CABI) for information and communication technology to link smallholders to high value markets.

- Increasing nutritional awareness and promoting increased consumption of vegetables by emphasizing integration of nutritional promotion messages through radio programs and information and communication technology, and improving dietary strategies to enhance local appeal and nutrient bioavailability of vegetables.
- Assessing the effectiveness of different dissemination approaches on adoption of various Theme Consumption-related awareness creation approaches, training activities and technologies such as development of new recipes as part of regional or country-specific dietary strategies.

Balanced diets through increased access to, and utilization of, nutritious vegetables

GOAL

Consumer health improved by increased consumption of nutritious vegetables for a balanced diet

PURPOSE

Increased public awareness, accessibility and utilization of nutritious and diverse vegetables

Output 1 : Knowledge of consumer behavior and nutritional properties of vegetables enhanced
Outcome: Research communities become aware and better understand consumers' attitude towards health, food safety and vegetable consumption as well as the nutritional and functional values of vegetables.

ACTIVITY 1.1

Assess consumption nutrition related outcomes among children, women and men of vegetable gardeners and consumers in Asia and sub-Saharan Africa

Output Targets 2014

- Ex-ante analysis of increased production and consumption of bitter gourd in India and Tanzania documented
- Baseline surveys conducted to understand consumer preferences and determine quality standards for providing new outlets for vegetable products from peri-urban farm enterprises in Burkina Faso, Cameroon and Ghana, Ethiopia, Tanzania, Malawi and Mozambique
- Baseline survey conducted on food habits and dietary diversity of urban and rural households in Cameroon, Ethiopia, Mali, Laos and Vietnam
- Baseline study documented on the effect of integrated vegetable-maize farming systems on household production and consumption decisions in Tanzania

Output Targets 2015

- Outcomes of vegetable consumption promotion in south Bangladesh on targeted consumers' knowledge, attitude and behavior change evaluated
- Baseline study documented on food habits and dietary diversity of urban and rural households in Cameroon, Ethiopia, Mali, Laos and Vietnam
- Baseline survey documented to understand consumer preferences and determine quality standards to provide new market outlets for vegetable products from peri-urban farm enterprises in Burkina Faso, Cameroon and Ghana, Ethiopia, Tanzania, Malawi and Mozambique

Output Targets 2016

- Baseline survey documented on food habits and dietary diversity of urban and rural households in Cameroon, Ethiopia, Laos and Vietnam
- Follow-up survey on the outcomes of nutritional promotional activities on consumer preferences, quality standards and quantity of vegetables consumed among target project beneficiaries in Burkina Faso, Cameroon and Ghana conducted

ACTIVITY 1.2

Study nutritional and functional values and benefits of vegetables from sub-Saharan Africa and Asia

Output Targets 2014

- Nutritional and functional properties of selected traditional vegetables from Africa and Asia evaluated
- Phytochemical and nutrient databases of vegetables developed for selected countries

Output Targets 2015

- Nutritional and functional properties of selected traditional vegetables from Africa and Asia evaluated

Output Targets 2016

- Nutritional and functional properties of selected traditional vegetables from Africa and Asia evaluated

Output 2: Dietary strategies and food based interventions developed, validated and implemented
Outcome: AVRDC – The World Vegetable Center, national agricultural research and extension system and nongovernmental organizations promote home, school and community gardening, distribute seed kits to disaster affected areas and advocate more nutritionally effective use of vegetables.

ACTIVITY 2.1

Design, validate and implement home, school and community garden interventions for enhanced access to and consumption of vegetables by poor household, especially women and children in Asia and sub-Saharan Africa

Output Targets 2014

- Case study on roles of school vegetable gardens in food systems and synergies with nutrition and health carried out in 1-2 selected countries in Asia and Africa
- Post-intervention data on the effect of home vegetable gardens on food consumption in Barisal, Bangladesh households collected and analyzed; and baseline and follow-up data on dietary patterns and awareness of students in selected schools in Bhutan, Burkina Faso, Nepal and Tanzania collected and analyzed.
- Specifically targeting women and children, nutritional seed kits distributed to home and school gardens and participatory demonstration vegetables gardens conducted in selected locations of Central Asia
- Effect of home gardens on poverty and food consumption, especially among women and children in Jharkhand, India documented

Output Targets in 2015

- Case study on the roles of school vegetable gardens in food systems, nutrition and health conducted and data analyzed in 1-2 selected countries in Asia and Africa
- Preliminary results from study on the effect of school vegetable gardens on dietary patterns and dietary awareness of students in Burkina Faso, Bhutan, Nepal and Tanzania made available

ACTIVITY 2.1

- Effect of home gardens on income and food consumption, especially among women and children in Barisal, Bangladesh documented
- Specifically targeting women and children, nutritional seed kits distributed to home and school gardens and participatory demonstration vegetable gardens established in selected locations of Central Asia

Output Targets 2016

- Additional case study of roles of school vegetable gardens in food systems and synergies with nutrition and health conducted in 1-2 selected countries in Asia and Africa, and data analyzed
- Effect of school vegetable gardens on dietary patterns and nutritional awareness of school girls and boys on Burkina Faso, Bhutan, Nepal and Tanzania documented
- Specifically targeting women and children, nutritional seed kits distributed to home and school gardens and participatory demonstration vegetable gardens conducted in selected locations of Central Asia distributed

ACTIVITY 2.2

Develop and distribute nutritious vegetable seed kits as disaster response and to other vulnerable groups in tropical and sub-Saharan Africa and Asia, emphasizing women and children

Output Targets 2014

- 5,000 kits produced in Taiwan and existing seed stocks in Taiwan, India, Indonesia, Tanzania and Mali made available for distribution in response to future disasters in exchange for funding to replenish seed stocks
- Easy-to-understand instructions on cultivation, field management, and food preparation in various local languages prepared for publication and disseminated in disaster-affected areas
- At least 1,000 vegetable seed kits for home/school gardens prepared

Output Targets 2015

- Existing seed stocks in Taiwan, India, Tanzania and Mali made available for distribution in response to future disasters in exchange for funding to replenish seed stocks
- Easy-to-understand instructions on cultivation, field management, and food preparation in various local languages prepared for publication and disseminated in disaster-affected areas

Output Targets 2016

- Existing seed stocks in Taiwan, India, Tanzania and Mali made available for distribution in response to future disasters in exchange for funding to replenish seed stocks.
- Easy-to-understand instructions on cultivation, field management, and food preparation in various local languages prepared for publication and disseminated in disaster-affected areas

ACTIVITY 2.3

Develop dietary strategies, nutrition-improved recipes and food preparation methods based on traditional diet and food practices for increased consumption of vegetables and nutritious/ healthy diets by poor households in Asia and sub-Saharan Africa

Output Targets 2014

- Dietary strategies for bitter gourd consumption for low income and high diabetic prevalent regions in India and Tanzania promoted and publication disseminated among men and women
- Nutrition-improved preparation and preservation techniques studied in Mali to enhance micro-nutrient bioavailability and vitamin retention in traditional vegetables
- Recipes disseminated for promotion in school garden programs in Mali, Cameroon and selected regions in Central Asia

Output Targets 2015

- Nutrition-improved preparation and preservation techniques that enhance micronutrient bioavailability and vitamin retention of traditional vegetables in Mali documented
- Recipes disseminated for promotion in school garden programs in Burkina Faso, Tanzania and selected regions in Central Asia

Output Targets 2016

- Recipes for promotion in school garden program in Central Asia disseminated

ACTIVITY 2.4

Develop, validate and implement promotion strategies for increased consumption of vegetables and nutritious/ diverse diets by poor households emphasizing on women and children in Asia and sub-Saharan Africa

Output Target 2014

- Effective communication and dissemination options scaled up for promoting traditional and standard vegetable nutrition and utilization in Central Asia, Bangladesh, Indonesia, Cameroon and Tanzania
- Effect of nutrition-sensitive agricultural promotion by seed companies on nutritional knowledge and intention for behavior changes in men, women and children in Bangladesh and selected countries in Africa studied
- Promotion strategies involving integration of vegetable gardening, livestock, food and nutrition components for enhanced vegetable consumption and good nutrition practices for rural and urban families in selected areas of Mali developed
- Farmer field days conducted in Central Asia, Cameroon and Tanzania to promote increased production and consumption of vegetables, ensuring participation of both men and women

Output Targets 2015

- Nutrition leaflets, posters, booklets and recipes books for Central Asia developed, printed and distributed to men and women

ACTIVITY 2.4

- Vegetable recipes for school and community garden programs in Mali, Cameroon and selected regions in Central Asia promoted and vegetable consumption and nutritious diets in Bangladesh promoted to men, women and children via participatory approaches
- Farmer field days conducted in Central Asia and the Caucasus to promote increased production and consumption of vegetables, ensuring participation of both men and women

Output Targets 2016

- Nutrition leaflets, posters, booklets and recipes books for Central Asia developed, printed and distributed to men and women
- Promotional activities of vegetable recipes for school and community garden programs in Central Asia undertaken
- Farmer field days in Central Asia and the Caucasus to promote increased production and consumption of vegetables, especially among women and children conducted

Output 3: Approaches to enhanced market efficiency and access developed, postharvest losses minimized and vegetable supply chains strengthened
Outcome: Small-scale farmers and other actors in Africa, Asia and the Pacific benefit from improved market coordination along vegetable supply chains, improved postharvest practices as well as from enhanced research capacities and networks.

ACTIVITY 3.1

Analyze components of supply chains, marketing systems and postharvest handling of vegetables in sub-Saharan Africa, Asia and Pacific

Output Targets 2014

- Postharvest handling and storage needs assessment survey in selected regions of Mali and Malawi and loss assessment surveys in selected regions of Nepal and Ethiopia conducted
- Options and opportunities for improving vegetable marketing value chain performance in Ethiopia, Tanzania, Malawi, Mozambique and Pakistan identified through field surveys and multi-stakeholder platforms
- Marketing systems and impact of the nutritional awareness of traditional vegetables on production and consumption decisions of farmers in Tanzania documented

Output Targets 2015

- Nutritional content of vegetables following application of validated innovative post-harvest handling technologies for selected vegetables in selected countries in sub-Saharan Africa and Asia monitored
- Feasibility studies on minimal processing and processing technologies as an alternative market in Ethiopia, Tanzania, Malawi and Mozambique conducted

ACTIVITY 3.1

- Needs and loss assessment surveys on postharvest handling and storage for vegetable crops in selected regions of Cambodia and Tajikistan conducted among men and women respondents; and value chains for at least two crops in Pakistan mapped and bottlenecks aimed at value chain upgrading for at least one crop in one province addressed

Output Targets 2016

- Nutritional content of vegetables following application of validated innovative postharvest handling technologies for selected vegetables in selected countries in sub-Saharan Africa and Asia monitored
- Needs and loss assessment surveys on postharvest handling and storage for vegetable crops in selected regions in Cambodia and Tajikistan documented
- Feasibility studies on the potential of minimal processing and processing technologies as an alternative market, to ensure year-round availability or for utilization of second grade product in Ethiopia, Tanzania, Malawi and Mozambique documented

ACTIVITY 3.2

Facilitate the establishment of enhanced market coordination mechanisms for vegetable supply in sub-Saharan Africa, Asia and Pacific

Output Targets 2014

- Awareness raising activities to encourage adoption of new postharvest technologies by men and women beneficiaries in Africa and Asia conducted via workshops and multi-stakeholder platforms
- Identified options and opportunities for improving downstream production value chain production performance of in Ethiopia, Tanzania, Malawi and Mozambique evaluated for their profitability with best-bet options targeted for promotion
- Pilot Participatory Guarantee System for high value vegetable crops in Fiji and Solomon Islands monitored and strengthened
- Public-private innovation platforms established and functional for supporting efficiency and marketing skill of men and women growers of produce and traditional vegetable seed in Arusha and Dodoma regions of Tanzania

Output Targets 2015

- Awareness raising activities to encourage adoption by men and women beneficiaries in Africa and Asia conducted via workshops and multi-stakeholder platforms
- Techniques for improved vegetable packaging materials via on-farm demonstrations in Babati, Tanzania disseminated to men and women
- Identified options for improving vegetable marketing value chain performance in Ethiopia, Tanzania, Malawi and Mozambique promoted via multi-stakeholder platforms

ACTIVITY 3.2

Output Targets 2016

- Developed and/or improved postharvest handling technologies disseminated for adoption by men and women beneficiaries in Africa and Asia via workshops and multi-stakeholder platforms
- Options for linking young men and women beneficiaries to direct high value vegetable markets in Ethiopia, Tanzania, Malawi and Mozambique explored and targeted promotional activities to meet niche consumer market preferences for increased vegetable consumption undertaken

ACTIVITY 3.3

Develop and enhance training curricula and materials on proper postharvest management and marketing skills for trainers in Asia, sub-Saharan Africa and Pacific

Output Targets 2014

- International Vegetable Training Course curricula and lecture/training materials on vegetable postharvest, marketing and nutrition at East and Southeast Asia office reviewed and updated annually
- Translated training materials in marketing and postharvest handling activities revised and disseminated to men and women beneficiaries in targeted locations in sub-Saharan Africa, Asia and Pacific Islands updated annually and disseminated

Output Targets 2015

- International Vegetable Training Course curricula and lecture/training materials on vegetable postharvest, marketing and nutrition at East and Southeast Asia office reviewed and updated annually
- Translated training materials in marketing and postharvest handling activities revised and disseminated to men and women beneficiaries in targeted locations in sub-Saharan Africa, Asia and Pacific Islands updated annually and disseminated
- Training materials developed and capacity building programs conducted, ensuring involvement of men and women, to reinforce linkages between producers and processor in Bangladesh and Tanzania

Output Targets 2016

- International Vegetable Training Course curricula and lecture/training materials on vegetable postharvest, marketing and nutrition at East and Southeast Asia office reviewed and updated annually
- Translated training materials in marketing and post-harvest handling activities revised and disseminated to men and women beneficiaries in targeted locations in sub-Saharan Africa, Asia and Pacific Islands updated annually and disseminated

ACTIVITY 3.4

Strengthen postharvest research capacity of national partners through trainings and awareness raising on post harvest loses and post harvest research in national and regional level in Asia, Africa and the Pacific, ensuring participation of both men and women

Output Targets 2014

- At least 1,000 participants from Tanzania, Ghana, Kenya and Bangladesh for Training of Trainers and farmer training courses trained in post-harvest handling practices
- Training programs in postharvest loss reduction successfully conducted and postharvest losses for at least two crops reduced by 10% in at least two project sites in Pakistan to improve farmer incomes

Output Targets 2015

- At least 1,000 participants from Tanzania, Ghana, Kenya and Bangladesh for Training of Trainers and farmer training courses trained in postharvest handling practices

Output Targets 2016

- At least 1,000 participants from Tanzania, Ghana, Kenya and Bangladesh for Training of Trainers and farmer training courses trained in postharvest handling practices

ACTIVITY 3.5

Adapting available technologies and developing new technologies to meet the needs of the target value chain actors and stakeholders in selected countries in Asia, Africa

Output Targets 2014

- Shelf-life performance of elite AVRDC-developed selected vegetable lines and varieties evaluated
- Trials on usage of ice packs to reduce deterioration of leafy vegetables during transportation and marketing conducted
- Field trials to determine the economic costs and potential benefits of the utilization of packaging liners and use of chlorinated water for cleaning produce after harvest in Tanzania conducted
- Appropriate postharvest handling technologies for selected vegetables to reduce losses and improve physical and nutritional quality out-turn in Burkina Faso, Cameroon and Ghana, Ethiopia, Malawi, Mozambique, Pakistan and Tanzania identified and evaluated

ACTIVITY 3.5

Output Targets 2015

- Shelf-life performance of elite AVRDC developed vegetable varieties evaluated
- Existing microbial and pesticide contamination in vegetables from urban markets in the target cities (in Ethiopia, Tanzania, Malawi and Mozambique evaluated
- Appropriate postharvest handling technologies for selected vegetables to reduce losses and improve physical and nutritional quality out-turn in Burkina Faso, Cameroon and Ghana, Ethiopia, Malawi, Mozambique, Pakistan and Tanzania tested and validated in the field with beneficiaries
- Results of research trials on use of evaporative coolers for short-term storage of vegetable crops to reduce postharvest losses in Tanzania validated and disseminated among targeted men and women

Output Targets 2016

- Shelf-life performance of elite AVRDC developed vegetable varieties documented
- Identified best-bet alternatives of economic costs and potential benefits of using packaging liners in Tanzania validated and disseminated among men and women beneficiaries
- Identified most adaptable postharvest handling technologies for selected vegetables to reduce losses and improve physical and nutritional quality out-turn in Burkina Faso, Cameroon and Ghana, Ethiopia, Malawi, Mozambique, Pakistan and Tanzania disseminated among program beneficiaries

Output 4: Policy recommendations with an aim to increase vegetable consumption developed, capacity strengthened and technology and knowledge disseminated
Outcome: Consumers are aware of the health-promoting benefits of increased utilization of vegetables through better access to nutritional education information, enhanced capacities of national agricultural research and extension systems and non-governmental organizations and improved policy support.

ACTIVITY 4.1

Conduct training courses and other capacity building and knowledge sharing platforms, ensuring participation of both men and women, to increase awareness and capacity of vegetable value chain actors and stakeholders to increase production, utilization and consumption of nutrient-rich vegetables in Asia, sub-Saharan Africa and Pacific

Output Targets 2014

- 3-5 day training courses on production of vegetable and seed, and , processing, consumption and conservation of vegetables delivered to 60-100 target beneficiaries in Burkina Faso, Cameroon, Ethiopia, Ghana, Malawi, Mali, Mozambique and Tanzania
- 1-2 farmer field days conducted in Central Asia and the Caucasus to promote increased production and consumption of vegetables
- Postharvest handling information disseminated in Indonesia via cell phone messages as a pilot study

Output Targets 2015

- 1-2 farmer field days conducted in Central Asia and the Caucasus to promote increased production and consumption of vegetables
- 3-5 day training courses on production of vegetable and seed, and processing, consumption and conservation of vegetables delivered to 60-100 target beneficiaries in Burkina Faso, Cameroon, Ethiopia, Ghana, Malawi, Mali, Mozambique and Tanzania

Output Targets 2016

- 1-2 farmer field days conducted in Central Asia and the Caucasus to promote increased production and consumption of vegetables
- 3-5 day training courses on production of vegetable and seed, and processing, consumption and conservation of vegetables delivered to 60-100 target beneficiaries (i.e., regular farmers, youth and women groups) in Burkina Faso, Cameroon, Ethiopia, Ghana, Malawi, Mali, Mozambique and Tanzania

ACTIVITY 4.2

Develop data collection protocols and policy briefs on outcome and impact assessment of program interventions in sub-Saharan Africa, Asia

Output Targets 2014

- VegOne, the centralized database for the Center's performance indicators implemented
- Generic framework for monitoring, evaluation, and technology dissemination for the Center updated annually
- Baseline data collected from men and women respondents on tomato production to assess the impact of tomato grafting in Indonesia collected and impact assessment of USAID-Indonesia in East Java and Bali conducted
- Preliminary behavioral change outcome among men, women and children evaluated of radio programming on production and consumption decisions of traditional vegetables growers in Tanzania

Output Targets 2015

- VegOne, the centralized database for the Center's performance indicators, implemented
- Generic framework for monitoring, evaluation, and technology dissemination for the Center updated annually
- Outcome evaluation study of contribution of improved vegetable cultivars to household income and nutritional outcomes via introduced school garden programs in East Java and Bali, Indonesia documented
- Evaluation of preliminary behavioral change outcome among men, women and children of radio programming on production and consumption decisions of men and women traditional vegetables growers in Tanzania documented

Output Targets 2016

- VegOne, the centralized database for the Center's performance indicators implemented
- Generic framework for monitoring, evaluation, and technology dissemination for the Center updated annually

Global Support

Administrative Services

Purchasing staff will be encouraged to explore on-line means to find price information so that the Center can obtain the best possible prices for goods and services. Staff members at Headquarters will participate in a training course for professional technical management personnel on managing the Center's toxic chemicals organized by the Environmental Protection Administration. This will ensure safe disposal of the Center's redundant and unused chemicals and chemical containers (toxic and non-toxic). Administrative Services will alert and assist staff to strengthen management and record-keeping of the Center's toxic chemicals. Discussion will be sought to consider the possibility of centralized management of the toxic chemicals and to improve the management of the safety/protection equipment already set up in the laboratory building.

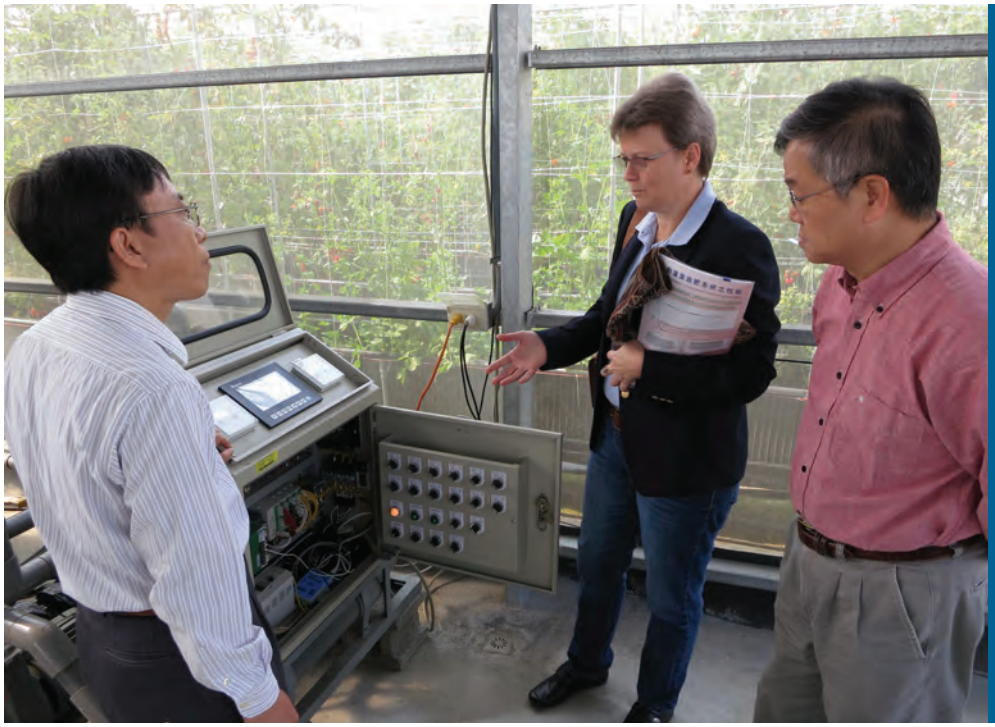
The Center's travel officer will continue to provide ticketing and other travel-related services to the Center's staff. The travel officer will, as much as possible, book and purchase air tickets on-line for staff members to reduce travel costs as airfare prices are expected to continue increasing in the foreseeable future.

Biometrics

Sound biometrical methods and access to statistical information and techniques used in research are important in achieving scientifically reliable and high quality research output. When scientists utilize AVRDC's Biometric Services, high quality research output is ensured. Problems in experimental trials and data analysis can be avoided with the rigorous and efficient application of biometrics.

AVRDC's biometrics resource covers all biometrics-related aspects of experimentation, from experimental design, field plot techniques, plot sampling techniques, remedial measures for problem data, and statistical analysis of data, to presentation and interpretation of results. Project proposals also go through the Biometrics review process before these are submitted to donors. Quality of all scientific manuscripts is ensured through comprehensive statistical review of reports to ensure and maintain AVRDC credibility among our donors, clients, and the entire scientific community.

The Biometrics Office will continue to provide the following biometrics consulting services to the Center's research scientists and staff: 1) statistical review of reports, proposals, abstracts, scientific papers and posters for publication, 2) evaluation of experimental/sampling plans, 3) statistical analysis of data, 4) capacity building through training programs on experimental design, data management and analysis, interpretation/presentation of results to improve and enhance the skills of staff and the national agricultural research system collaborators in conducting research, and 5) advice on how to use statistical software available at AVRDC.



Working with partners on policy and practice

Communications and Information

Communications and Information provides editorial, media and public awareness, library, graphic design, photography, visitor, and corporate marketing support to the Center staff. Activities that will engage the group over the next three years:

- 2014: Priorities will include standardizing electronic archiving practices; updating the lobby display in the Laboratory Building to enhance its educational value for visitors; and promoting greater use of video and mobile technologies for extension information dissemination, surveys, and documentation—especially to extend information access to women, who may be discouraged from attending workshops or field days. A vendor has been located to establish an online photo archive accessible to all regional offices. Efforts to expand the Center's media reach will continue through targeted placement of news releases and closer collaboration with reporters, commentators, bloggers, and partners.
- 2015: Communications and Information will focus on strengthening the Center's local presence and refining its global image through media training for staff.
- 2016: Actions to position the Center as the global leader for vegetable research and development will intensify through greater use of position papers and targeted awareness campaigns.

Financial Services

The Center's Strategic Plan includes substantial budget growth and funding diversity as its main financial objective. This requires maintaining the level of financial discipline that was attained in past years. Financial Services will continue to collaborate closely with the Grants and Partnership Development team to ensure proper and timely reporting to donors on their investments in the Center, and to help ensure that the Center pursues only projects and funding sources that are viable and in line with the Center's Strategic Plan.

There is increased emphasis from donors regarding financial health and impact from their investments; concerted efforts will continue to improve the Center's financial health indicators to match the growth in activities. Maintaining cost control and efficient operation of service units remain key areas.

In 2014 the Center will begin using a new report generator in Maconomy, the enterprise resource planning system. The new report generator brings increased flexibility and will allow the Center to more fully exploit available data. Efforts to increase the functionality of Maconomy will continue in 2015 and 2016.

The Finance group intends to strengthen the financial management capacity of the regional offices and in 2014 will organize a training session at headquarters for regional financial administrators.

Food and Dormitory Services (FDS)

AVRDC's Food and Dormitory Services strives to provide high quality catering services and accommodation facilities to the Center's staff and guests. To further improve the quality of services, training courses for the chefs may help them provide more diverse international cuisine for guests with different preferences and dietary requirements.

To maintain a healthy level of income, Food and Dormitory Services hopes to support symposia and workshops at Headquarters in the coming years, in addition to the annual support for trainees, students, AVRDC staff and guests and visitors. Funding will be sought to waterproof the Cafeteria and Dormitory building walls to reduce and prevent further damage caused by water seepage, and to update the dormitory furniture to improve the living conditions of trainees and staff members residing in the training hostel.

Global Technology Dissemination

The Global Technology Dissemination (GTD) group conducts a range of capacity building, technology dissemination and agricultural development activities. The group is responsible for innovating the processes and strategies for the Center's development-oriented projects to maximize impact at the farmer level. This is implemented by coordinating a wider group of 34 AVRDC scientists worldwide who work on technology dissemination and capacity building to provide a more unified and coherent effort to create outcomes and impacts.

The group works across all four of AVRDC's research and development themes, and plays a vital role in implementation of the Center's projects. It is currently involved in projects in 14 countries across Asia, Africa and the Pacific. Through these projects, thousands of men and women farmers and extensionists will receive training in vegetable technologies in 2014-2016. Monitoring and evaluation will be conducted to document the outcomes and impacts from project activities.

GTD manages the AVRDC Headquarters Demonstration Garden, which showcases the Center's technologies—including more than 100 crop species or varieties year-round—to visitors and trainees. Staff provide tours of the Garden to hundreds of visitors from more than 40 countries annually. Testing and adaptation research of new technologies will be carried on, such as greenhouse fertigation for vegetable crops. The group also multiplies rootstock germplasm for grafting to facilitate dissemination of flood- and disease-resistant lines.

Feedback from the Field, a bulletin that communicates technology applications and urgent issues from the field to its readers, is scheduled to be published quarterly. In collaboration with the breeding groups, GTD maintains and updates a web-based seed catalog which greatly facilitates germplasm transfer. The group continues promoting new AVRDC-improved lines and other technologies by updating the AVRDC website and compiling information on the Center's mature technologies into a database, as part of AVRDC's intellectual asset management. The database is used to enable efficient technology innovation and dissemination via the AVRDC website, projects and workshops. Collaborating with other groups at the Center, videos, training manuals and extension publications will be developed to disseminate the Center's technologies in ways that enable adaptation and adoption by end users.

Directly in line with the Center's mission, a pro-poor approach is used and oriented towards meeting local stakeholders' needs and maximizing impact. This approach will be employed when GTD provides participatory training courses on crop management technologies, coordinates and organizes exhibitions, field days and training workshops, and coordinates the Center's Disaster Response Program, which produces and distributes seed of hardy, fast-growing and nutritious vegetable crops to disaster survivors. The group continues to provide a crucial service role by facilitating administrative issues and logistics for trainees, typically from more than 12 countries, who come to Headquarters for capacity building activities in many disciplines.

Grants and Partnership Development

The overall goal for Grants and Partnership Development is to be an effective and efficient institutional support function for the research and development agenda of AVRDC. This is realized mainly through donor intelligence, quality review (proposals, technical reports, contracts), and drafting of contracts. In this facilitation and coordination role, Grants and Partnership Development is the Center's focal point for resource mobilization and project management/administration.

A special initiative launched in late 2013 to support a more systematic flow of information between Global Theme Leaders and Regional Directors for proposal development will be fully tested and evaluated. Grants and Partnership Development will foster deeper involvement of Global Theme Leaders (and Regional Directors as appropriate) in ensuring the technical content and quality of proposals and technical reports.

Efforts will continue to ensure the Deputy Director General for Research receives relevant information in a systematic manner. Grants and Partnership Development populates Maconomy, the Center's enterprise resource planning system, with concept notes and proposals as well as project data and agreements, and strives to improve its functionality in regard to resource mobilization and project management/administration.
Grants and Partnership Development supports the Center's themes and as much as possible participates in and contributes to Global Theme Meetings. Efforts will be increased to develop partnerships to attract new donors/funding.

Grants and Partnership Development will continue to:

- Facilitate, coordinate and support resource mobilization efforts: donor intelligence and priorities; review, edit and submission of concept notes and proposals; development of partnerships.
- Monitor and support project management/administration: negotiate, draft, review and edit contracts; review, edit and submission of technical reports; solve a multitude of other project-specific issues.
- Develop and manage tools for resource mobilization and project management/administration.

Human Resources

Staff members are among the Center's key comparative advantages, bringing diverse competencies to their positions along with the capability of serving efficiently in many locations around the world. Retaining and nurturing this talent pool is of strategic importance to the Center. As in previous years, the Center will continue its efforts to improve staff skills, strengthen the enabling culture, improve engagement for performance, and build a synergistic team.

From 2014-2016, the priority skill development area will be project management and monitoring & evaluation. The Center has secured several new research and development projects that demand efficient project management and M&E practices. The Center is actively participating in several CGIAR Collaborative Research Projects (CRPs), and these partnerships are likely to increase in the future. AVRDC staff require a higher level of collaborative and partnership skills for working in large system projects with multiple partners. The Center has planned joint skills development programs with the CGIAR centers to meet these needs.

Other skills that will be developed during this period are in the field of analytics, environmental protection with emphasis on low carbon technologies/ practices, and leadership and team skills. A follow-up training course on gender research is also planned. Based on the feedback from the previous year's survey, enabling mechanisms will be put in place to help the staff enhance their scientific publication pursuits. The performance and rewards systems will be reviewed and fine-tuned to improve engagement for higher performance and efficiency.

Information Technology Services

Information Technology Services continues to reinforce the importance of safeguarding the Center's digital resources with repeated messages and seminars across all Center locations. Migration from the soon-to-be-discontinued Windows XP is a priority.

The group will develop new policies and work on those that need to be streamlined in an effort to meet the needs of the modern working environment, and simultaneously, the needs of our scientists and researchers. Among the key priorities in this area would be improving internet security, including protection right up to the user level.

AVRDC's VegOne information system is on a continuous improvement plan. New modules will be add to this monitoring and evaluation system, launched in October 2013 to manage institutional indicators. Orientation and training seminars and workshops will be held at all regional locations.

Internal Audit

Many documents generated from the Center's regular activities are stored electronically, and it is important to secure the safety of these documents. Internal Audit will work with Information Technology Services to monitor the Center's major databases. In addition, Internal Audit will also audit individual databases to verify their appropriateness and function.

Internal Audit will monitor toxic chemical management at regional offices to ensure hazardous chemicals are handled according to the Center's regulations and host country legal requirements. Internal Audit will continue to monitor property management and to emphasize upholding the responsibilities of property custodians within the Center.

In 2014-2016, Internal Audit will follow through on planned audit tasks such as the travel process, the functioning of Maconomy, the Center's enterprise resource planning system, and operations at regional offices. Internal Audit will also make efforts to reinforce existing systems and procedures to assist the Center's smooth functioning and delivery of targeted outputs.

Technical Services Office (TSO)

Crews of the Technical Services Office enhance the safety and security of the Center's personnel, environment and facilities. The support of the Technical Services Office will remain a prerequisite for the Center's field and laboratory activities, providing casual labor, grounds and garden maintenance and also security services. New irrigation and drainage ditches in the experimental fields will be constructed as necessary.

The feasibility of replacing 2-stroke engines of lawn mowers and grass clipping blowers with 4-stroke engines to reduce air pollution will be assessed. The Center's high voltage transformer has been in place for more than 40 years. For the Center's electrical safety, renewal is being considered. Estimated cost for renewal at the same location on campus is being compared with costs for renewal plus relocation away from the laboratory building to reduce the heat and noise in the laboratories. The wire fence along the north side of the Center's farm at Headquarters will be reinforced to prevent trespassers and to protect the Center's research trial activities and crops.

2014 Projected Budget

In October 2013 the Board's Executive Committee endorsed a provisional 2014 budget of US$ 16.2 million. This budget will be reviewed early in 2014 and a final budget will be submitted for approval by the full Board in April 2014. The budget represents an increase in volume of activities when compared to the previous years and shows a modest surplus of US$ 22,000.

The Center expects, compared to 2013, a 25% increase of project activities financed by restricted funds. The Center is modernizing its facilities and equipment at an increased rate. This is funded by the accumulated surpluses of the previous years, which are contained in the Capital Replacement Fund.

The Center has developed a contingency plan for 2014 to be able to cope with higher or lower actual revenues.

Table 1 - Financial activities for the year 2013

	2013 Actual				2013 Budget	
	Unrestricted	**Restricted**	**Total**	**%**	**Total**	**%**
Revenues						
Unrestricted grants	9,316,199		9,316,199	53%	9,214,376	62%
Restricted grants		8,277,201	8,277,201	47%	5,663,857	38%
Total	**9,316,199**	53%	**8,277,201**	47%	**17,593,400**	100%	**14,878,233**	100%
Expenditures						
Personnel						
- International	2,740,026	1,587,763	4,327,789	27%	3,970,012	27%
- Local	4,069,621	661,936	4,731,557	30%	5,172,218	35%
Sub-total Personnel	6,809,647	2,249,699	9,059,346		9,142,230	62%
Operating expenses						
- Operational expenses, services	1,363,516	3,177,911	4,541,427	29%	3,092,962	21%
- Travel	218,536	968,879	1,187,415	8%	711,382	5%
- Trainings, workshops and other meetings	127,157	521,444	648,601	4%	454,755	3%
- Equipment (depreciation costs)	68,834	269,134	337,968	2%	647,804	4%
- Direct Overhead charge		1,090,134	1,090,134	7%	916,413	6%
- Contingency			0	0%	800,000	5%
Sub-total Operating Expenses	1,778,043	6,027,502	7,805,545		6,623,316	45%
Sub-total	**8,587,690**	**8,277,201**	**16,864,891**	107%	**15,765,546**	106%
Indirect cost recovery (overhead)	-1,094,332		-1,094,332	-7%	-916,413	-6%
Total	**7,493,358**	48%	**8,277,201**	52%	15,770,559	100%	**14,849,133**	100%
Changes in net assets	1,822,841		1,822,841		29,099	
Net change in Self-sustaining Operating Fund			62,398			
Net change in Capital Replacement Fund			-187,953			
Net assets at the beginning of the year			4,016,579			
Net assets at the end of the year*			5,713,865			
** Allocated to:*						
Working Capital Fund	2,000,000					
Accumulated Fund	2,116,511					
Capital Replacement Fund	800,000					
Fixed Asset Fund	182,000					
Self-sustaining Operating Fund	615,354					
Total	5,713,865					

Table 2 - 2014 Final budget estimate (USD '000)

	2014 Estimate		2013 Actual	
Revenues	**18,113**		**17,593**	
Budget Allocations by Objects				
Personnel				
- International	5,503	30%	4,328	27%
- Local	4,999	28%	4,732	30%
Operations				
- Operational expenses, services	4,917	27%	4,541	29%
- Travel costs	1,255	7%	1,187	8%
- Trainings and Workshops	650	4%	649	4%
- Equipment (Depreciation costs)	408	2%	338	2%
- Overhead Charge	1,136	6%	1,090	7%
Contingency	350	2%		
Sub-total	**19,218**	106%	**16,865**	107%
Indirect cost recovery (overhead)	-1,136	-6%	-1094	-7%
Total	**18,082**	100%	**15,771**	100%
Changes in net assets	**31**		**1,823**	
Net assets at the beginning	5,714		4,017	
Change in net assets	31		1,823	
Net change in Self-sustaining Operating Fund	60		62	
Net change in Capital Replacement Fund	-800		-188	
Carried over/forward *	5,005		5,714	
* Net Assets as of 31 December 2012:				
Working Capital Fund			1,500	
Accumulated Fund			1,272	
Capital Replacement Fund			525	
Fixed Asset Fund			166	
Self-sustaining Operating Fund			553	
Budget allocations by Themes				
I. Strategy Themes				
I-1 Germplasm: Germplasm conservation, evaluation and gene discovery	957	5%	1,246	8%
I-2 Breeding: Genetic enhancement and varietal development of vegetables	2,238	12%	2,590	16%
I-3 Production: Safe and sustainable vegetable production systems	4,011	22%	3,439	22%
I-4 Consumption: Balanced diets through increased access to and utilization of nutritious vegetables	5,640	31%	4,780	30%
II. Administration and Services	5,236	29%	3,716	24%
Total *	**18,082**	100%	**15,771**	100%

* Excluding contingency in Estimate 2013

Table 3 - Breakdown of Y2014 Estimated Revenues (USD '000)

Donor	2014 Estimate		2013 Actual	
Unrestricted Funding				
Republic of China (ROC)	4,695		5,211	
United States Agency for International Development (USAID)	1,000		1,000	
UK Department for International Development (UK/DFID)	2,326		2,368	
Germany	273		271	
Japan	24		24	
Korea	50		50	
Thailand	149		151	
Philippines	50		0	
Asia and Pacific Seed Association (APSA)			150	
Sub-total	8,567		9,225	
Other revenues	130		91	
Total	**8,697**	**48%**	**9,316**	**53%**
Restricted Funding *				
Australia/Australian Centre for International Agricultural Research (ACIAR)	871		520	
Consortium of International Agricultural Research Centers (CGIAR)	712		933	
European Union	198		0	
Republic of Germany/BMZ/GIZ	1,021		1,357	
Commodity value-chain development support project (PADFA)	176		0	
Republic of China (ROC-COA/NSC/MOFA)	320		1,416	
Swiss Agency for Development and Cooperation (SDC)	1,178		343	
USAID	3,745		2,665	
Others	1,195		1,043	
Sub-total	**9,416**	**52%**	**8,277**	**47%**
Total Revenues	**18,113**	**100%**	**17,593**	**100%**

* Contribution less than US$ 150,000 grouped under "Others"

Table 4. Budget Projection for 2014 - 2016 (USD '000)

	2013 Actual	2014 Estimate	2015 Projection	2016 Projection
Budget Allocation by Category				
Personnel				
- International	4,328	5,503	5,778	6,067
- Local	4,732	4,999	5,249	5,511
Operations				
- Operational expenses, services	4,541	4,917	5,163	5,421
- Travel costs	1,187	1,255	1,318	1,384
- Trainings and Workshops	649	650	683	717
- Equipment (Depreciation costs)	338	408	428	450
- Overhead Charge	1,090	1,136	1,193	1,252
Contingency		350	368	386
Sub-total	16,865	19,218	20,179	21,188
Indirect cost recovery (overhead)	-1,094	-1,136	-1,193	-1,252
	15,771	**18,082**	**18,986**	**19,935**

Budget Allocation by Themes								
I. Strategy Themes								
I-1 Germplasm: Germplasm conservation, evaluation and gene discovery	1,246	8%	957	5%	1,005	5%	1,055	5%
I-2 Breeding: Genetic enhancement and varietal development of vegetables	2,590	16%	2,238	12%	2,349	12%	2,467	12%
I-3 Production: Safe and sustainable vegetable production pystems	3,439	22%	4,011	22%	4,212	22%	4,423	22%
I-4 Consumption: Balanced diets through increased access to and utilization of nutritious vegetables	4,780	30%	5,640	31%	5,922	31%	6,218	31%
II. Administration and Services	3,716	24%	5,236	29%	5,498	29%	5,772	29%
Total *	**15,771**		**18,082**		**18,986**		**19,935**	

Key Staff

Staff Name	Position Title	Location	Nationality
Acedo Jr., Antonio	Postharvest Specialist	Hyderabad, India	Philippines
Afari-Sefa, Victor	Scientist - Socioeconomics and Global Theme Leader - Consumption	Arusha, Tanzania	Ghana
Ahmad, Shahabuddin	Vegetable Sector Leader (Bangladesh)	Dhaka, Bangladesh	Bangladesh
Ali, Mansab	Horticulture Project Leader (AIP Project)	Islamabad, Pakistan	Pakistan
Chang, Jan	Postdoctoral Fellow - Molecular Entomology	Shanhua, Taiwan	Taiwan
Chang, Yin-Fu	Deputy Director General - Administration & Services	Shanhua, Taiwan	Taiwan
Chen, Huei-Mei	Associate Specialist, Biotechnology/ Molecular Breeding	Shanhua, Taiwan	Taiwan
Chen, Willie	Assistant Specialist, Global Technology Dissemination	Shanhua, Taiwan	Taiwan
Dhillon, Narinder	Vegetable Breeder - Cucurbits	Bangkok, Thailand	India
Dinssa, Fekadu Fufa	Vegetable Breeder	Arusha, Tanzania	Ethiopia
Dubois, Thomas	Regional Director, Eastern and Southern Africa	Arusha, Tanzania	Belgium
Easdown, Warwick	Regional Director, South Asia	Hyderabad, India	Australia
Ebert, Andreas	Genebank Manager and Global Theme Leader - Germplasm	Shanhua, Taiwan	Germany
Fleissner, Klaus	Agronomist/Breeder - Vegetable Cropping Systems	Yaoundé, Cameroon	Namibia
Ghai, Tilakraj	Consultant	Punjab, India	India
Hanson, Peter	Plant Breeder (Tomato and Indigenous Vegetable Research) and Global Theme Leader for Breeding	Shanhua, Taiwan	USA

Staff Name	Position Title	Location	Nationality
Holmer, Robert	Regional Director, East and Southeast Asia	Bangkok, Thailand	Germany
Hong, Yoonpyo	Postharvest Specialist (seconded scientist from RDA/Korea)	Shanhua, Taiwan	Korea
Hsu, Sylvia	Manager - Food and Dormitory Services	Shanhua, Taiwan	Taiwan
Hughes, Jacqueline d'Arros	Deputy Director General - Research	Shanhua, Taiwan	United Kingdom
Inukonda, Nagaraj	Director of Human Resources	Shanhua, Taiwan	India
Iramu, Ellen	Project Coordinator - Pacific Islands	Honiara, Solomon Islands	Solomon Islands
Keatinge, J.D.H.	Director General	Shanhua, Taiwan	Ireland
Kenyon, Lawrence	Plant Virologist	Shanhua, Taiwan	United Kingdom
Krishnan, Bharath	Manager - Information Technology Services	Shanhua, Taiwan	India
Kumar, Sanjeet	Scientist - Pepper Breeding	Shanhua, Taiwan	India
Kwazi, Nadine	Executive Assistant to the Director, Regional Center for Africa	Arusha, Tanzania	Zambia
Ledesma, Dolores	Board Secretary and Biometrician	Shanhua, Taiwan	Philippines
Lin, Chih-Hung	Associate Specialist, Bacteriology	Shanhua, Taiwan	Taiwan
Lu, Vincent	Internal Auditor	Shanhua, Taiwan	Taiwan
Luther, Greg	Technology Dissemination Specialist	Shanhua, Taiwan	USA
Luther, Kartini	Assistant to Deputy Director General - Research	Shanhua, Taiwan	USA
Ma, Chin-Hua	Associate Specialist, Bacteriology	Shanhua, Taiwan	Taiwan
Macharia, John	Project Manager (Income and Nutrition through Vegetables Project)	Arusha, Tanzania	Kenya
Mak, Adrienne	Manager - Management Support & Human Resources Services	Shanhua, Taiwan	Taiwan
Manickam, Ravishankar	Research Site Coordinator	Jharkhand, India	India
Mariyono, Joko	Project Site Coordinator (Indonesia)	Jawa Timur, Indonesia	Indonesia

Staff Name	Position Title	Location	Nationality
Mavlyanova, Ravza	Regional Coordinator for Central Asia and the Caucasus	Tashkent, Uzbekistan	Uzbekistan
Mecozzi, Maureen	Head, Communications and Information	Shanhua, Taiwan	USA
Nair, Ramakrishnan	Vegetable Breeder - Legumes	Hyderabad, India	India
Nenguwo, Ngoni	Postharvest Specialist	Arusha, Tanzania	Zimbabwe
Öberg, Annelie	Manager - Grants and Partnership Development	Shanhua, Taiwan	Sweden
Overweg, Dirk	Director of Finance	Shanhua, Taiwan	The Netherlands
Palaniswamy, Usha	Project Manager (Vegetables Go to School Project)	Shanhua, Taiwan	USA
Rajendran, Srinivasulu	Postdoctoral Scientist - Agricultural Economics	Arusha, Tanzania	India
Ramasamy, Srinivasan	Entomologist	Shanhua, Taiwan	India
Rouamba, Albert	Vegetable (Onion) Breeder	Bamako, Mali	Burkina Faso
Schafleitner, Roland	Head, Molecular Genetics	Shanhua, Taiwan	Austria
Schreinemachers, Pepijn	Agricultural Economist	Shanhua, Taiwan	The Netherlands
Stoilova, Tsvetelina	Scientist - Genetic Resources	Arusha, Tanzania	Bulgaria
Tenkouano, Abdou	Regional Director, Africa	Bamako, Mali	Burkina Faso
Tsai, Wen-Shi	Associate Specialist, Virology	Shanhua, Taiwan	Taiwan
Wang, Jaw-fen	Plant Pathologist and Global Theme Leader - Production	Shanhua, Taiwan	Taiwan
Yang, Ray-yu	Nutritionist	Shanhua, Taiwan	Taiwan
Yeboah, Martin	Scientist (Vegetable Breeder & Horticulturist) and Liaison Officer for Cameroon	Yaoundé, Cameroon	Ghana

Acronyms & Abbreviations

AARNET	ASEAN-AVRDC Regional Network
ACIAR	Australian Centre for International Agricultural Research
AIRCA	Association of International Research and Development Centers for Agriculture
ASEAN	Association of Southeast Asian Nations
AVGRIS	AVRDC Vegetable Genetic Resources Information System
BCMV	*Bean common mosaic virus*
BRICS	Brazil, Russia, India, China, South Africa
BYVMV	*Bhendi yellow vein mosaic virus*
CAADP	Comprehensive African Agricultural Development Program
CAAPP	Central Africa Agricultural Productivity Program
CACV	Capsicum chlorosis virus
CAPSA	Centre for Alleviation of Poverty through Sustainable Agriculture
CATIE	Tropical Agriculture Research and Higher Education Center
CFF	Crops for the Future
CGIAR	Consultative Group on International Agricultural Research
CIP	International Potato Center
CMS	Cytoplasmic male sterility
COA	Taiwan Council of Agriculture
CRS	Catholic Relief Services
ECCAS	Economic Community of Central African States
ECOWAS	Economic Community of West African States
ERP	Enterprise resource planning system
FAO	Food and Agriculture Organisation of the United Nations
FARA	Forum for Agricultural Research in Africa
FSC	Food Security Center, University of Hohenheim, Germany
FTF	Feed the Future
GAA	Germplasm Acquisition Agreement
GCARD	Global Conference on Agricultural Research for Development
GIZ	Gesellschaft für Internationale Zusammenarbeit
GRSU	Genetic Resources and Seed Unit
GTD	Global Technology Dissemination
HORTCRSP	USAID Horticulture Collaborative Research Support Program

ICARDA	International Center for Agricultural Research in the Dry Areas
ICBA	International Center for Biosaline Agriculture
ICIMOD	International Center for Integrated Mountain Development
ICIPE	Africa Insect Science for Food and Health
ICIS	International Crop Information System
ICRAF	World Agroforestry Centre
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IFAD	International Fund for Agricultural Development
IITA	International Institute for Tropical Agriculture
INBAR	International Network for Bamboo and Rattan
ITS	Internal transcribed spacer
IVTC	International Vegetable Training Course
JIRCAS	Japan International Research Center for Agricultural Sciences
KGKV	Krishi Gram Vikas Kendra
KU	Kasetsart University, Thailand
LC-MS	Liquid chromatography – mass spectrometry
MAS	Marker-assisted selection
MGD	Millennium Development Goals
MOFA	Taiwan Ministry of Foreign Affairs
MTA	Material Transfer Agreement
MYMV	*Mungbean yellow mosaic virus*
NARES	National agricultural research and extension systems
NGO	Nongovernmental organization
PADFA	Projet d'appui au Developement des Filieres Agricoles
PCR	Polymerase chain reaction
PepMoV	*Pepper mottle virus*
PGS	Participatory guarantee scheme
PVMV	*Pepper veinal mottle virus*
QTL	Quantitative trait loci
RAD	Restricted enzyme associated sequencing
RCA	Regional Center for Africa
RIL	Recombinant inbred line
RNAI	RNA interference
SDC	Swiss Agency for Development and Cooperation
SMTA	Standard Material Transfer Agreement
SLCuPV	*Squash leaf curl Philippines virus*
SPC	Secretariat of the Pacific Community
SRTT	Sir Ratan Tata Trust
SSR	Simple sequence repeats
TSWV	*Tomato spotted wilt virus*
TYLCV	*Tomato yellow leaf curl virus*
ToLCTV	*Tomato leaf curl Taiwan virus*
TYLCTHV	*Tomato yellow leaf curl Thailand virus*
UN-ESCAP	Economic and Social Commission for Asia and the Pacific of the United Nations

USAID	United States Agency for International Development
VEGINET	Vegetable Science International Network
VINESA	Improving income and nutrition in Eastern and Southern Africa by enhancing vegetable-based farming and food systems in peri-urban corridors
WAAPP	West Africa Agricultural Productivity Program
WARDA	Africa Rice Center
WASH	Water, sanitation, hygiene
WECARD/ CORAF	West and Central African Council for Agricultural Research and Development/ Conseil Ouest et Centre Africain pour la Recherche et le Développement Agricoles
ZECC	Zero energy cooling chamber