7th EPMR

External Program and Management Review 2007

Report of the 7th External Program and Management Review

March 3, 2008

AVRDC
The World Vegetable Center

AVRDC - The World Vegetable Center

Report of the 7th External Program and Management Review

March 3, 2008

CONTENTS

EXECUTIVE SUMMARY

In the years ahead the mission of The World Vegetable Center and its ability to fulfil it, will be more relevant, critical and urgent in terms of the future of humanity than at any time since the Center was established.

The context for this includes the growing challenges of satisfying sharply rising global demand for food amid increasing shortages of water and arable land, the rising price of energy and farm inputs, intractable poverty and rapid urbanisation of the poor, environmental decline, the globalisation of food and emerging climate change. Within this matrix of issues the Center faces its own particular challenges of rapidly expanding need for its expertise, its identity and structure, the adequacy and range of its funding sources, where best to locate itself and its R&D effort, the need to attract and retain talented staff and how to disseminate its scientific outcomes as swiftly as possible to the people who most need them, in order to fulfil its mission.

The World Vegetable Center has established a clear role for itself as a leader in the worldwide debate about food and in particular, about horticulture, exemplified in its leadership of the Challenge Program and in helping to establish the Global Horticulture Initiative. This role seems bound to grow in future.

Starting from a position where funding was scarce and interest in horticulture low, the Center has managed a period of restructuring and sudden, rapid expansion with skill and effectiveness. It now faces the twin challenges of consolidating the new structures which have been put in place, and adapting them for further probable rapid growth.

The Panel finds it important that the institute continue to develop its global identity as The World Vegetable Center, with tendrils in all relevant regions and with a global mandate, rather than a particular regional identity. In pursuit of this we encourage the Center to grow its Regional Centers (RCs), particularly Africa and South Asia, as rapidly as is rational and to devolve to them greater authority and resources to manage and coordinate their own region-relevant research and development. Rapid expansion in the Center's research activity – exemplified by programs such as vBSS - will sooner or later necessitate the introduction of a third tier of management, and the Panel feels it is most logical if this consist of the RC Directors and if the overheads for RC research vest with the RCs.

The Panel finds the new research theme structure to be an efficient and logical approach to the issue of managing the Center's science and encourages its consolidation. However in implementing this, the Center will need to define a balance between theme science and the increased freedom of the RCs to manage their R&D. This will involve careful co-ordination at the planning stage and clarifying lines of reporting and management. Further restructuring will provide the basis for moving from project-driven to strategy-driven and regionally-driven

research programs. The Panel commends the current focus on nutrition – which is unique among IARCs – and wishes to see it strengthened and deepened with the addition of a Nutrition Research Unit.

Further, the Panel urges a greater strategic focus on the issue of development, which is clearly defined as part of the Center's charter and is in its original name. At present this is conceptualised largely within research programs – where there is a natural tension between 'R' and 'D' – and is not being addressed in a systematic way. Since 'development' is the means by which the Center delivers on its mission, the Panel argues that there is a need for a distinctive development capability established within the Center accompanied by a clear plan, a budget and a responsible manager. We offer some suggestions for this, leaving the decision about how best to implement it to management. We point out that many donors offer discrete development funding as well as research funding.

The Panel sees substantial scope to improve the Center's knowledge management and dissemination system. It offers a simple conceptual model for achieving this and urges the Center to move beyond the traditional mode of relying almost entirely on partners for communication with poor farmers and consumers but, with its partners, to develop a strategic capability exploiting modern mass communication methods which are low cost, reach millions and can thus help to deliver the mission and alleviate poverty for more people more quickly.

Coupled with the Center's rapid growth and rising stature globally, the Panel feels it is important for it to bed down its human resources and employment policies, to ensure that talented staff are both attracted to the Center and retained, that younger staff are mentored, that certain inequalities in reward that have crept in over time are progressively ironed out and that Occupational Health and Safety (OH&S) issues are fully attended to for staff at all levels.

The Panel considers that the same factors – the Center's growth and rising international stature – make its strategically opportune to diversify its sources of funding and encourages it to explore closer links with selected private partners in the food sector, to consider the potential market value of both its germplasm bank and its knowledge bank, to look at a co-operative research structure which might attract paying partners, to explore strategic expansion into fruit research and to consider a global horticultural R&D trust fund.

In summary the 7th EPMR finds that The World Vegetable Center is a vibrant, dynamic and inspirational organisation that is coping well with the stresses of change and sudden growth. It has an enthusiastic, dedicated and talented staff and is well-led by the current management. The Panel sees very considerable opportunities for future growth as the world awakes to the emerging risk of regional food shortages and pressure increases to overcome the twin problems of malnutrition and over-nutrition. It considers the World Vegetable Center should position itself to play an

even greater international leadership role by projecting horticulture as the primary answer to this challenge.

ACKNOWLEDGEMENTS

The EPMR panel wishes to acknowledge the time, care, generous assistance and candour of members of the Board, senior management and staff of the World Vegetable Center in helping us to prepare this report. We thank them all.

Further we wish to acknowledge the many representatives of NARES, seed companies, non-government organisations and scientific partners as well as the ordinary farmers and citizens of Africa and Asia who unstintingly gave us their time and views about the future for vegetable production and consumption and the great opportunities created by research and development such as that carried out by the World Vegetable Center.

John Lynam

Chair, 7th EPMR

March 3, 2008

BACKGROUND OF THE EXTERNAL PROGRAM AND MANAGEMENT REVIEW

The previous AVRDC External Program and Management Review (EPMR) was conducted in 2000. Since then, the Center has changed leadership with Dr. Thomas A. Lumpkin appointed as Director General on 1st January 2003 and he implemented a program to expand the Center's activities globally and to ensure greater impact on alleviating poverty and malnutrition by improved production and consumption of safe vegetables. As a consequence of the rapid expansion of the Center's role in global horticulture, a 7th EPMR was proposed. The 7th EPMR was particularly important to evaluate the successes of the Center and also to focus the Center's future activities to achieve the impact which is vital to the poor in the developing countries as well as to the Center itself.

The overall purposes of the 7th EPMR were:

- to review the achievements of the Center since the 6th EPMR, taking into account its evolving structure and activities;
- to provide guidance to the Center's long-term strategic research program especially in view of developments in biotechnology, in information and communication technology, financial management and the shifting roles of the public and private sectors;
- to offer advice on how the management can provide the most effective and efficient leadership and services for the Center to reach its research and development goals;
- to assist the Center in planning its continued global expansion in an effective way, taking into account geo-politics, resource availability and global networks and organizations, thus ensuring continued delivery or international public goods to achieve high levels of impact;
- to assess and make recommendations on the need for the Center to demonstrate measurable, positive changes in the lives of the poor in developing countries in relation to the Center's output of international public goods;
- to provide stakeholders with an independent assessment of the Center's performance, in terms of research and development impact, and governance;
- to make recommendations on how to institute a dynamic corporate management style which evolves to address new challenges and opportunities.

The EPMR Panel

The invited reviewers were selected from 70 recommended candidates received by the Board of Directors. The final list was selected to form a panel which represents different disciplines or facets which are pertinent to a review of an international center focused on vegetable research and development (e.g. horticultural science,

molecular biology, crop management, nutrition, development, information and communication technology, and business administration). All reviewers are familiar with international agricultural research and have extensive experience with developing countries.

Dr. John Lynam (Chair)

Managing Director, Kilimo Trust, Uganda

John Lynam received his doctorate from Food Research Institute, Stanford University, USA. His career focuses on smallholder-led agricultural development in the tropics. He had extensive experience in developing, managing, and funding agricultural research in both national and international systems in Latin America, sub-Saharan Africa and Asia. As managing director of Kilimo Trust, he establishes and develops new funding entities for smallholder agricultural development in East Africa, designs a funding strategy for the Trust and develops projects for funding within the strategic framework. He has served as a member of review teams on Evaluation and Impact Assessment of Training Activities in the Consultative Group on International Agricultural Research (CGIAR) and on External Evaluation of INTSORMIL.

Dr. Julian Cribb (member)

Science Communication Consultant, Australia

Julian Cribb is a self-employed principal specialist of the Julian Cribb & Associates, specialized in science communication. He is also Adjunct Professor in the science communication at the University of Technology Sydney and a Fellow of the Australian Academy of Technological Sciences and Engineering. His particular skill is in helping scientific agencies to design low-cost but effective means to transfer their knowledge and technologies to various beneficiaries. Examples of his involvement in the international agricultural research are: served as a Director of the Australian Centre for International Agricultural Research (ACIAR) and as the Secretariat for International Landcare, and conceived "*Future Harvest*", the global public awareness campaign for the CGIAR.

Dr. Chagema Kedera (member)

Managing Director, Kenya Plant Health Inspectorate Service (KEPHIS)

Chagema Kedera's doctorate is in Plant Pathology with minor in Plant Breeding from Kansas State University, USA. As the managing director of KEPHIS, he is mandated to undertake plant protection; plant variety protection; seed certification; and fertilizer, soil, water, and pesticide formulation and residue analysis including environmental monitoring. He has served as Chairs of Commission on Phytosanitary Measures (CPM), Organization of Economic Cooperation and Development (OECD) Agricultural Seed Schemes, Communication and Participation Discussion Group of Food and Agriculture Organization/World Health Organization (FAO/WHO) Global Forum of Food Regulators, Kenya National Taskforce on Horticulture, International Steering Committee on Removing Barriers to Invasive Plants Management in Africa, and a member of Central Advisory Service Board to CGIAR on Intellectual Property Rights (IPR).

Dr. Michael Krawinkel (member)

Executive Director, International Society of Tropical Pediatrics, Germany

Michael Krawinkel's expertise is in nutrition and his doctorate is in habilitation from the University of Keil, Germany. He is currently a professor of Human Nutrition/International Nutrition & Pediatrics at the University of Giessen, Germany. He has served as a member of Scientific Advisory Board of the German Federal Ministry of Economic Cooperation and Development, an advisor to the Germany's Gemeinschaft für Technische Zusammenarbeit (GTZ) and KfW-Development Bank, to WHO, to the Medical Research Council South Africa, and to the Danish Council for Strategic Research. As the Panel member, he focused on the nutritional issues of AVRDC-The World Vegetable Center scientific and training activities.

Dr. Jai Singh (member)

Managing Director, Tokita Seed India (P) Ltd

Jai Singh represents private sector stakeholder in the EPMR Panel. He obtained his doctorates from Indian Agricultural Research Institute and Tokyo University of Agriculture in seed genetics and plant breeding. In his capacity as a managing director of seed company, he focused his review on breeding and production systems of AVRDC – The World Vegetable Center research program and development with specific references to specific need-based breeding to address problems faced by farmers/growers, impacts of climatic changes, rapid urbanization, market chains of vegetables, genetically modified-vegetable crops, and IPR.

Documents for the EPMR

Particular AVRDC – The World Vegetable Center documents were made available to the EPMR Panel to facilitate the review process. The documents were organized into: 1. Organization, Strategy, and Priorities (Organization, Medium Term Plans and Strategic Planning), 2. Governance and Management (Finance and Human Resources), 3. Quality and Relevance of the Science Undertaken (Research and Development, and Partnership and Collaborative Programs), and 4. Accomplishments and Impact (Output and Impact). The Panel also had access to the report of the 6th EPMR and the actions taken based on its recommendations. All the documents were made available to the Panel on a web site dedicated to the 7th EPMR and were accessible to the members by a password. All the documents are available in the attached compact disc.

The EPMR Program

The review was conducted in the 3 Regional Centers and the headquarters. John Lynam and Chagema Kedera reviewed Asian Regional Center (ARC) and Regional Center for South Asia (RCSA), while Julian Cribb and Michael Krawinkel reviewed Regional Center for Africa (RCA). The ARC review was conducted in two phases to accommodate flight availability in John Lynam's and Chagema Kedera's itinerary. Jai Singh was not assigned to review any Regional Center since he was engaged to fulfill an obligation during the period. At the conclusion of the Regional Centers' review, all Panel members, except Chagema Kedera, converged and reviewed Headquarters. Because of a visa problem, Chagema Kedera was not able to come to Headquarters. He conducted his review by long distance phone interview from Bangkok, Thailand.

During the review process at Headquarters, Panel members interviewed separate lists of staff based on the specific focuses of the review agreed upon between the members. The Panel participation in the concurrent 2007 AVRDC - The World Vegetable Center Internal Review and Planning Workshop (IRPW) provided a deeper insight into the Center's work which in turn led to subsequent interviews with different staff originally not in the requested interview list. Interviews with staff from Sub-Regional Office for West and Central Africa, Regional Program for Central Asia and Caucasus, National Breeding Units of Mali, Cameroon and Madagascar who were attending the IRPW were also conducted.

Table 1. Time line of the 7th EPMR program

Date	*Events*
4 November 2007	EPMR meeting and briefing in Bangkok, Thailand
5 November 2007	John Lynam and Chagema Kedera reviewed Asian Regional Center
6-7 November 2007	Julian Cribb and Michael Krawinkel reviewed Regional Center for Africa
6-7 November 2007	John Lynam and Chagema Kedera reviewed Regional Center for South Asia
8-9 November 2007	John Lynam and Chagema Kedera reviewed Asian Regional Center
10-16 November 2007	John Lynam, Julian Cribb, Michael Krawinkel, Jai Singh reviewed Headquarters
17 November 2007	EPMR Panel wrap-up meeting in Bangkok, Thailand
11 February 2008	Deadline for draft report to be submitted to the Center's Management
29 February 2008	Deadline for draft report to be submitted to the Chair of the Board of Directors
16 April 2008	Panel Chair presented and discussed the EPMR final report

	to/with the Board of Directors
16 April – May 2008	The Board of Directors and the Management responded to the Panel recommendations
May 2008	Compilation of the complete EPMR final report

Chapter 1

EXTERNAL ENVIRONMENT AND MISSION

Our mission:

To alleviate poverty and malnutrition in the developing world through the increased production and consumption of safe vegetables.

In the coming seven years and beyond, the mission of The World Vegetable Center will be of greater relevance, importance and urgency to the future of humanity than at any time since AVRDC was first established in 1971.

The pace of change in both the external environment and in the Center itself has accelerated significantly since the last review and these trends will be the key drivers of the Center's mission and operations in the medium term. Issues such a climate change, water scarcity, peak oil, rising global food and energy prices and economic uncertainty have emerged into the foreground of the context in which the Center now operates and will influence it profoundly for the foreseeable future.

This overview highlights several key issues which will affect the Center, its funding, strategy, operations and the research decisions it makes in the coming years. These are drawn from a range of authoritative science-based sources and serve as a backdrop for consideration of the more detailed discussion and recommendations in following chapters.

1. Food demand

Global demand for food is forecast to increase by 110 per cent by 2050, due primarily to economic growth in countries such as India and China and secondarily to population growth chiefly in developing countries (UNEP).

However it may be necessary for world vegetable and fruit production to rise significantly faster than this in order:

- to improve the health of both poor and rich people through better nutrition and to combat chronic disease in both
- to produce more food per unit area and with fewer inputs of energy, water and nutrients
- to provide affordable food to growing populations of urban poor as well as rural poor
- to make better use of arable land, especially in densely populated regions
- to reduce the need for vegetables to be transported long distances at a high levels of energy expenditure, CO2 emissions and consumer cost.

The World Vegetable Center is the natural scientific body to stimulate and lead worldwide awareness and thought on these issues and the role of vegetables in the

future global diet. Working closely with and through the Global Horticultural Initiate it should seek to expand its influence on policy formation and the public debate.

The World Vegetable Center also needs to develop high skills in listening to farmers and consumers needs and requirements in charting its programmes.

The Center may consider commissioning a study into *strategic* expansion into fruit research over the coming decade, due to:

- gaps in fruit research at the international level
- the complementary nature of fruits and vegetables in a nutritional sense, providing micronutrients, bioactive plant ingredients and fibre
- compatibility with its existing R&D capabilities
- the lack of distinction between fruits and vegetables at farm or consumer level and the scope for synergies in both production and nutrition
- to build its profile as the world's leading horticultural institute and source of policy advice on food and nutritional issues
- opportunity to increase resource mobilisation, R&D synergies and efficiencies; better use of infrastructure and skills.

2. Dieting the rich, feeding the poor

"There is general consensus on the importance of limited fat, in particular saturated fat, and of ample consumption of fruits, vegetables, wholegrain cereal and legumes for reducing chronic disease risks.

"Healthy eating should aim at increasing consumption of fruits and vegetables, complex carbohydrates, and discourage high-fat and possibly also high-sugar foods.

"There is now sufficient evidence to show the deleterious consequences of too much (or too little) food, too much fat, not enough fibre, fruit and vegetables to take action when preventive changes are still possible."

Source: Nutrition in adolescence: WHO Discussion paper, 2005

The world has a double burden of nutritional constraints in its 850m malnourished people, and its 1.4 billion calorically over-nourished people. Solving the second problem may go some way to solving the first by freeing more agricultural and research resources for food production in poor countries.

Vegetables have a vital role to play in curbing both malnutrition and caloric over-nutrition. By tackling this double problem, The World Vegetable Center may be able to mobilise greater research resources to solve the problems of the poor. One opportunity is to persuade major international food companies and supermarket chains that they should invest in R&D which will assist both their wealthy customers and at the same time address the needs of poor farmers and consumers. The World Vegetable Center will need to develop a *value proposition* likely to influence these

potential new sources of funding capable of achieving a win-win for poor and well-off alike. (See Funding Environment, below)

3. Water scarcity

Only if we act to improve water use in agriculture will we meet the acute freshwater challenges facing humankind over the coming 50 years (IWMI 2007)

Approximately 1.7 billion people, one-third of the world's population, presently live in countries that are water-stressed. This number is projected to increase to around 5 billion by 2025, depending on the rate of population growth. - IPCC

The world is entering an era of water scarcity, with up to two thirds of people facing acute scarcity within a generation. Groundwater is falling in most regions where it is used for food production, rural surface water is becoming scarce throughout the dry countries and cities are forecast to commandeer half the world's water by 2050, implying a significant reduction in irrigation supplies of the order of 30 per cent or more.

With demand for food rising, this indicates large improvements in water use efficiency per nutritional unit may be needed as well as major reductions in water losses in the food chain. (Currently it requires about 1 litre of water to produce a calorie of food.)

Possible implications for The World Vegetable Center include:

- Rising external pressure (and funding) for greater emphasis on water use efficiency in crop types and farming systems
- Substitution from grains and meat to horticultural (fruit and vegetable) crops as more water efficient per unit of nutritional intake
- Growing consumer demand for 'low water' foodstuffs
- Greater emphasis on rainfed systems and the harvesting of rainwater for use during dry spells.
- Shifting of vegetable production into new areas and climatic zones as the climate warms and/or local rainfall increases
- Need for low cost (eg plant-based) systems for cleansing groundwater used for irrigation and drinking of toxic materials
- Development of saline and brackish water farming systems
- Demand for intensive urban horticultural systems using recycled water or stormwater where these sources can be made sufficiently clean
- Expanded interest in marine algae culture
- Use of plants for phytoremediation of contaminated urban water to purify it for reuse (eg in horticulture)
- New demand for low-water vegetable protein production in bioreactors.
-

4. Energy costs

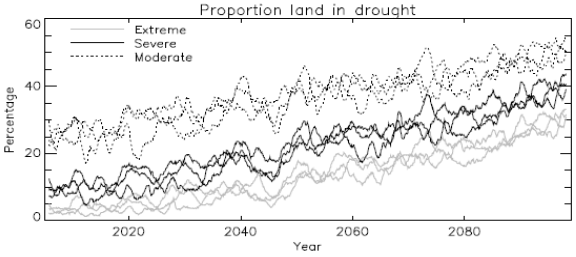
The world is close to or has recently passed 'peak oil' according to several sources, and energy prices appear to reflect this. Growing global oil scarcity and the potential for *ad hoc* disruptions to supply make a strong trend to energy intensity in developing world agriculture extremely risky.

To insure against this The World Vegetable Center needs to review, or give greater emphasis to, its research effort into:

- Low-input farming systems, including organics, which reduce reliance on mechanical tillage, industrial fertilisers and high energy inputs
- Expanded urban/periurban horticulture to reduce food miles
- Reducing food chain losses (ie reducing transport costs/unit of nutrition)
- Reducing energy demand in high-value cropping systems
- Use of vegetable wastes in biofuels or composts for local on-farm use
- The future role of vegetables as food for the poor in substituting for crops now being burnt as biofuels or diverted to meat production. (400mt of grain is forecast to be burnt as fuel by 2020, equal to the world rice crop)

5. Global environmental change

Climate change is a major threat to rural livelihoods and to food and environmental security in the developing world. Current agricultural practices are having considerable negative consequences for climate, water resources, biodiversity and other aspects of the Earth System. (Harris G., Report to CGIAR, 2007)



Modelling by the UK's Hadley Center for Climate Change (above) projects the potential for a 50 per cent increase in droughts worldwide by the late 21st century, primarily affecting the mid-latitudes and countries which are already dry. Many of these countries are also poor. While this timeframe is outside the immediate scope of this review, it nevertheless provides an important context, physical geopolitical and financial, for the Center's future planning.

Possible implications for horticultural research from current climate change scenarios include demand for:

- Rising demand for varieties and systems able to cope with greater climate extremes and variability, notably drought, heat, salinity and desertification

- agricultural adaptation and mitigation pathways that are both pro-poor and minimise deleterious feedbacks to the Earth System
- novel ways to reduce or negate the contribution of vegetable production to greenhouse gas emissions (eg plantstone carbon lockup)
- early warning detection of pest and disease responses to climatic signals
- crop-types that signal biotic and abiotic stresses
- vegetable cropping systems which reduce soil erosion and desertification
- scope for nutrient recycling within vegetable production systems
- spillover effects on vegetable production of global demand for grain to be burnt as fuel in response to demand by public concern over climate change.

6. Urbanisation of the poor

The current focus of The World Vegetable Center is on the rural poor. In coming decades this balance will shift as more poor people move to cities. By 2050 half the world's poor will be urbanised. Implications may include:

- Shifting emphasis from high value to low-cost foods
- Shift in production emphasis from rural to urban & periurban settings
- Demand for alternative cheap food sources, eg industrial scale vegetable protein culture
- Intensive vegetable production systems that minimise land use (eg rooftop culture)
- Challenge of promoting novel vegetables with high nutrition/low cost to populations unfamiliar with them.
- Loss of young, innovative farmers from rural areas
- Popularisation and education in vegetable growing as a source of employment, income generation and entrepreneurship in rural areas as a social strategy to slow urban migration and slum development
- Role of vegetable production in reducing urban unemployment and the social dislocation which accompanies it.

7. Food globalisation

Food globalisation is an established trend which contains many paradoxes for the poor. While it offers some poor farmers a route out of poverty, it also increases food miles, pesticide and energy use, environmental degradation, the cost of food to other poor people and the cost of farming inputs to all farmers. There is a strong risk that food quality and nutritional essentials may be drawn to the cities and away from the rural poor.

The World Vegetable Center needs to consider both the wider benefits and the downsides of new high-value farming systems and crops before committing

significant research resources to them, and to ensure it maintains a pro-poor balance in its choice of research projects.

In the longer term there is a risk that subsidised vegetable production out of richer countries may undermine the prices earned by vegetable farmers in poorer countries, distorting markets and exacerbating poverty. The Center with its growing economic expertise is well placed to observe and highlight this issue in global policy debate.

Globalisation of the seed trade carries several implications including:

- Growing importation of international hybrid varieties will replace indigenous varieties and landraces, causing loss in local genetic and agricultural diversity which The World Vegetable Center breeding strategies may have to compensate for
- Large companies may supplant smaller local seed companies on whom The World Vegetable Center relies to deliver seeds to the poor
- Seed prices to the poor may rise too rapidly. As most farmers will want to plant improved varieties for higher yields, the challenge will be to ensure the availability of enough good quality seed at prices poor farmers can afford.
- Driven by supermarket buying practices, market demand for vegetables may favour imported 'exotic' varieties over indigenous vegetables with more desirable nutritional profiles.

8. Health constraints

Vegetable production needs high manpower inputs. These are endangered by the epidemic spread of HIV/AIDS as well as other infectious diseases, e.g. malaria, schistosomiasis (bilharciosis), tuberculosis and dengue fever. Even simple diarrhoea compromises the productivity of agriculture labour force.

It has been observed that this leads to a significant reduction in farmland under agricultural use as well as to a reduction in diversity of agricultural production. This especially affects vegetable production because of its high demand for horticultural knowledge and labour.

The World Vegetable Center may wish to consider an emphasis on vegetable varieties and technologies which require lower labour inputs, which help protect the health of rural workers and which integrating food safety aspects into postharvest considerations in order to reduce food-borne and food-transmitted disease loads.

9. Funding environment

While the global situation in agricultural research funding for the poor is easing, the issue for The World Vegetable Center is whether this improvement will release sufficient resources (a) for the needs of the vegetable sector globally and (b) for the Center's own growth in the context of the demand for its expertise identified above and its own new programs.

There is opportunity is to diversify into new sources of funding and support which do not depend on traditional donors or compete with other Center activities. The following are offered as suggestions for further investigation, should they seem promising to the Board:

- Food firms and supermarkets. Hitherto elusive, these may be addressed through
-
    - Use of a high profile former food company CEO as 'ambassador'
    - Approaching companies not as donors but as investors
    - Development of a value proposition that benefits investors and the poor
    - Targeted approach

- Strategic expansion into fruit research would enlarge the Center's R&D portfolio to the major portion of the world diet, significantly enhancing its global significance, stature and its overall case for donor, investor or philanthropic funding.
- Consider adopting a 'Cooperative Research Center' structure in which partner research institutions and companies contribute both funds and scientific resources to join, or for specific projects.
- Significantly increase international profile in the quality mass media through a planned approach based on the Center's achievements and expert opinion, as a platform for attracting more donors/investors.
- Open the germplasm collection on a commercial basis (e.g. fee+royalty) for the biodiscovery of new pharmaceutical and industrial compounds, in order to fund the facility's long-term expansion and preservation.
- Use the indigenous vegetables research as a platform for commercial publishing (not by the Center itself) of food, cooking and health books, generating a royalty stream to underwrite its other outreach activities. (See Outreach section)
- Establish a Vegetable R&D Trust Fund to which farmers and seed companies can donate as they rise in the value chain, enabling wealthier producers to contribute to work which benefits both them and poorer farmers.

The Panel considers that overcoming the limitations imposed by the current funding model is essential if the Center is to deliver on its mission statement in the years ahead, as well as respond effectively to the challenges outlined briefly above. This is discussed further in Chapter 3: Management and Administration.

CHAPTER 2:

RESEARCH AND DEVELOPMENT PROGRAMS

2.I Emerging Issues at Center Level

Balancing Growth, Restructuring of Research Programs and Decentralization of Research

The implementation of The World Vegetable Center's strategic plan written and approved in 2002 stalled over the ensuing 3-4 years due to lack of funding. This was a period when agriculture was not a high donor priority. Research at the Center fell below the critical mass needed to maintain a center whose mission was to support the horticultural sector throughout the developing world. Because of the reduction in operations, a decision was taken to eliminate the program structure—and in effect a management level—and organize the research purely within the disciplinary units. The situation started to improve in 2005 and the Center now appears to be on a sustained growth path. Growth brings opportunities - but it also brings a need to rethink the efficient organization of research and development activities and to adapt management systems to an expanding organization. This section reviews how the center is reorganizing its research and development programs as a platform for continued growth, deepening its research programs and improving the strategic alignment of its research to achieve its mission.

Two drivers motivate the structural changes taking place in The World Vegetable Center. The first is a growing imperative to realize the Center's global mandate for horticultural research. The shift from an Asian to a global focus began in 1992 with the creation of the African and Asian regional programs. These started primarily as training offices and distribution points for The World Vegetable Center technology components developed at headquarters, in essence as outposts with very little research capacity. Rethinking the role and function of the regional centers, the capacity needed within the centers, and the number of regional centers will be crucial to how The World Vegetable Center carries out its global mandate in future. This is an important strategic issue which this report analyzes in some detail, as it will provide not only the framework for realizing the mandate but will also define the framework for both optimal decentralization of its research programs and increased clarity and impetus in its development work.

The second driver is the need to develop more coherence betweenThe World Vegetable Center's research, development and outreach programs and its mission. The research structure in the 2002 strategic plan was built around essentially breeding and production systems, and the unit structure that evolved from that included specific crop breeding programs, support units across the plant protection spectrum, germplasm, a nutritional quality section, socio-economics and a larger unit on crop and ecosystem management - about 15 different research units in total. In 2007 this essentially disciplinary structure was reorganized into five themes that

recognized both the continuum of research needs across the horticultural value chain and the increasing importance of health and nutrition issues in the growing demand for horticultural products. This was a significant broadening of scope for The World Vegetable Center research, but one that has positioned the Center much more effectively in terms of impacts on its target beneficiaries, the poor and the malnourished.

The panel considers that this rethinking of how best to organize The World Vegetable Center research and development activities is essential in positioning it:

- to attract larger projects,
- to better prioritize future growth,
- to deepen research strategies,
- to optimally devolve research and development activities, and
- to ensure synergy between the regional centers and the research themes.

As most of these changes have occurred in the past year, there is a still significant fluidity in the re-visioning process, there are expected imbalances across the research themes to be addressed and significant differences between regional centers in their development. Moreover, there remain uncertainties as to how best to exploit the potential synergies between the regional centers and the research done at headquarters. These are a natural part of a major restructuring exercise and will require time to balance, particularly when virtually all research is funded through restricted core.

The problem of allocating a relatively fixed amount of core funding within a growth process that relies on attracting restricted core projects creates both opportunities and tensions in an organization. This, in itself, adds another layer of complexity to the implementation strategies and the further integration of research and development activities across the Center, which has two main options in dealing with this problem. The first is to maintain as flexible a structure as possible which allows the institution to shift staff and infrastructural resources in response to project opportunities. This is basically the unit structure which The World Vegetable Center maintained up to a year ago, where disciplinary units could be allocated in relation to project structure and needs. However, this can result in a very fragmentary research program, a loss of strategic focus, too high a level of internal competition for projects with loss of team cohesion and an undervaluing of the mission. The theme structure was imposed significantly to counter these tendencies and the Panel feels that this rebalancing is both appropriate and bearing fruit (or vegetables, as the case may be). Thus, the second option is to develop projects within a strategic framework, with more fixed criteria as to what the Center will undertake in its research projects, and with a more pro-active and better grounded approach in interactions with donors. The panel accepts that this is the course the Center will follow into the future

and fully supports this repositioning. It is well represented by the more strategic focus of its latest Medium-Term Plan as compared to previous plans.

Role and Function of the Regional Centers

The first regional programs were established in 1992 and were in part a response to perceived political tensions surrounding the location of The World Vegetable Center in Taiwan as well as a focal point for training and access to Center expertise and technology. The expansion in the number of regional centers to South Asia and West Asia/North Africa—as well as the regional office for Central Asia and the Caucasus along with the significant growth in research capacity in the Regional Center for Africa (RCA), are leading to a redefinition of the role of the regional centers within The World Vegetable Center. The role of the regional centers is presently relatively open and varies significantly between the different regional centers. This exploratory phase is appropriate but there is a need for increased clarity over the next few years, particularly as the theme structure deepens and gains coherence.

The emerging issues revolve around three further sets of issues. The first is how the regional centers implement their traditional role in training, capacity building, and networking with national research partners. The regional centers in Southeast and East Asia and South Asia and the regional office in Central Asia have organized their activities principally around this function. This has raised issues of the strategic direction of training activities, how to fund networks in the regions, and how best to organize joint research with national partners. The report deals with these issues in the discussion of the various regional centers and with the cross-cutting issue of training withinThe World Vegetable Center.

The second issue is more fundamental to the future evolution of The World Vegetable Center research and encompasses the questions of what research should be devolved to the regional centers, how should this devolution be best coordinated with the Themes, and what research capacities and infrastructure should be developed within the regional centers. These questions are being driven by the expanding research programs in the Regional Center for Africa. This center has some unusual characteristics: it is the only RC where The World Vegetable Center has developed its own agricultural experiment station, whereas the others rely on the research infrastructure provided by their host institution. The Regional Center for Africa is building its programs on the enhanced funding opportunities available in Africa, as exemplified by the vBSS program. The issue is whether The World Vegetable Center should plan for such an imbalance across regional centers or should the horticultural revolution in Asia argue for greater research devolution to the regional centers.

The third issue and also a fundamental one for the future evolution of Center program structures is the potential role of the regional centers in bringing more coherence to the development and impact of the Center in the process achieving

a better alignment of The World Vegetable Center research and development activities with the mission, to alleviate poverty and malnutrition in the developing world. Historically, The World Vegetable Center tended to concentrate and manage both research and development activities at headquarters. To a certain extent this was made possible by a principal focus on Asia. With the expansion in the work in Africa and the difficulty of managing this work from headquarters, there is an opportunity to rethink how the development aspect of the Center's work can best be organized, implemented and energized.

As mentioned before, development is explicitly a part of The World Vegetable Center's mandate. This freedom to work on the development end of the horticultural revolution is a particular advantage when compared to the CG centers. There is nowadays a clear tendency for traditional donors to fund more development activities with explicit development outcomes, and Bill & Melinda Gates Foundation is an example of this. This implies the Center now needs to have a more strategic view about how to organize its development work and how to maintain appropriate balance with its research programs. The role of the regional programs then becomes instrumental in how the Center implements this part of its overall mission. This is a principal theme that will run through this report.

Achieving a Strategic Alignment within The World Vegetable Center Research

Achieving strategic coherence across The World Vegetable Research's research activities is both an important process within the Center and at a critical stage. It has raised some challenging thematic tensions for The World Vegetable Center whose scope of possible research topics is so broad and diverse as to be virtually unbounded. Some of these tensions are discussed here, before going into detail on the research themes themselves. The first tension is how to maintain the significant range of diversity from varieties, to species, to genera that encompasses vegetable germplasm at the same time as meeting the needs of market-driven "commodification" of the sector where the driving tendency is toward standardization and specialization. This issue is exemplified by the division of work between characterization and selection of indigenous vegetables and the breeding work done on "exotic" vegetables of global market importance.

The second tension is how to balance the constraints to horticultural development across the value or supply chain. Perishability of the product, cosmetic appearance and consumer acceptance, the high margins that encourage excessive input use and the pressure to reduce seasonality to meet market needs are all issues specific to the horticultural sector, compared to most field crops. These characteristics, in turn, have implications for organizing an integrated research agenda and establishing relative weights to research across the value chain. The traditional strength of The World Vegetable Center research has been in the breeding area, together with supporting work on production systems. The Center has lately seen the need to expand into post-harvest and market organization. These are particularly

critical to expanding the reach of horticultural development to poorer regions and poorer populations, as well as the overall development of the sector in Africa, while at the same time they significantly expand the scope of the Center's research activities.

The third tension lies in realizing the health benefits of increased consumption of vegetables. This has three conflicting strands to it, namely the concern about vegetable food safety among higher-income, urban populations, the potential health benefits from such nutritional components as antioxidants for the same population and the nutritional and health benefits to poorer populations of enhanced consumption of particular micronutrients. These issues also are unique to horticulture and can serve as an effective bridge between traditional agricultural research and the field of nutrition, fields which have been difficult to bridge in the past. The Panel feels this offers a significant opportunity for The World Vegetable Center to open a unique area of research, but at the same time notes the need to maintain balance within the overall research portfolio.

The new research theme structure attempts to embrace all three spectra. The potential scope of the research at The World Vegetable Center is very broad - but this is essential for it to achieve international recognition as The World Vegetable Center. Nevertheless, the scope problem raises fundamental issues of how the Center achieves focus within its research programs to ensure productivity, how it achieves synergy across its research themes, and how it optimally deploys its research across the different regions in relation to very different needs. These are very complex questions and the movement to the research theme structure is forcing the Center to collectively address them. This is a process very much in the formative stage in The World Vegetable Center and one that will set the course for its future development.

The Center has moved toward a theme structure covering germplasm, genetic improvement, production systems, post-harvest and market systems, and nutrition. The themes on germplasm and genetic improvement are of long standing and have fewer issues about how they are organized, although the genetic improvement theme needs to address issues of decentralization of activities to the Regional Centers. The theme on production systems incorporates a range of quite different research units, and the principal question is how to achieve strategic coherence across the activities and capacities grouped within the theme. Post-harvest and Nutrition are younger themes in the process of development (although building on more specialized pieces of past research in the two areas) and have the advantage of being able to develop their strategies *de novo*. However, the themes have the challenge of generating a sufficient, critical mass of projects to be able to implement the Center's overall research strategy.

Development within the Research Structure

In the whole process of growing the regional centers and restructuring research programs, the issue of development has remained largely undefined. To some this is due to the need to get the regional and research structures in place before development was systematically addressed. It is also a function of the need to bridge between both research and development activities in many, if not most, of the Center's research projects.

The panel feels that development is the area most in need of a more strategic approach within the Center, particularly as The World Vegetable Center is in the relatively unique position among the international centers of explicitly incorporating development activities into its work and is therefore in a position to show international leadership in how to structure and implement an integrated research and development agenda. The panel recommends that the whole development area be given greater clarity and priority in the Center's re-visioning and restructuring process and that a more strategic approach be taken, as it essentially provides the mechanism by which The World Vegetable Center delivers on its mission. Such a strategic approach to development may incorporate two foci: one 'producer and poverty-alleviation' oriented, and the other 'nutrition and consumer' oriented. Both directions are within the scope of the mandate of The World Vegetable Center and open up perspectives not only for the excellent research strategies but also for excellent development strategies.

The panel considers that there are at least five possible ways The World Vegetable Center can incorporate development more strongly into its strategy and program structure.

1. The first is to incorporate the development end of the continuum into each of the program themes. To a very significant extent this is how the Center currently approaches the problem. This allows a more explicit overlay of research questions and hypotheses on what are principally development activities - for example, selecting the most effective approach to scaling up home gardens as a means of improving nutrition in targeted rural areas. However it militates against a more strategic and systematic approach to the development issue.

2. The second alternative is to explicitly incorporate development and impact as a research theme, either by reorganizing the current theme structure or through the addition of a sixth theme. The rationale in this case is that a research structure can be imposed on the whole of development work at the center. Such a theme might incorporate work on dissemination and upscaling, pilot work on alternative market arrangements, impact assessment, and a significant part of the Center's socio-economic research. This

approach has the advantage that development is acknowledged explicitly as a theme of equivalent importance with other research themes, and of attracting those donors with a development/delivery focus.

3. The third alternative is to bring together various components such as training, communication, social science and market research into a special development division, with a defined budget and a senior manager responsible for it, possibly a DDG to signify its importance.

4. The fourth is to make development operational through the Regional Centers through strategies that explicitly recognize and enable the RC to target its research and development activities to the poor and the malnourished. This strategy recognizes that development approaches through horticultural development must be targeted to the particular characteristics and needs of each region and than any development approach will need to integrate seed systems, production systems, post-harvest, market development, nutrition, and outreach. Moreover, this would also allow a more focused and strategic approach to developing survey and monitoring systems for impact assessment.

5. A fifth option is a synthesis of 4 with either 2 or 3 above, by developing a stronger development focus in head quarters through a development division or theme - but at the same time devolving authority and resources to the RCs to pursue the most productive approaches in their areas.

This issue is discussed further, with recommendations, in the Chapters dealing with Development and Impact and Future Organizational Issues.

Chapter 2.II

REGIONAL CENTERS

The Regional Centers are a critical element in The World Vegetable Center's vision of being a global leader in horticultural research and development and in its ability to deliver its mission of alleviating poverty and malnutrition.

Prior to the review period, there were only two regional centers, the Regional Center for Africa (RCA) based in Arusha, Tanzania, and the Asian Regional Center (ARC) in Bangkok, Thailand. The regional centers at that stage were intended mainly to establish a global presence and were conduits for the research products ofThe World Vegetable Center, particularly finished breeding lines. The activities at ARC were dominated by a large training program funded by the Swiss and those at RCA by work on indigenous vegetables and training. Research performed outside of headquarters was almost exclusively focused on Southeast and East Asia and was managed from headquarters through country programs. Over the review period two additional regional offices were established, in India for South Asia (RCSA) and in Syria for the Middle East and with a regional coordinator for Central Asia and the Caucasus region in Uzbekistan. The mandate area for ARC was in the process readjusted to Southeast and East Asia. At the same time the number of projects increased significantly in RCA, particularly with a large Bill & Melinda Gates Foundation-funded project on breeding. These changes solidifyThe World Vegetable Center's global capacity through its network of regional centers which now covering the principal horticultural producing areas of the developing world, although a regional Center for Latin America remains pending.

The Regional Centers now offer scope to both devolve research activities from headquarters and/or to establish more distributed networks of research activities across the regions, for example in breeding. The RCs are also a critical link between private and public sector research activity in different countries, with scope to maximize the global research done in horticulture. However, realizing this potential will require building the capacity of these regional programs, including their staff. At present responsibility for their laboratories, offices and in sourcing project funding is almost evenly divided between headquarters and regional centers. Moreover, the Panel feels that regional centers will provide a springboard for the World Vegetable Center's future development strategy and work.

2.II.1. Regional Center for Africa

Overview

The Regional Center for Africa is an impressive and a dynamic center that has coped admirably with the stress of sudden growth. It has dedicated staff who are

committed to what they do and appear to be making significant progress with limited resources.

The operations at RCA provide the foundation for a significant expansion in horticultural R&D to address the Millennium Development Goals and World Vegetable Center mission statement in Africa. Programs such as vBSS and ProNIVA are both ambitious and inspiring and can achieve maximum impact, both scientifically and on farm, in the shortest time possible if implemented appropriately. This includes improvement and further development in certain areas related to staffing, management, facilities, outreach and Center structure.

Overall, RCA seems to be doing well, to be well-managed and to afford promising potential for the World Vegetable Center to fulfil its mission in the future

This goal is an enormous challenge in Africa, where between 1990 and 2002 there was decline in food security, whereas in East Asia it rose by 47per cent and in and Southeast and East Asia by 12 per cent, according to UN figures. Also the proportion of people living below the poverty line is highest in Sub-Saharan Africa and these are farthest from attaining the Millennium Development Goals. In Africa the use of fertilizers and machinery has actually declined while the area of land under irrigation has been static. These factors were central to the *Green Revolution´*s impact on yield increases in Asia.

As a consequence, Africa has not generally participated in the large yield gains seen in Latin America and Asia in the last decade, leading to greater food insecurity. Food insecurity has more than one dimension: it is not just the insufficiency of available food; it is also the increased susceptibility of the population to disease, and the loss of human productivity and income from agriculture. For the World Vegetable Center this implies that addressing African needs in particular requires an expansion of the scope of its activities in Themes four and five, as complement to the activities already undertaken in Themes one to three.

Horticulture faces a further major constraint in that farmers often give first priority to the production of staple crops. This is reflected in the comparatively low area under vegetable production in Sub-Sahara Africa (FAOSTAT 2005), where the global interest in 'high value crops' is not driving farmers into expansion of production. As a result vegetable production remains among the lowest worldwide and vegetable consumption is well under the recommended level of 73 kg per capita per year (FAOSTAT 2004, 2005).

On the economic side horticulture is a potential engine for creating jobs because more labour is required in the production of vegetables than cereals (Weinberger and Lumpkin 2004). Therefore, horticulture not only provides nutrient-rich healthy food to people but is also an important employment and income generating activity for the poor. The main factor limiting the labour force in Sub-Saharan Africa these days is the HIV/AIDS-epidemic. Mean infection rates of >30% of the population

in Southern Africa represent a major challenge for horticulture to identify farming technologies which can be managed either by young or older people, as the epidemic inflicts most deaths in the 20-50 years age group. Although there are strong and well-funded programs to secure access to medical treatment for AIDS-patients, the disease and the need to care for the people affected will remain a constraint for families and households and limit their productivity for many years ahead.

In the past decade a trend has emerged in which more and more societies in developing countries are facing an epidemic of obesity. According to WHO-figures 25-50% of women aged 30 and older in most countries of Sub-Saharan Africa are overweight, with a body mass index (BMI) of ≥25 kg/m^2. Overweight is by no means the same as well-nourished: often it is the result of high caloric intake of fatty food, while micronutrient deficiencies still prevail (e.g. iron and iodine deficiency).

The mandate of The World Vegetable Center to increase the consumption of vegetables has three advantages for preventing and managing this unhealthy development:

- vegetables can be a primary source of the necessary micronutrients,
- vegetables help to improve the diet by reducing its caloric density
- vegetables provide bioactive plant ingredients which reduce weight gain and improve glucose tolerance. The impact of the third aspect is underlined by the observation that 80% of chronic disease deaths occur in low & middle income countries.

Because of its size and importance, the Regional Center for Africa provides the paradigm for the future development of the World Vegetable Center and its network of regional centers. It is important that it be correctly structured, have the right degree of autonomy and be run in a way that is both efficient and capable of being emulated in other centers. The following issues and recommendations address aspects of this.

RCA status

The first issue is for a regional center to have a secure foothold within its region from which to conduct research and to deliver on its programs in the long term.

At the time of the Panel's visit, RCA was attempting to clarify its legal status as a diplomatic mission with tax exemption in Tanzania with the Tanzanian Government. The uncertainty surrounding this holds major implications for the future of the Center as a regional node of the World Vegetable Center in Africa, for running large-scale programs such as vBSS, and for the ability to deliver on the mission in Africa. The issues it raises also hold ramifications for future RCs in other regions of the world.

In the view of the RCA's local legal representative this situation was due to the Tanzanian Government's reluctance to appear to be favouring a Taiwan-based institution, and risk offending the PR China.

For RCA the main effects were:

(a) uncertainty in official and legal status with all the ramifications for employment, planning and major new research activities (eg vBSS) and

(b) having to pay tax on imported equipment and materials, inflating the overall cost of research. This especially hampers RCA's ability to extend its infrastructure in response to the growing needs of the new and ongoing projects.

The panel explored various options which the Board may wish to consider should this situation remain unresolved. In no special order, these are:

(i) Register a not-for-profit company as a subsidiary of RCA, to import equipment tax free, as a temporary measure until the larger status issue is resolved with the Tanzanian Govt.
(ii) Register RCA as an NFP company, as suggested by RCA's lawyer. (We consider this to have several drawbacks.)
(iii) Trust that a new certificate of registration issued by the Taiwanese Govt will satisfy the Tanzanian Govt.
(iv) Trust the assurances of Tanzanian officials that diplomatic status will eventually be granted.
(v) Move RCA to another country, with the attendant risks, costs and potential for senior staff loss.
(vi) Join the CGIAR and acquire independent legal status under its umbrella, but with possible consequences for Taiwanese support.
(vii) Register The World Vegetable Center in several countries besides Taiwan, if it is legally and politically possible to do so, thereby cementing its international character. Apply to Tanzanian Govt for diplomatic status using one of these other registrations.
(viii) Restructure The World Vegetable Center as an international research network with a federated or cooperative research center structure, registered in a neutral location OR with each of its nodes registered in the continent of residence.
(ix) Continue to operate in Tanzania as a international NGO and absorb the increased costs from not having tax-exempt status.

Beyond the immediate situation affecting RCA at the time, we feel there are good reasons to consider a 'cooperative research center' model for a decentralised World Vegetable Center with a number of nodes and partners for the longer term besides legal status. These include:

- Greater scientific flexibility through the ability to admit new research partners,
- New sources of revenue and resources contributed by individual universities, companies and agencies who may from time to time become direct partners in the organisation, and leave when the work is complete
- Capacity to select the best scientists worldwide for particular projects and tasks without directly hiring them, but by contracting them through their institutions
- Greater regional autonomy to focus on particular regional needs and challenges
- A more collaborative and less centralised model in line with international R&D management trends, leading to more rapid focus on urgent regional issues and ability to shift research emphasis quickly from one issue or scientific field to another with less institutional *impedimenta.*
- A more "international" appearance and structure, less liable to fall foul of inter-country disputes and disagreements.

It was envisaged that the new structure might be known as The World Vegetable Centers (plural), akin to the US Centers for Disease Control etc.

Recommendation 2. II.1: Should no immediate solution be forthcoming, proceed with option (i), and, in order to avoid such problems in future, give consideration to option (ix).

Research Management

At November 2007, of 9 projects at RCA only the smallest had been fully conceptualised at The World Vegetable Center headquarters (IPM CRSP, $US 10,000). The project lead of the vBSS-project is with the DDG Research at The World Vegetable Center-HQ but all day-to-day decisions are made at RCA. Proposals for all other projects were written at RCA with lesser or greater input from HQ, and the RCA is responsible for them (e.g. PRONIVA, IndigenoVeg). Therefore the research management in RCA (and possibly other regional centers) needs to encompass three main types of research:

a. facilitation of projects for scientists in the HQ ('shuttle breeding'),
b. facilitation of other projects implemented in the center but not initiated by RCA scientists, and
c. projects initiated by RCA staff.

All types of research make use of the center´s infrastructure, especially the farm. Therefore farm management issues are also addressed in this section.

Historically, RCA seems to have developed as a facility to allow scientists from the HQ to implement shuttle breeding and conduct farming experiments under African conditions. The center is located in a region which is suitable for growing vegetables, and this situation is underlined by the fact that Tanzanian horticulture activities are concentrated in the area as well.

With the HQ-driven type of research scientists in the regional center mainly have the task of supporting research projects not designed by themselves. Therefore they are expected to collaborate in more than one project and even in projects not well-suited to their personal research capacity. This has led to a situation where at RCA all senior scientists are involved in all projects with principal investigator´s responsibilities, i.e. as scientists not only performing the research but also publishing the results in scientific journals. This method of splitting responsibilities into small percentages of each scientist´s work and time does not encourage individual responsibility and initiative but rather causes a sense of competing priorities. Though these research projects were designed and principally performed by RCA-scientists overheads and core funding are mostly - or even totally - spent at the HQ, a source of some frustration. Core funding was only used to sustain the main training courses.

The Panel found uncertainty among RCA's scientists about their reporting lines. Whereas the director RCA indicated that all reporting goes across his desk (except for 'shuttle breeding') some scientists presume that they are bound to report to the Deputy Director General - Research (DDGR) at the World Vegetable Center headquarters. In addition to this unclear situation there is a third reporting line to the theme coordinators, which appears not yet to be fully integrated. RCA scientists may also report to HQ on shuttle breeding and to leaders of programs they are in. All this amounts, potentially to five different lines of reporting!

This makes for a divided chain of command which needs to be addressed to avoid a situation in which scientists are responsible to the DDG-R for some things, the Director of RCA on others, and other leaders on further matters, leading to confusion over reporting, priorities and responsibility chains. It may also cause confusion among the various managers of these scientists as to who has priority claim on their time and resources.

RCA has traditionally conducted a 4-month training course for vegetable researchers, extension workers and farmers to strengthen the national research programs. The panel noted that although the course takes up significant resources and time (half the total work time of the training specialists and some of the time of other scientists) there was no mechanism to evaluate its usefulness/impact in terms of the The World Vegetable Center mission. This consequently compromised research capacity at RCA. The course was discontinued in 2006 to allow for its re-evaluation in terms of its relevance, effectiveness and resource requirements.

With the advent of the vBSS-project, RCA now has the task of implementing a huge, region-wide project with a number of new scientific and administrative staff coming in. This not only requires new office and lab space but is also a challenge for the research management and administrative functions of the RCA and headquarters. First, the scientific coordinator of the vBSS-project must put together the process and panels for the selection of the new scientists for the four hubs in Cameroon, Madagascar, Mali and Tanzania. Second, since the breeding itself cannot be 'outsourced' by placing the breeders into private seed companies, RCA itself will become a research leader and base for the project. And third, RCA management does the additional project administration as far as it is not to be done by the project administrator who is in charge for the whole vBSS-project all over Africa. It was unclear to what extent RCA will receive at least part of the overhead budget of the vBSS-project to support and maintain its general functions. For the time being there seems to be a compromise by making the financial administrator - paid by vBSS - 50% responsible for RCA's general administration.

To develop and retain attractive working conditions for scientists in the RCA, changes in research management and the chains of reporting seem inevitable.

Recommendation 2. II.2:

a. **Prepare clear job descriptions and worksheets for scientists clearly indicating their assignment to individual research projects and training activities. Review these worksheets annually in order to adjust them to the achievements, goals and career aspirations of individual staff (acc. to Human Resources Policy).**

b. **Define the role of scientists in the RCA, providing them with time for self-initiated research projects including proposal writing and preparing research reports, scientific conferences and publication in peer-reviewed journals.**

This extension of their workplace definition is necessary to motivate the present staff and to attract new scientists. It will also enable researchers to work with the World Vegetable Center/RCA for a good part of their career without losing touch with scientific communication.

c. **In order to attract the most capable scientists for its research the World Vegetable Center should assist the career aspirations of its scientific staff after they leave the Center (as it does not and should not offer tenured appointments).**

d. **Clarify reporting lines for scientists, going straight to the scientific coordinators of the projects and through these to the Director of the**

Regional Center, who then reports to the Deputy Director General - Research.

This will involve delegation of responsibility by the DDG-R but a clear reporting line will help to motivate staff, enhance responsibility in line management, reduce priority conflicts and improve outcomes. DDG-R still has influence through the DRCA and through the definition of objectives, activities, outputs and milestones defined in the theme meetings and the Internal Review and Planning Meetings. She/he will also be involved in supervising project proposals and reports leaving the Center.

e. Extend the working contracts for senior scientific staff to a basic three year minimum with the option of one or two renewals.

The Center can expect scientists to generate maximum scientific value when they experience secure working conditions. This will also provide RCA with scientific continuity as contracts can be staggered so they do not all end in the same year.

RCA Research Farm

The Farm is a vital part of the research infrastructure of RCA. Under the current research management structure the responsibility for the farm lies with the senior scientists and one farm manager whose workload is substantially filled with daily employment and payment of casual labourers. The present working conditions are not effective in motivating the staff and casual labourers. This may cause the loss of research-experienced field workers. To restructure the farm as an adequate research facility requires the motivation of staff at all levels, the retention of the most skilled, technical improvements in the infrastructure (e.g. drip irrigation) and improved working conditions including OH&S.

Recommendation 2. II.3:

- **As all research projects in RCA - including those initiated at HQ - need the farm as an essential research tool it should receive funding from the core budget or project overhead funds. Individual projects can contribute to the farm budget in proportion to their use of it.**
- **The farm manager should be given a clear definition of her/his responsibilities. The farm manager should report to the Director of RCA.**
- **Instead of daily appointments the farm labourers should be offered weekly or monthly contracts including a benefit package. This will motivate them more, ensure a steadier and more experienced workforce to support the scientific experiments, and allow the farm manager to attend more closely to infrastructure issues.**

- **The better educated and more experienced farm labourers should be offered annual contracts including a benefit package. They should have opportunity to qualify as field officers. This will help address a perceived shortage of experienced field research assistants.**
- **As for the whole World Vegetable Center, RCA should accelerate the introduction of a Human Resources Policy for its staff, including field workers.**
- **Occupational health and safety (OH&S) need to be strengthened to avoid potential health hazards in farm work. This includes awareness, procurement of and training in use of safety equipment, regular monitoring and supervision of occupational health and safety standards.**

Research Themes

RCA is engaged in almost all research themes but is structurally very weak in some. This reflects the former policy of using the RCA mainly for applied parts of research designed by HQ staff. This policy has been questioned above and its future shortcomings may be illustrated with regard to Theme 5: Nutritional security, diet diversification and human health.

RCA can develop regional demand-driven research activities in nutrition by implementing a capacity in assessing nutrition and dietary behaviour as well as consumer demands. The rich number of indigenous and exotic vegetables available in the region and their use in numerous recipes should be addressed by qualified staff in order to obtain knowledge on the maximum benefit from diversification of diets in order to reducing malnutrition and micronutrient deficiencies.

The former and present practice of open organoleptic assessments of indigenous and exotic vegetables in RCA does not meet scientific standards. The equipment required extending such research into the taste, consistency and appearance of raw and processed vegetables is not expensive and can be sourced locally.

Analytical capacities may be built-up in HQ for the time being, and cooperation with academic and research institutions in the region as well as abroad may also help to obtain relevant data on nutritional value of the vegetables in the region. A future Nutrition Research Unit in RCA can also provide the link to cooperative health research into functional aspects of vegetable consumption, i.e. intake of phytosteroids, insulin, carotenoids and other bioactive substances.

'Fruits and vegetables' are increasingly mentioned together as being essential elements of a healthy diet, and are seen by governments and consumers as part of the same horticultural system. At the same time an increasing number of people manage to overcome caloric undernutrition yet remain on diets which are deficient in vitamins and antioxidants. This can be addressed in joint projects aiming at

healthy diets for the poor. In this regard, benefit can be derived from the location of RCA in Arusha, facilitating the cooperation in research with Bioversity (already established) and ICRAF in Nairobi.

The RCA research program includes variety development, variety release, and sustainable seed supply and good quality seeds. These activities have to be undertaken with the input from the NARES, public and private institutions, NGOs and farmers

Recommendation 2.II.4: Establish a 'Nutrition Research Unit' within RCA facilitating dietary assessment, and database-founded nutritional analyses in close collaboration with the Nutrition Section in The World Vegetable Center-HQ. The NRU should include space for the scientifically sound performance of organoleptic investigations into vegetables and vegetable-based meals.

As this unit will provide essential data for research to all themes aiming at meeting nutritional needs it may be initially funded by core funds. In future, projects buying the assistance of the unit will need to budget for the units expenses.

The location of a nutrition laboratory capable of analysing not just food composition but also bioavailability of nutrients from vegetables and vegetables based meals and diets in RCA should be considered. Depending on funding opportunities it may prove easier to implement such a unit in RCA than in Taiwan. In principle, such laboratory analysis can be performed equally well in either site provided it was adequately equipped and furnished.

The World Vegetable Center should also encourage the NARES to play an active role in the collaborative research activities and where technical weaknesses are noted, facilitate the twinning process to achieve implementation. RCA should develop jointly with NARES, National Seed Authorities and key seed industry stakeholders protocols or procedures for the evaluation and release of vegetable varieties. This will set criteria for the release of new vegetable varieties, making them eligible for national variety listing and eventual seed certification if and when required.

RCA should include in its programs elements of Good Agricultural Practices as they relate to vegetables form farm to fork.

RCA Training, Development & Outreach

If The World Vegetable Center and RCA are to achieve their mission of alleviating poverty by increasing production and consumption of vegetables in Africa they need to reach many millions of farmers and consumers with the outcomes of excellent science in the shortest possible time. As the medium term plan states: *"Each day 300 mothers die in childbirth due to iron deficiency and 4000 children die from ... vitamin A deficiency."* For such as these, a leisurely rate of uptake of new varieties and technologies is not an option.

The challenge is to develop an outreach capability that is efficient, affordable and capable of reaching very large numbers of poor people very quickly, through the mass media as well as through NARES, seed firms, NGOs and others. Methods for achieving this are discussed in the section of the report dealing with knowledge management and outreach and in the Appendix.

The RCA has in a short time achieved a high regard among farmers in the immediate surrounding area. Through training and seed provision it is also known to horticulturalists and seed companies in Eastern and Southern Africa. The experience the RCA gained through its local activities in Arusha, Tanzania, can be regarded as a model for similar activities which the NARES and non-governmental organisations can be stimulated to support elsewhere in Africa and in other regions.

Recommendation 2.11.5

A. Training: The Center should develop a more strategic approach to training based on the potential to achieve maximum impact.

Aspects of this training could include:

- Developing a methodology for training that targets those most likely to transfer The World Vegetable Center research outcomes to the largest numbers of farmers most rapidly and effectively. Evaluating training by measuring the effectiveness and impact of those trained at reaching the most farmers quickest.
- Surveying partner training needs regularly and design programs around them.
- Creating special short courses for those able to reach millions of producers and/or consumers – eg agricultural journalists, food writers, cooking writers, science and health writers and broadcasters, key editors – to highlight new opportunities in vegetable production, nutrition and consumption.
-

B. Outreach: set up an Africa node for communication and outreach, staffed by at least one full-time professional science communicator reporting to the Director RCA but also working closely with the Communication Manager in Taiwan.

This node could develop African farmer-oriented outreach material from existing The World Vegetable Center material and new research outcomes for dissemination via both partners and mass media.

For example this could be used to produce a low-cost mass circulation news sheet (on newsprint) aimed specifically at farmers, 4-8 pages, in Swahili/English, for

distribution via NARES, seed firms, NGOs, farmer groups, agricultural equipment firms and farmers' markets. A circulation of 250,000, 2-4 times a year, paid for by advertising or sponsorship would potentially reach more than a million readers. Provision should be made for future translation into French, Portuguese, Malagasy and Shoona as soon as sub-centers and vBSS-hubs develop into subregional foci. See Appendix.

It could recycle the same stories for radio on CD, RSS feed or MP3 web download to broadcasters Africa-wide.

It could also develop a "Seeds for Schools" pilot project in which children educate their parents (farmers or consumers): a small low-cost seed kit with basic growing, nutrition, preparation and cooking information containing a few seeds (NIVs, new exotics) for distribution to every primary school. See Appendix.

It could assist in developing & implementation of a mass communication strategy for vBSS, specifically to:

- Maximise uptake of new varieties by farmers and consumers
- Demonstrate achievements of vBSS in a highly visible way (eg media) with a view to program renewal
- Developing and disseminating consumer and farmer guides to yet unfamiliar African vegetables.

2.II.2 Asian Regional Center

The Asian Regional Center covers eleven countries in the Southeast and East Asian region which is home to about 1.5 billion people. Vegetable consumption and demand in this region has seen an increase due to rapid urbanization, increasing population and a significant rise in incomes. Production, however, is not keeping pace with the rising demand. Issues in vegetable production sector range from low yields, high production and marketing costs and seasonality in supplies-especially in the rural areas within the region. Although there are some favorable upland areas, most of the areas are in the lowland tropics where vegetables are difficult to grow resulting in shortages of vegetables, and contributing to malnutrition and micronutrient deficiencies.

The Asian Regional Center (ARC) started as the Thailand Outreach Program (TOP) in 1982 in Kasetsart University (KU) as a bilateral agreement between The World Vegetable Center and the Royal Thai Government. Later, it evolved into a larger, region-wide program called the Regional Training Program (RTP). The combined program was upgraded to a regional center status and was named AVRDC-ARC on 10 November 1992. The main office for AVRDC-ARC is located at the Bangkhen campus of KU in Bangkok, and a Regional Training Center, equipped with facilities

for conducting seminars, training and on-farm trials is located at the Kamphaengsaen campus of KU at Nakhon Pathom Province. The Regional Training Center was built with a grant from the Swiss Agency for Development and Cooperation (SDC) in 1999. KU set up the Tropical Vegetable Research Center (TVRC) beside the Regional Training Center to work with the AVRDC-ARC in the spirit of the Memorandum of Agreement signed in 1992.

To better serve its mandate, ARC collaborates with both local and international organizations especially the National Agricultural Research and Extension Systems (NARES), agricultural institutions and NGO's such as Pesticide Action Network Asia and Pacific (PAN, AP) and International Development Enterprise (IDE). As a not-for-profit organization, AVRDC-ARC exists primarily with the support of the Royal Thai Government and donors such as the Swiss Government, the Japanese Government, Asian Development Bank and other international development agencies. ARC works directly with the Association of South East Asian Nations (ASEAN) through the AARNET (ASEAN-AVRDC Research Network on Vegetable Research and Development). ARC handles several crops including mungbean, soybean, yardlong bean, snapbean, okra, amaranth, water convolvulus, tomato, and pepper,

In the quest to promote synergy, in enhancing the continuum from research to development in the Southeast and East Asian region ARC focuses on :

- Creating awareness and promoting adoption and understanding of advanced vegetable production techniques in line with Good Agricultural Practices (GAP) in collaboration with ASEAN
- Developing participatory approaches (in local languages) to educate poor communities in more efficient vegetable production, providing an enabling environment for empowered communities to develop new tools for use and for sale, and ultimately encouraging utilization and marketing of more nutritious vegetables in the Greater Mekong Region
- Enhancing the management skills of professionals involved in agricultural development through appropriate regional training programs
- Partnering regional and international agencies to educate farmers and encourage empowerment of communities to play a greater role in biodiversity conservation and utilization for the well being of the communities.

This focus has enabled the ARC to develop a cohesive working system in the region with the various NARES and other institutions particularly with regards to training. There is need to examine how this strategy can be nurtured to address the development agenda of the World Vegetable Center.

Training

For virtually a decade training was the core activity of ARC and executed in a collaborative arrangement with Kasetsart University. ARC focused its efforts in the annual Regional Training Courses (RTC) taking into account the current trends and the need to enhance the managerial skills among researchers and extension specialists to meet the challenges of modern techniques in vegetable production. This included creating awareness and providing hands-on practice on advanced agricultural techniques to enhance linkages between research and extension in helping farmers understand the scientific basis of technologies introduced and developed. Thus farmer education forms an important part of the training, thereby facilitating accountability and impact oriented research and extension.

In total, 531 participants from 21 countries were trained at ARC over the last 25 years. From 2000-2007, a total of 130 participants from 12 countries attended the course in Thailand. In addition 15 participants from seed companies in 7 countries in Asia and Australia attended the course on Seed Health Testing organized at Kasetsart University Bangkhen Campus in partnership with the Asia & Pacific Seed Association (APSA), International Seed Testing Association (ISTA) and Kasetsart University (KU).

The panel found the training program to be well structured and focused on the needs of the countries in the region. It was noted that various training modules had been developed e.g. "growing healthy crops" and "field to market" which cover most of the key issues in vegetable production, handling and to some extent marketing. Participants in one of the training programs indicated that they find the training useful. With the changing global trends towards emphasis on Good Agricultural Practice (GAP) there will be need for the training program to intensify efforts in this area as proposed i.e raising awareness of ASEAN GAP. The training expertise developed at ARC, particularly collaborating with other institutions, needs to be sustained and if possible a model developed and adopted byThe World Vegetable Center. It will be essential that the training program incorporates an inbuilt audit system to assess the impact of the training program in relation to the mission ofThe World Vegetable Center. The synergistic mix of learning experiences in classrooms and field studies should be enhanced.

It is expected that future funding for training will be tied to either research or development projects. Instead of a general, but comprehensive, production and marketing course, future courses will be more specialized, with some stratification between research and development activities. ARC is well situated to take advantage of the significant capacity in Thai universities, and this could include extension into post-harvest issues, marketing, and nutrition. The northern Thai universities have particular capacity in training for students from Cambodia and Laos. These specialized courses could draw on curricula already established within these universities. Future training activities thus can be built on the well established history of ARC in the region but at the same time can be better targeted to

particular needs. At the same time, with links to projects, training can be reinforced both mentoring and application of concepts and methods within the research project.

Networks and capacity building

The Asia Regional Center continues to implement a regional collaborative program and activities. Through CLVNET (Vegetable Research Network for Cambodia, Laos PDR, and Vietnam), low productivity in vegetables and low capacity for research and development were identified as limiting factors in vegetable production that require attention. To ensure sustainability and impact CVLNET maintained the goal of enhancing vegetable productivity in the region and increasing the capacity of the national agricultural research systems (NARS) staff in the three countries. On-farm trials for many vegetable crops have been conducted in Cambodia, Lao PDR and Vietnam in which the yields of the promising lines were observed to be much higher than the local varieties under various environmental conditions. The trials resulted in dissemination and release of superior varieties to farmers, together with appropriate production technologies including promotion of IPM e.g. intercropping and biopesticides were successfully employed to control DBM. Seed production technologies were effectively disseminated to researchers, extension specialists and lead farmers through numerous regional and local courses. A seed production network of 25 lead farmers in Lao PDR was established and improvements in infrastructure were made that will assist NARES in Cambodia and Lao PDR to produce and store more vegetable seed in the future. Numerous regional and in-country courses were conducted for over 2000 government officials, researchers, extension specialists, leading producers and farmers to promote capacity building.

ARC, with funding from the Swiss Agency for Development and Cooperation (SDC), successfully implemented and completed the "Human Resource Development Project for the Mekong Region Phase IV" (HRDP IV). With the over-all goal to increase farmers' income and improve diets in the poor areas of the Mekong Region by strengthening capacities in vegetable research and development at National Agriculture Research and Extension Systems in Cambodia, Vietnam and Lao PDR. The project has supported 60 trainees at the regional training courses held in Kamphaengsaen, Thailand. Most alumni work with NARES. In-country training courses focusing on increasing capacities of agricultural extension institutions in vegetable production and refresher courses on implementing Farmer Field Schools have also been conducted.

Research support extended to NARES in Cambodia, Lao PDR, and Vietnam has led to the release of several new vegetable crops and varieties to farmers and to the introduction of new cropping technologies and environmentally safe pest and disease control. Approximately 1,000 vegetable accessions have been distributed annually to Vietnam, Cambodia, Lao PDR, and China. In strengthening research and training competencies, researchers and extension staff from Cambodia, Lao

PDR, Myanmar, Democratic People's Republic of Korea (DPRK) and Vietnam participated in the Regional Training Courses with emphasis on vegetable production, research and extension.

Several technical guides and books on vegetable production have been translated into local languages. The regional website has been operating since 2001 and is revised monthly to update technical information and regional activities. Strengthening knowledge and information sharing, media agencies are utilized by some national partners. The established ASEAN-AVRDC Regional Network on Vegetable Research and Development (AARNET) continues to enhance vegetable R & D cooperation as well as the development of indigenous vegetable-related industries within ASEAN. AARNET aims to promote sustainable and improved production of good quality and safe vegetables for consumption and trade.

Network activities of The World Vegetable Center in the region, however, highlight some of the overlaps in responsibilities. CVLNET is managed from headquarters, while AARNET is managed from ARC, but has little funding and therefore less potential to link the NARES in the three less developed countries of the region to the better developed capacities in the rest of the region. If ARC is to build an interacting network which takes advantage of the large differential in research and development capacities in the region, then future project development of the CVLNET type should be done within a collaborative mode through AARNET. ARC has a relatively unique institutional arrangement compared to the other Regional Centers, in that it has a strong collaborative research and training program with Kasertsart University. The future vision of ARC networking activities in the region should be in extending this model to other strong universities in the region, and in the process developing an interactive research and development network. This will require some determination of research and training capacities in the region, which would then become a basis for future project development within the AARNET.

The panel found the networking and capacity building programs comprehensive and adequate in addressing the requirements of the region. The efforts made to have training information and brochures translated from English into the local languages are commendable as it facilitates effective communication with the farming community. It was however not very clear as to what role the individual NARES were playing in /contributing to the program in order to enhance ownership for improved sustainability. It might be useful for ARC while preparing the capacity building and networking programs to factor in and encourage contributions (including in-kind) from the NARES. This in effect will commit the NARES to the program while at the same time ensuring that the World Vegetable Center is implementing its global objective. Capacity building efforts at national level on Good Agricultural Practice should be facilitated through the networks. The collaboration with Kasetsart University over the years has been effective in facilitating the training needs for the region. However linkages with other institutions

in the region should be encouraged to facilitate both short term and long term training, including graduate student research. This would include liaison with the private sector - eg seed companies – where it is involved with extension activities.

Research and Germplasm

A number of vegetable research activities are undertaken within the ARC mandated countries in collaboration with various organizations. Mungbean, which is an important crop in the region, has received significant attention, resulting in the development of lines with high yield potential, resistant to diseases and pests, and with wide adaptability. The research activity has also included the characterization of the various insect pests and pathogens leading to application of appropriate technologies for their control. For example in collaboration with the International Center for Management of Pest Fruit Flies (ICMPFF) AVRDC-ARC initiated preliminary studies to study the impact of protein baits to manage the melon fruitfly and oriental fruitfly. Other studies undertaken include the presence and impact of parasitoids on *Maruca vitrata* population dynamics in agro-ecosystems on yard long bean in both the dry and rainy season. In addition investigations into the value and use of the various vegetables have been initiated; there have been evaluations of the antioxidant activity of indigenous vegetables during the rainy and dry season with the support of JIRCAS. This recognizes the important role of indigenous vegetables in addressing issues of malnutrition and the growing demand for food. Another significant activity is the IFAD sponsored project on facilitating the access of the rural poor and participation in commodity markets in Vietnam, with the aim of improving market efficiency for vegetables.

A germplasm collection including studies on seed storage requirements of different kinds of vegetables is maintained and this has been growing steadily through sharing and exchange of vegetable accessions with other institutions. In the effort to achieve environmentally friendly and safe vegetable production systems, organic farming trials have been initiated.

ARC has established linkages established in terms of research and breeding. It is suggested that it should provide a support base for shuttle breeding for cucurbits, regional gourds and cucumber with the headquarters and where possible with RCSA. This however has to take into account the role private seed companies may be playing in terms of breeding of these vegetable. The varietal trials and release system in the region needs to be streamlined to ensure that The World Vegetable Center receives gets due recognition in terms of the identity of its varieties planted by farmers or marketed by seed companies.

ARC Development and Headquarters Coordination

ARC has a long history within The World Vegetable Center, albeit dominated by the SDC training project, a relatively unique institutional arrangement with Kasetsart, and the potential to develop a research and development network in the region that

exploits the significant disparities in capacities. However, most of the projects undertaken in the region are managed from headquarters, which raises the question of the role that ARC should play into the future. Clarity on this question is needed in order to go forward with programs both at ARC and at headquarters. The issue is made particularly difficult because a significant part of the research managed at headquarters is based on projects in the region, which in turn creates both conflicts and competition.

Several considerations would seem to drive resolution of the future role of ARC:

- First, the Southeast and East Asia region is particularly important to The World Vegetable Center in pursuing its global mandate, and The World Vegetable Center should clearly articulate a strategy for this region comparable to the other regional programs.

- Second, it is not clear how a regional program might be coordinated from headquarters. The significant amount of work that The World Vegetable Center currently undertakes in the region is done through the research themes with little in terms of a regional strategy.

- Third, ARC's location in the humid tropics gives it a particular advantage in research in this agroecology, with potential for optimizing some of the breeding activities currently carried out in headquarters.

Given the logic inherent in the creation of the regional centers, the Panel feels that ARC should continue to deepen its research and development programs. However, this will require clarity on the relationship with headquarters in project development, management responsibility, potential devolution of positions to ARC, and improved coordination of programs within the region.

Recommendation 2.II.6: The Panel recommends that ARC be given the same status and managed in the same manner as the other regional centers.

2.II.3 Regional Center for South Asia

The Regional Center for South Asia (RCSA) was only established in 2006. RCSA is responsible for eight countries that run from Afghanistan to India to the Maldives and is based at ICRISAT in Hyderabad, India. The World Vegetable Center has had projects in the region running back a decade and institutes such as the Indian Institute of Horticultural Research have collaborated with the center since 1994. This provides a good base on which to develop a regional research and development program. As the RCSA is only getting established, the Panel will principally focus on

the future plans of the regional center and the interactions with both headquarters and national partners.

This region is dominated by one large country, India, and several smaller countries. Demand for vegetables in India is growing rapidly, driven by rising incomes and increasing health concerns of an urbanizing population. Marketing and retail systems are adapting very quickly to this demand, particularly supermarkets and specialized fresh vegetable shops. Marketing systems in the other countries in the region are not changing so quickly, although growth in vegetable consumption across the region is strong. What is characteristic of this region is the huge diversity in agroecologies, production systems, types of vegetables and consumer preferences within types, and marketing systems. At the same time, because of the large internal market in India, there has been significant growth in capacity of private sector seed companies in breeding and for the larger companies, even transgenics. The public sector research institutions in India are also very strong in breeding and production systems and ICAR runs the all-India coordinated vegetable trials in more than 30 locations.

The Panel felt that this capacity in India was not being fully exploited, particularly the interactions between the many Indian universities and research institutes working on vegetables, the flows of breeding materials between public sector institutes and private sector companies, and the potential to link India's powerful capacity into a regional network. Public-private sector flows have been improving. The Indian Institute of Horticultural Research (IIHR) has sold lines to private companies, starting with 10-12 lines in 2002 to 50-60 lines in 2007—mostly inbred lines with novel traits. These, however, are sold on a non-exclusive basis. By comparison, 40 private sector companies participate in the all-India vegetable trials and Mayhico has 10-12 entries testing the Bt gene for shoot and fruit borer in eggplant. The World Vegetable Center has the potential to act as "honest-broker" firstly in the Indian context—especially developing between germplasm flows between the public and private sectors-- secondly in brokering research networks in the region, and thirdly in providing a more systematic conduit for its germplasm. These issues then raise the question of how much capacity should RCSA build and how much should it rely on networking existing and growing capacities in the region.

Breeding and Germplasm

RCSA has screened elite mungbean lines from breeding lines supplied from HQ and selected three for the paddy-wheat crop rotation of the north Indian state of Punjab. Variety **NM-668** developed in collaboration with Punjab Agricultural University, Ludhiana, is extra early and has a yield potential of 1500kg per hectare. Mungbean is one of the major pulses eaten by the poor and rich people of India and is the major source of protein for poor population who are also vegetarian. A total of 65,000 kg of seeds (25,000 kg from Punjab Agricultural University and 40,000 kg through the Seed Village concept of RCSA) was distributed to the farmers of

Punjab for planting as an extra crop in between the wheat and paddy planting seasons, thus providing additional income to the farmers.

The issue of what type of breeding capacity to develop in RCSA is in many respects the dominant question in the short to medium term. In addition to the mungbean work there are collaborative breeding programs between IIHR and the tomato and chili breeding programs at headquarters. The tomato project focuses on resistance to bacterial blight and MAS and has collaborative links between Thailand and India. The chili project attempts to pyramid resistance genes for a range of diseases into locally adapted lines in India and three countries in East Asia. These two projects represent the next generation of The World Vegetable Center breeding programs—in the past IIHR has received 100-150 single and 3-way cross hybrids in various species—in trait deployment rather than finished breeding lines. However, they only begin to touch the potential for trait deployment in a country like India when there is only a collaboration with IIHR and limited flows between IIHR and the private sector. In the future, projects such as these could feed directly into a South Asia "trait deployment" network, where a range of public and private sector entities have access to the traits and methods.

Horticultural breeding has achieved significant yield and quality gains at the farm level in the Indian context. As the director of IIHR notes, the move in the country is toward niche breeding, in terms of agroecological adaptation and local consumer preferences. The role of the public sector is increasingly shifting to a focus on traits, particularly quantitatively controlled traits which are accumulated over generations in particular genetic backgrounds. The role of The World Vegetable Center in this context should be to optimize the flow of germplasm within a large and complex Indian horticultural breeding system, and use its Indian location as a conduit for germplasm flows to the rest of the region.

The Panel considers that within a devolving Center breeding program, RCSA would have a competitive advantage in breeding for cucurbits, including the range of gourds produced on the sub-continent. Three breeding cycles are possible compared to one at headquarters. Many of the indigenous vegetables in the region are cucurbits, and many of the private seed companies are involved in breeding for these vegetables. Locating a cucurbit breeder in RCSA would provide a locus for many of the other research themes. It is felt that this would be more strategic than reviving the mungbean breeding in the Center—where the ARC could focus on mungbean breeding.

At the same time RCSA needs to conceptualize the organization of regional varietal trials, which will be linked to the new position just created at headquarters for international varietal trials. Given the all-India set of trials which test finished varieties for release, in which the World Vegetable Center can participate, the Center should concentrate on testing its material for response to biotic and abiotic stresses. How to

add value to existing multi-locational trials will be an issue in the design of the regional testing system and its links to center-wide set of trials.

Production Systems

The other principal area of research carried out by RCSA is into production systems, although again this area is just beginning to be organized. This area covers a number of quite different systems, including peri-urban systems, organic agriculture, home gardens and whatever systems will characterize the production areas under the Sir Ratan Tata Trust grant. These are all very different systems and it is not apparent where the logical entry point is for each of them. With the organic research at headquarters, in ARC, and in RCSA, there is need for common methods so that there are comparable results. Research methods for organic systems have to be different from those in other production systems and The World Vegetable Center has the opportunity to be a leader in this area, particularly with organic systems grown under such varying agroclimatic conditions.

Home gardens, in turn, are viewed more in terms of an extension tool, primarily focused on indigenous vegetables. Work on home gardens needs to be integrated with the nutrition theme, particularly the type of work that would come under the Consumer Nutrition Unit. This work would logically focus on areas with high rates of poverty and malnutrition, and would particularly need to add components on such issues as preparation methods, weaning foods, and nutritional impacts. While there is both work in RCA and RCSA on home gardens and indigenous vegetables, there is as yet neither a clear research agenda for this system, nor a clear understanding of dissemination methods that also target nutritional impacts.

One frame around which to focus the work on production systems is the Sir Ratan Tata Trust Foundation project in Jharkhand, where the overall objective is to increase vegetable production and consumption as a means of improving rural livelihoods. Poverty rates in this district are high and the farming population is dominated by very small sized farms, where intensive horticulture would have a comparative advantage, assuming there was appropriate access to markets. Reports suggest farming in the state is dominated by cereal-based systems. Diversification into horticulture would be a test of the methods required for the introduction of horticulture as another crop. On such small farms, competition with subsistence crops is often a constraint and the strategy may require the introduction of improved staple technologies as well. Moreover, there may be need to target home gardens for very land constrained farmers, and market horticulture for those with sufficient resources to enter such markets. This work could then feed back to on-station research into production systems. The task for production system research is to develop better research priorities based on overall strategies and goals of the RCSA—discussed below.

Post-harvest and Nutrition Research

RCSA has yet to develop any research thrusts in these two areas. The director of IIHR indicated that the post-harvest area was a particular gap in their research program and the Center could provide leadership in this area. However, it is difficult to determine how to focus work in either of these areas. The impression is sometimes given that The World Vegetable Center does research in all areas with potential application in all contexts, but this is obviously impossible in a field as diverse as horticulture. Clarity is needed about the areas in which the World Vegetable Center excels and in which it will continue to develop its global leadership. For RCSA, there are two possible ways to decide priorities. The first is to mount a well structured diagnostic and characterization study for the region - in essence a needs assessment. Alternatively, the program can be built in progressive phases. As suggested above, the initial phase would be built around the work in Jharkhand, where the end objectives align perfectly with the Center's mission in the region. The achievement of that mission will require an integrated strategy that runs from varieties to production systems to post-harvest and nutrition research. This work would eventually extend to other states and to other countries in the region. The choice will depend on acquiring an understanding of the constraints on developing horticulture in South Asia that will best impact on the livelihoods of poor households.

Networks, Capacity Building and Training

South Asia has one of the stronger capacities in horticultural research in the tropics in the private sector, universities, and research institutes. As suggested throughout this section, the RCSA needs to taken optimal advantage of this capacity through its R&D activities. This will have at least three aspects: networks and collaborative research, training, and the honest broker role, all of which should interact in a synergistic way.

RCSA initiated its work by organizing a regional meeting of horticultural researchers that came to an agreement to form a network, SAVERNET. How to organize and fund the network is still being worked through. The Panel's observation is that this should probably be thought of as a two tier network. The core activity will be testing of vegetable germplasm. However, the Cereals and Legumes Asia Network (CLAN—tested varieties for over 12 years with ADB funding but with little success in getting them into the hands of farmers. With vegetables, the private sector companies have to be equal partners in the testing. Public research in India has also produced several good open-pollinated varieties but these varieties have not percolated down to the farmers. National Seed Corporation (NSC) was instrumental in the spread of cereals like wheat, paddy, pulses and oil seed crops but did not make a significant dent in the maintenance, production and distribution of vegetable seeds, especially open pollinated types. Open pollinated seeds of vegetables are primarily used by the poor and marginal farmers around small towns in interior areas - but these have not attracted the private sector due to the low margins it would receive. How to develop the testing network so that varieties can

feed into different dissemination pathways is a critical issue in the design of the network.

The other possible tier to the network is collaborative research projects of the type undertaken with the Punjab Agricultural University on mungbean breeding. However, such projects need not just focus on breeding, but should extend into the other thematic areas. These projects would capitalise on the stronger research capacities in the region, but the results would be available to all the other institutions participating in SAVERNET. Research done in this type of modality is very cost effective, taking advantage of existing capacities and when done with universities, has the additional resource of graduate students. What research would be done in this mode, particularly whether it had regional applicability, would be determined by the network members.

Given the variable capacity across the region, the design of a training strategy as well requires an institutional needs assessment. Training in the other regional centers has focused on short and long courses, as well as some graduate student attachments. There is a need to rethink training as a part of the evolving RCSA. Firstly, graduate student research can be a significant contributor to research efforts and at the same time developing human capital in horticultural research. This should be a primary focus and a core component of the second tier of SAVERNET. Long courses generally target researchers in institutes that have capacity constraints, that is those in some of the smaller countries in the region. The World Vegetable Center should work together with select universities in India to develop such courses. The World Vegetable Center can collaborate on the curriculum and the training materials, but universities would have a comparative advantage in offering such courses. Short courses should, in general, only be offered as part of an ongoing project, where the training needs are highly targeted within the frame of the project. This will be the principal mechanism for funding such training, and it maximizes the learning by doing potential of such courses.

The World Vegetable Center Strategy for Horticulture in South Asia

The long term vision for RCSA is that it becomes a core component of The World Vegetable Center research program and at the same time be a locus for development work in South Asia. This is a complex undertaking and should be guided by a strategic plan for the region. Whether this is developed collaboratively as core component of SAVERNET or within an internal, interactive process within the Center is best decided by the Director-General and management.

The full potential for horticulture in South Asia has yet to be realized, and The World Vegetable Center is well positioned to facilitate and guide that process. However, as the above brief discussion has intimated, there is a large range of strategic choices on the way forward, and these need to be clarified both for internal

planning purposes, but also so as to mobilize the considerable capacities that exist in the region.

Recommendation 2.II.7:

Building on the first regional stakeholders meeting, a strategic plan for horticultural research and development within South Asia should be formulated to guide the development of RCSA.

Chapter 2.III

RESEARCH THEMES

RESEARCH THEME 1: GERMPLASM

Accomplishments

The Germplasm Collection is The World Vegetable Center's most precious asset and investment in the fight against the global challenges of poverty and malnutrition. In a 21st Century context of changing climate and unremitting growth in humanity's demands for food, water, land and other resources, it becomes more priceless still.

At the time of the Panel's visit the Collection contained an estimated 56,130 accessions, representing over 300 species of vegetables from more than 140 countries. This material is made freely available to both the public and private sector, who have used the pool either to breed up and directly release improved crop types, or to use in their in-house breeding programs to release as their own strains and hybrids. The role of the Germplasm Collection in the distribution of material or accessions is well documented in terms of numbers – at least half a million seed samples given to over 180 countries – but the number of varieties or hybrids developed and released by private or public breeders using The World Vegetable Center's accessions is far less clear, and this limits our ability to map and measure the benefits being delivered internationally by this unique resource.

Documentation and feedback

The Germplasm Collection is the backbone of the Center's varietal and hybrid development program. However the Panel felt it is also important to develop a more organized tracking, documentation, distribution and feedback system, so that the true impact of the Center's work in alleviating poverty and improving nutrition for poor farmers and consumers can be more clearly understood – and its value more widely appreciated by donors and investors. The Panel appreciates it is not always easy to obtain this feedback, especially from small seed companies who may not have detailed records themselves, but urges the Center to place more stringent feedback requirements on future distributions of material.

Seed characterization, evaluation and documentation is an ongoing process at the Center's Germplasm Collection, but at present nearly 50 per cent of the total collection still remains to be characterized, evaluated and documented. This is a very important activity, demanding of time, money, resources and manpower, the impact of which is difficult to access. There is some risk that, as the collection grows, the backlog will grow. Furthermore the Panel feels that, as the as pressures on the global food supply rise due to both demand and environmental factors, the calls on

the World Vegetable Center to provide material suitable for addressing regional food shortages and short-term crises will grow. It therefore feels this activity should be given a higher priority as, apart from anything else, this will also facilitate and speed up the work of the Center's own breeders, pathologists, nutritionists and physiologists as well as those of its partners.

Regional collections

The involvement of the Regional Centers in South East Asia, South Asia and Africa and other regional offices/trial stations in the Germplasm Collection needs special focus. In this Report the Panel is urging a greater devolution of responsibility and resources to the regional centers as part of the World Vegetable Center's planned growth strategy. This applies significantly to the germplasm collection. The wider reach afforded by the growth in number and scale of the Regional Centers clearly carries with it the opportunity to significantly expand the Collection's total number of accessions, as well as to decentralize and reduplicate the collection itself to some degree, creating a level of insurance against unforeseen circumstances affecting any of the nodes of the World Vegetable Center. The 7346 elite accessions which are being stored under Global Crop Diversity Trust and annexure 1 of ITPGRFA in Norway from January 2008, represent a further dimension of this policy.

The Regional Centers' own germplasm collections will also be very important in assuring a ready supply of regionally relevant material to local breeders, provided the material is held under scientifically-controlled conditions and maintained in good condition according to the standards laid down by the central collection in Taiwan. At present it is not clear that this is the case, and the Panel feels there are grounds for improving the technical condition, characterization and documentation of the Africa collection in Arusha, as an example.

We encourage the Germplasm Collection as a whole to ensure regular multiplication and germination testing is undertaken both centrally and in the regions to guarantee the viability of all parts of the collection, and to see that the responsible staff are well trained.

Funding the Collection

Elsewhere in this report (Ch.s 1 and 3) we raise the issue of the need to diversify sources of funding to the World Vegetable Center in order to encompass its future growth, one of which relates to the Germplasm Collection. It is an important principle that seeds from the collection be distributed freely and without charge in order to reach as many poor farmers as quickly as possible, and the Panel fully supports and endorses this.

However at the same time, and in view of the dramatic expansion of the global biotechnology sector, we feel it is opportune for the Center to consider regarding the collection in two separate lights – (i) as a source of seed material to be delivered free of charge to poor farmers or those supplying them, and (ii) as a potential source

of novel genes for biodiscovery of interest to commercial biotechnology companies and scientific agencies engaged not only in crop development but also in biotherapeutics, nutriceuticals and other health-related products.

We consider the feasibility should be explored of having a commercial enterprise, based upon the latter activity, generating revenue to support the former, public good activity – in other words, helping the Collection to fund its poverty alleviation work by charging for particular commercial services provided to the private sector. It is envisage that a fee could be charged to any company wishing to screen the Collection for novel bioactivity genes, and a royalty levied on any resulting discoveries incorporated in commercial products. We stress this activity should be self-supporting and not encroach on the time, resources of main work of the Collection. We further note that the growing focus on nutrition within the World Vegetable Center is likely to focus the collection increasingly on crops with desirable health profiles, and that many of these will contain particular genes of potential value in their own right, increasing the prospects for successful biodiscovery.

We frame this as a suggestion, rather than a recommendation, because there are clearly mainly issues, ethical, IP, financial and managerial to be thought through. However we believe the increasingly close partnership between the World Vegetable Center and the commercial seed sector makes partnership with the biotech sector in gene discovery a somewhat logical evolution, and there is no reason why they should not pay for it.

The Panel's detailed recommendations for the Germplasm Collection follow.

Recommendation 2.III.1.1-12 :

The Panel recommends:

1. **The Panel recommends the Center strengthen and expand the scope of its Material Transfer Agreement (MTA) both for the public and private sectors, to obtain feedback for impact assessment**.

2. **Completion of the nutritional audit of accessions to facilitate the center's nutritional research needs.**

3. **Exploration of the scope to generate funds through involvement of the biotech sector or large food companies.**

4. **An increased focus in collection policy on tackling and solving key human health issues with new kind of vegetables and also on documenting the possible toxic effects of the Indigenous Vegetables (IV) .**

5. **Priority be given to completing the characterization, evaluation and documentation of existing accessions, their inclusion in AVGRIS and availability via the web.**

6. **A special initiative should be considered to explore the Collection for sources of resistance to drought, heat, salinity, acidity and other abiotic stresses.**

7. **The collection and evaluation of local and indigenous vegetables by the Regional Centers in South East Asia, South Asia, Central Asia, and Africa should be regarded as a priority as open-pollinated varieties, land races and local indigenous varieties in these regions are being rapidly swamped by improved varieties, hybrids and exotics.**

8. **Careful consideration should be given to the protocols and documentation for the storage, handling and distribution, import and export of GM brassica material expected to emerge from the CIMBAA project. (Such documentation will also assist in impact assessment)**

9. **The bilateral agreement for collections between HQ and the regional centers should be reviewed and strengthened to further advance the collection and exchange of vegetable germplasm worldwide.**

10. **The online data base information and AVGRIS system needs to be fully implemented and put into widespread use.**

11. **Greater emphasis be placed on utilisation vis-a-vis collection, evaluation and characterisation.**

12. **Duplicate storage of germplasm, especially the elite lines, should be prioritised. The 'Black Box' arrangement with Norway should form the basis for similar agreements with gene banks like Tsukuba Gene Bank in Japan and Taiwan Gene Bank, as is currently being negotiated with Korea.**

Chapter 2.III.2

Research Theme 2: Breeding

The breeding program was in the past the core program of The World Vegetable Center, supported by plant protection, germplasm, marker development and nutritional analysis. When financial resources were scarce, the center concentrated on output from this program. This research program, therefore, has a continuity that is not present in some of the newer research themes. As such, breeding has led the devolution and decentralization process, as reflected in the vBSS program to develop breeding capacity, populations adapted to African conditions, and varieties that meet the needs of both African production systems and African consumers. How the breeding program devolves into the other regions is a central issue in the forward planning of the research theme. Particular issues are the core activities of the breeding program located at headquarters, the division of labor between regional centers and headquarters, and what breeding programs should be devolved completely to the regional centers.

Vegetable breeding has several distinctive features that distinguish it from breeding for staple grain crops, pulses, or root crops. First is simply the wide choice of different species that can potentially be included in a breeding program. This list is continually expanding, as many indigenous vegetables in the tropics move into commercial production. Second is the range of traits that are important in horticultural crops with cosmetic appearance; therefore pests and diseases are critical to both production and marketing. To this can be added local preferences in shape and color as well as nutritional content, particularly with the rising health consciousness of urban populations. Third is the significant and increasing breeding capacity within private-sector seed companies. The Center faces the issue of how to develop an appropriate division of labor with the private sector in breeding, with a particular focus on hybrids, at the same time that its public good role calls for a focus on open pollinated varieties (OPVs), which often do not have well developed seed distribution channels. These are all interesting challenges, and this section will assess the current breeding program, but will principally focus on issues in forward planning.

Accomplishments

The World Vegetable Center has achieved a remarkable breeding record in tomato, chili, mungbean (though not strictly a vegetable, it caters for the protein intake in poor, vegetarian populations) and vegetable soybean (likewise not a vegetable but raw boiled pods are eaten as a snack in East Asia). Since 2000 the center has released 39 varieties of tomato grown in 9 countries, 12 varieties of mungbean grown in 5 countries, 14 varieties of hot pepper grown in 5 countries and 8 varieties of indigenous vegetables.

Several elite lines of The World Vegetable Center have been used by the private sector as one of its parent lines or as a source of particular traits in backcrossing programs. However, it has been difficult to track this important source of impact in tomato and hot pepper, as not all the private sector companies openly acknowledge the lines from the Center which they used in their breeding program. Although the Center has undertaken a significant breeding effort on mungbean and vegetable soybean, the area sown by farmers to these varieties in the targeted regions in ARC and RCSA is not known with certainty (a study, however, was done on planting of improved varieties in China).

There has been a dedicated effort over the last five to six years to improve linkages to the private sector. This significantly improves the potential for impact of new varieties given that the companies are the principal means of producing and distributing improved seed. Collaborative breeding research projects on specific themes were undertaken with interested seeds companies in Asia under the umbrella of the Asia & Pacific Seed Association (APSA). Under this collaborative research program, all participating companies contribute equally to a research fund that is provided as restricted core funding to The World Vegetable Center. In the first project Ty-2 markers for virus resistance in tomato were developed and were made available to participating companies who are using these markers in their hybrid development programs. A second breeding project is currently being undertaken to develop semi-elite lines with resistance to important diseases in tomato, hot pepper, cucumber and pumpkin. The Center is well positioned to expand this kind of collaboration, whereby it can target principal breeding constraints as identified by numerous seed companies and the research outcomes can be spread quickly to farmers through the private sector's obvious strength in commercial seed multiplication, sales and marketing.

Organization of the Breeding Program at The World Vegetable Center

To breeding horticultural crops at a global scale it is important to recognize the dauntingly wide scope of possible choices. This includes firstly a huge number of potential species which, if indigenous vegetables are included, would surpass the total number of species worked on by the entire CGIAR system. Then for each species there are many traits of importance, which are often defined by regional preferences and agro-climatic conditions. For many species, breeding sites require particular conditions for flowering, and obviously for selection and evaluation. Commercial production areas in much of Asia are planted to well-established varieties, where there has been several generations of breeding. In such cases, breeding focuses on adding traits of importance that will increase market value. On the other hand, in sub-Saharan Africa there is virtually no breeding history for horticultural crops on the continent and varietal development must pursue a two-track strategy. The shorter-term approach is to test a range of existing varieties. The

longer-term approach is to develop populations adapted to African conditions, from which future varieties will be developed.

Over recent years, with the growth in the Center and the development of the regional centers, the breeding program has started to develop a more decentralized and devolved character. During the early part of the review period, when resources were scant, AVRDC had a very centralized breeding program, producing finished OPVs and hybrids, which in many ways could not fulfill the requirements of a global center. The World Vegetable Center needs to conceptualize its breeding strategy in terms of a global system, building on the capacity that exists in the private sector in Asia and in many larger NARS, particularly India and China. In sub-Saharan Africa a large breeding capacity is being put in place through the Bill & Melinda Gates Foundation-supported vBSS program. The need is to move toward a better articulated breeding program with the three regional centers in Asia, increased capacity in those centers and a clearer division of labor. Also, moving to the next stage in the evolving relationship with the Asian private sector is an essential complement to the development of a more integrated horticultural breeding system in Asia.

Re-ordering the Breeding Programs

The Panel recommends a re-ordering and re-organization of the breeding programs. HQ should focus more on the basic and analytical breeding tools like developing the trait-linked markers, development of elite breeding lines with value added traits like resistance to virus, bacteria or abiotic stress, and organization of an international varietal testing system. The Center has the infrastructure and facilities to undertake such work, while the regional centers should concentrate on the more applied breeding aspects like selection, population improvement, multiplication and maintenance of indigenous vegetables (IVs). Based on what we have learned, the following suggestions are offered:

(a) HQ should focus on development of elite and pre-breeding lines of Tomato, Hot Pepper, Cabbage, Cauliflower, Chinese cabbage, Pakchoi, and Broccoli. The Center has the available facilities and breeders to address these needs. The development of hybrids and crossing programs and screening of top crosses of tomato and hot peppers should be done at the regional centers or at NARES facilities in line with regional selection criteria. For example, screening for the TYLCV tomato lines/top crosses should be done in South Asia where the disease is prevalent and there is a large acreage of tomatoes under cultivation. Location there also offers significant savings in the high cost of crossing and field observation. Top crossing and fieldwork are much cheaper in South Asia than at HQ. Similarly for hot peppers, screening and development of top crosses is should be done in South Asia or Indonesia, where there is major acreage as well as commercial growing and breeding efforts.

(b) Expand and revise the Brassica breeding program at HQ and focus on the development of OP'S and elite and pre-breeding lines of Cabbage, Cauliflower both tropical and sub tropical (both can be bred at HQ), Chinese Cabbage, Broccoli, Pakchoi and other minor leafy vegetables of the East and South East Asia region.

(c) Cucurbit breeding (Pumpkin and Cucumber) started at the HQ but needs re-organisation. HQ cannot handle more than one cycle/year and the Panel suggests that selection, making top crosses and generation enhancement and screening for cucumber, pumpkins, melons and gourds (gourds are not currently in the breeding program and probably should be) ought to be done in South East Asia (ARC) or in RCSA as these are the target regions areas for production and have the largest commercial growing areas. Breeding efficiency will increase because of the scope to attain more than 3 crop cycles/year under open cultivation in south Asia or south east Asia (RCSA or ARC).

(d) Mungbean and Vegetable Soybean Breeding need to be revived at ARC (Mungbean) and Vegetable Soybean in RCA (Africa) and RCSA in collaboration with with NARES.

(e) Onion and Okra breeding should be initiated and strengthened in Africa. Both are very important crops of the region. Okra breeding efforts can be supplemented through RCSA as there is already sufficient germplasm available in south Asia/India. Both these regions offer 2-3 crop cycles and can provide screening against YVMV (Yellow Vein Mosaic Virus) under open cultivation.

(f) Cucumber, Melon and Watermelon are significant crops in Central Asia and breeding should be performed in the central Caucasus/Caucasus in order to deliver a quick impact in varietal development of these crops that meets consumer preferences.

(g) Gourds (Bitter Gourd, Bottle Gourd, Ridge gourd, Sponge gourd) breeding, selection, multiplication should be carried out in Southeast and East Asia (ARC) or in RCSA as these crops can be grown at 2-3 cycles/year and the region has a large hectarage under these crops. Breeding at HQ is not advisable due to climate, cost and lack of local cultivation.

Partnerships with Private Sector Seed Companies

The World Vegetable Center is in the rare position of having both a well functioning seed distribution system provided by the private sector—at least in large parts of Asia—and at the same time having a growing breeding capacity that is increasingly well financed. However, this private sector capacity is not evenly distributed by region (it is underdeveloped in both sub-Saharan Africa

and the Caucasus), by country within a region (eg. Cambodia and Laos in Southeast and East Asia), and by sub-region within a country (usually being scarce in areas where the poor are concentrated). Two strategic issues arise from this distributional problem. The first is how The World Vegetable Center will help in the development of private sector seed capacity in those areas not currently served by private sector seed companies. This is clearly the strategy within the vBSS project, with some movement in this direction in the Caucasus. Such interventions may involve opening up regional seed markets, as for example the increasing competition and private sector investment from opening markets in the East African Community. Alternatively, this may involve market creation for seed where there was little before, to motivate private sector investment.

Such market creation leads to the second issue of The World Vegetable Center's approach to varietal release and seed systems in areas not covered by commercial seed companies. To a significant extent this is a problem faced by IARCs working on crops where hybrids are not possible and the Center can draw on this experience, which has been somewhat checkered. On balance, the experience does suggest that market development leading to private sector investment is the most sustainable path, which the Center can readily develop. The starting point is the production of OPVs, development of community-based seed systems where there is provision for seed certification, and development of horticultural output markets. Such a program is best tested in regional centers, as part of their overall approach to development.

The more direct partnership with the private sector has been in research that supports breeding and varietal development. This has been principally accomplished through APSA. This "multilateral" linkage in defining research priorities is to be recommended, rather than The World Vegetable Center doing contract research on a "bilateral" basis. However, APSA contains a significant diversity of seed companies, with some having relatively deep breeding capacity, with a focus on hybrid production and moving toward the use of marker assisted selection. However, other companies source varieties from various sources, includingThe World Vegetable Center, for multiplication, marketing and sales. The Center might evaluate whether some stratification is useful in providing breeding materials to private sector companies. As breeding capacity develops within the regional centers, the provision of more finished varieties should shift to them, while HQ continues to focus on providing more upstream research.

As a provider of public goods through reliance on public funds, the World Vegetable Center in its relationship with the private sector needs to guarantee universal access to its germplasm and other IPR, such as molecular markers. This starts with the MTA for provision of breeding materials and other IPR. The quid pro

quo that use of The World Vegetable Center materials be recognized by private companies has yet to be fully acknowledged. The Center has few "sticks" that can be applied, apart from cutting off access to germplasm, which is counter productive. It may be possible to utilize APSA to regulate this aspect of the MTA. The area which is becoming critical is that of protecting access to Center materials, when the dominant trend within the Asian region is toward plant breeders' rights, patenting and licensing. This will become particularly significant with the development of transgenics. In this regard, the CIMBAA project is helping to define an approach to the problem, where a public-private consortium is trying to maintain incentives for private sector investment by allowing an initial grace period for commercialization, while IPR is held by the Center, which can then license access to the IPR if need be. The learning inherent in this project on this and several other aspects of public-private product development is to be commended and the expectation is that the lessons learned will be written up and published.

Molecular Biology and Transgenics

As the breeding program moves more towards identifying and isolating high priority traits, there is a natural application of molecular markers. These have been very successfully developed and applied in breeding for Ty-2 virus resistance in tomato, equally at The World Vegetable Center, at national programs such as IIHR in India, and in some private seed companies. Developing breeding tools and methods, such as marker assisted selection, is a natural comparative advantage of the Center, particularly when a range of traits are to be managed in a breeding program and pyramided in commercially acceptable varieties. The work on markers should follow the priority constraints that are identified by regional centers, NARES networks and private sector groups. However, given the cost and time required to do this type of work, priorities need to be rigorously set. Movement into developing markers for abiotic constraints, although a priority, will move this work to levels of higher cost and risk. Phenotyping will have to be done at sites developed within the regional centers and The World Vegetable Center does not have the physiology expertise needed for such work. Prioritization seems critical as work expands in the area of molecular markers.

The World Vegetable Center has assumed a quite conservative approach to the development of transgenics. On the one hand, transgenics offer the potential to focus on some of the more intractable traits that have not been amenable through plant breeding. This is particularly the case for insect pests, if not for some of the abiotic constraints. On the other hand, horticulture is associated in the consumer mind with health and nutrition, and the continuing debate on transgenics both in Europe and in Asia has led to a relatively conservative approach on the part of private seed companies. As well, developing transgenic solutions comes at a relatively high cost, with the tests to meeting

biosafety requirements often exceeding the actual development costs. Markets for vegetable seed are not large by comparison to hybrid maize, and individual companies are often not in a position to fund either the development costs or the biosafety trials.

The Center is utilizing the CIMBAA project to test the potential for transgenic approaches. This public-private partnership is developing dual-gene Bt brassicas that are resistant to several pests, but particularly diamond back moth. The IP is owned by the private company participating in the project and provides some funding for the development costs, while the three public institutions have sourced project funds for development costs and biosafety trials. Each stage of the project is well designed using the complementary strengths of the different institutions, and the project now is working through which varieties to transform with the gene construct. The World Vegetable Center holds the licenses for distribution of transgenics in the developing world, and it will be a test to see which companies or NARES request this material for incorporation into either breeding programs or for distribution through their seed networks. The focus is on India and there is a test of another model in the Bt Eggplant being developed by the Mayhico company, with support from USAID under their ABSP program. This program gives full rights to Mayhico, with the competitive advantage that this would give the company in the Indian seed market. The Panel endorses a systematic learning approach to the development of transgenics, which will provide the basis for assessing future investment in this line of research.

With transgenics, the lesson from many countries is that consumer acceptance often governs farmers' willingness to take up new varieties and technologies. The Panel encourages The World Vegetable Center to continue to develop its 'listening capability'(primarily market and social research) – referred to in the Chapter on Knowledge Management and Outreach – in order to focus its scientific effort on those crops and practices with the best prospects of early and rapid acceptance by consumers and farmers in particular regions.

Indigenous Vegetables

The World Vegetable Center has identified two independent lines of research in genetic improvement of horticultural crops. One line, which was the focus of the discussion above, is what might be termed commercial crops - that is crops such as tomato that are widely grown throughout the world, including the tropics. These crops have well developed markets and marketing systems oriented towards urban consumers, efficient seed systems, and well developed quality characteristics. They have a long research history, a good research capacity and several generations of successful varieties. Indigenous vegetables, on the other hand, are mainly grown and consumed in rural areas—although this changing for selected species in many regions-- they are regionally specific in terms of local preferences (such as bitterness in Africa) and they are an

important nutritional component in poor rural households. Moreover, they have little research history and The World Vegetable Center is taking a very significant leadership role in developing these species.

More implicitly than explicitly, the Center has defined two distinct strategies for each of these lines of research. The dominant strategy is organized around the commercial crops, and as such principally targets commercial producers, given the reliance on private sector seed companies to distribute new varieties. The second strategy is organized around indigenous vegetables and principally targets marginal regions and poorer rural households, especially given some of the nutritional benefits deriving from some species. The research focus combines nutritional evaluation with germplasm activities, particularly collection and characterization of these species, principally in the regional centers, followed by selection, purification, multiplication and distribution of seed packages that are designed for home gardens. The relative resources devoted to each strategy are quite different, which implies a significant difference in the ability to pursue the Center's mission of alleviating poverty. In many respects the strategies for targetting the poor are too limited and could be significantly supplemented by, on the one hand, commercializing some indigenous vegetables—RCA is testing this in urban markets in East Africa and there appears to be significant potential as well in South Asia—and, on the other hand, developing horticultural production and market systems in regions where rural poverty is the highest. The panel endorses the work on indigenous vegetables in particular and encourages further deepening of this work in the regional centers.

Sub-Saharan Africa Vegetable Breeding and Seed System (vBSS) Project

vBSS is a very dynamic approach to addressing the real issue of making available quality seeds of improved vegetable to poor and marginal farmers. It requires many operational and logistical issues to be managed. To enhance its effectiveness, the Panel offers the following suggestions:

(i) Produce more Vegetable Breeders: As there are very few full time vegetable breeders, efforts should be made to educate, train and produce more highly-skilled breeders and who can make a career in this field. The World Vegetable Center might explore ways to produce more Masters and PhD graduates in vegetable breeding using contract agreements that take them into vBSS once their training is complete.

(ii) Make available pure and commercial IV seeds: The focus should be on selection, purification, multiplication and making available the seeds of improved varieties of indigenous crops.

(iii) Enhance the availability of OPS : Increased efforts may be required to develop and breed indigenous OPVs in the brassica group l (e.g. cabbage,

cauliflower, Chinese cabbage, broccoli) so that poor farmers have a choice of OPVsS instead of hybrids, which are usually imported and expensive.

(iv) Commercial Seed Distribution and Sales and Marketing Operations: A clear policy of developing OPVs within vBSS is desirable from the start, as the private seed sector is focused on the promotion of hybrids.

Achieving the Mission of the Breeding Program

The breeding theme has defined its mission as the development of "varieties designed for use by low income farmers, developed in partnership with those who work closely with them, in environments with major needs and primary reliance on conventional breeding techniques". However, the strategies for achieving these objectives are less clearly defined, particularly in the Asian context, where there is a reliance on private sector seed companies to develop finished varieties and to distribute them to farmers. Private sector companies tend to target farmers who are primarily:

- Urban to peri-urban
- In regions where there is large-scale commercial vegetable cultivation
- Wealthier
- Better informed about the latest developments
- Use the latest seeds, chiefly high-value hybrids.

Because of the commercial interest, this class of farmers are well serviced by the private seed companies. However there exists a far more numerous group of farmers whose needs are not being met as they are the poor, too remote to be reached, lack cultivation expertise and access to seeds, have little or no access to commercial vegetable markets, lack inputs and credit, or whose water, soils and climate are unsuited to commercial-style vegetable production. This class of farmers makes up 50-80 per cent of the population in south Asia, is malnourished and consumes less than 50kg /year of vegetables (primarily potato, dry chilli and onion). Their needs are a priority for The World Vegetable Center. For this reason there should be even more research into hardy local indigenous crops and how best to disseminate them to growers. At the same time there is a need to train and provide demonstrations to village leaders and the better farmers in the techniques and varieties of crops like tomato, brassicas, etc. so that they start to grow more of these vegetables too. This will initially help to improve family nutrition and, through home production, reduce the coast of food purchases and so address the poverty issue. Down the track, interested and advanced farmers can be further trained on a cooperative basis to produce for neighbouring small towns and for local vegetable markets.

Recommendation 2.III.2.1: The Center should continue to re-focus its breeding programs in a regionally appropriate way, with elite level science and breeding concentrated at headquarters and downstream breeding of locally-relevant varieties in the regional centers.

Recommendation 2.III.2.2: The Center should ensure it maintains an explicitly pro-poor balance in its efforts to develop commercial crop varieties and developing indigenous vegetables and open-pollinated varieties more suited to the needs of poor farmers and households.

Recommendation 2.III.2.3: The Center should continue to pursue its cautious approach to biotechnology and transgenics, building its core scientific expertise but at the same time tuning its listening ability to the wishes and needs of consumers in target countries, as this offers the best prospects for rapid adoption.

Chapter 2.III.3

Research Theme 3: Production Systems

Horticultural systems are management- and knowledge-intensive, driven in large part by the relatively high prices received for the product. Management of soil fertility, pests and soil moisture optimize the yield potential of the continuing improvement in the genetic potential of the crop. However, management requires both a significant skill base, often associated with education, and the working capital to invest. This increases risk, which is reduced by the ability to control biotic pressures, fertility, and moisture constraints, and is only assured through effective access to markets. Vegetable production is very much a business venture and moves farmers into a commercial orientation. That said, there is significant variation in the relative intensity of management due to farmers' resource base, their ability to control for constraints and their access to markets. This produces a range of very different vegetable systems, with significant variations in input use, management intensity and productivity. Improved access to market, higher prices potentially due to organizational innovations, lower cost inputs, as well as new technology, can all lead to improvements in management intensity and productivity. The World Vegetable Center's work at both the market level as well as at the production system level has potential to bring about a synergistic effect on farmer productivity.

Overview of the Research Theme

The theme on seed and production systems is ambitious with both the largest number of outputs and activities, and the largest number of staff. It combines all the work on plant health, integrated crop and soil management, organic agriculture, seed systems, and dissemination methods. Because of the breadth of activities that come under this theme, it has proved difficult to focus the theme and create clear objectives and an associated strategy. There are two issues which drive this situation. The first is a 'parking problem' of where to put many of the individual research units. The second is a complexity problem related to the multiple objectives inherent in improving vegetable production systems. Vegetable systems, except for home gardens, have a commercial orientation. Moreover, they are high value. This leads in turn to high input use, which creates both environmental externalities and health concerns. Thus research on production systems has a wide range of potential objectives including reducing cost of production, increasing productivity, reducing pesticide residues, reducing post-harvest losses, and minimizing environmental externalities. The relative weight given to each objective will vary according to the intensity of the system, for example contrast Asian peri-urban systems with African rainfed systems or Southeast and East Asian upland systems. Moreover, meeting virtually all of these objectives depends on improved farmer management, more rational use of inputs particularly pesticides, and reduced use of water in irrigated systems.

The last point offers a way to resolve the "parking problem". There are very different implications for organizing research between seeking genetic solutions to these issues and relying on management solutions. The first relies on breeding for resistance or tolerance to biotic and abiotic constraints, thereby reducing input use, risk, and costs. The second relies on doing the same but through integrated crop management. However, only certain constraints have been found to be tractable through genetic approaches - chiefly plant diseases. In other crops molecular approaches are yielding some progress for abiotic constraints and transgenic approaches show some promise for insect pests (see the discussion of the CIMBAA project). However, such solutions are only in the prototype stage for crops on which there has been a much longer research history and at least a decade away in terms of application to vegetables. The argument then is that plant disease (Activity 1.4) and varietal release (Activity 6.2) are best integrated into Theme 2 on breeding. This will allow the production theme to focus on crop management solutions to production system objectives and the very challenging question of how to disseminate the outcomes to poor farmers.

The large research problem that the theme is attempting to address is how to develop sustainable and safe vegetable production systems for the tropics. An even larger question surrounding this problem is what will motivate farmers to adopt these more sustainable and safe management practices. In general, adoption will occur if farmers who are aware of the technology see there is either reduction in production costs or risks—potentially in charges on pollution or charges for the real cost of water-- or there are market standards that enforce good practices. (See the discussion on quality assurance in the Theme 4 discussion.) Although there has been significant work on Good Agricultural Practice (GAP), these in general have few enforcement mechanisms, particularly for domestic markets. The World Vegetable Center is therefore working on the problem from two sides, in terms of both production costs and enforceable market standards. Costing externalities and water are beyond the scope of the Center's mandate.

In many ways organic farming systems offer the "gold" standard in moving production systems to sustainability and the production of safe produce. These combine market certification with stringent management of input use. The management system depends critically on the development of non-input techniques for managing pests and diseases and soil fertility - appropriate varieties, integrated pest management, and integrated soil fertility management, all areas in which the center currently works. Techniques developed in the pest and soil management area can be equally applied in organic systems, as well as systems that seek to rationalize their input use. There are therefore potential complementarities across the production systems research in component work in the soils, pest, and water area. The issue is how to maximize these complementarities through research on production systems that principally should be carried out across the regional centers.

One of the more challenging issues in production system research is disseminating practices that depend on improved farmer knowledge and management. Moreover, many of these practices such as community-based seed systems for OPV's and indigenous vegetables, biocontrol in IPM practices, and to a significant extent organic systems depend on joint adoption at a community level. Disseminating new production practices in vegetable systems requires significant capacity in extension approaches and strong farmer awareness measures. In countries where there is a sufficient density of export horticulture, such as in Kenya, extension services are provided by private sector entities, particularly IPM practices that require very strict residue management. How to bridge the gap between very sophisticated private sector systems and the capacity problems usually found in public sector systems is an issue that the theme is also addressing. Finally, dissemination requires innovative work on extension methods, the combination of these with mass communication strategies, and whether to focus on system components, such as IPM, or more systemic approaches such as organic agriculture.

Recommendation 2.III.3.1: Theme 3 should focus its research objectives further and develop a research strategy that exploits synergies in component research across different systems and develops system targets in the principal regions in which The World Vegetable Center is working.

Integrated Soil and Water Management Strategies

There is a fundamental issue of whether to direct limited staff resources towards more basic research questions, such as soil-plant-pathogen interaction in the rhizosphere, or to focus soils research on more applied issues of plant nutrition, for example in indigenous vegetables, or improving water holding capacity. The more basic research particularly would help to support research into organic agriculture and the management of intensive systems. On the other hand, soil fertility is known to be particularly limiting in the African context, and more applied work will certainly be needed there, as well as in other areas. Where nutrients are limited, there is also the question of the impact on nutritional content, particularly micro-nutrients. The problem is compounded by the fact there is very little existing capacity in soil science within the Center. To date research in this area has been opportunistic, for example focusing on tsunami-affected areas in an on-farm research mode, rather than strategic in its focus. There are significant trade-offs in deciding where to focus a research strategy in soil and water management.

In Africa nutrients are normally a limiting factor in vegetable production, especially outside the nitisol areas of the East African highlands, where vegetable production is particularly important. Potassium and micro-nutrients are often limiting, in addition to nitrogen and phosphorus. Soil organic matter is a principal determinant of exchange capacity and soil moisture holding capacity. Vegetables are often

grown close to homesteads where organic matter is highest. Managing vegetable production under fertility constraints requires balancing nutrients and managing organic resources. Work in this area is probably best done in partnership with CIAT's Tropical Soil Biology and Fertility Program, based in Nairobi—which also shares a soil laboratory with ICRAF. For vegetables it requires better characterization of production systems in key regions on the continent and integrated approaches to water and pest management. However, it is important to stress that little research of this type can be done on station—nutrients are not limiting there—and must be done in farmers' fields where nutrient status can be predetermined.

Optimizing drip irrigation and nutrient solutions has potential applicability throughout vegetable growing areas in the tropics. However, several institutions already work in this area and the issue is how to effectively disseminate the technology. This requires farmer awareness of and demand for the technology. It is dependent on the relative profitability of this method compared to other methods, investment resources, cost of water and farmer knowledge—and on suppliers of the technology. Where these preconditions are not met, there will be little potential for effective application of the technology. In effect, micro-irrigation poses not so much a technical problem as one of understanding under the conditions most appropriate for it and the ability to effectively integrate it with other crop management components.

On the other hand, a move into more basic research would only be justified if a significant capacity is built in staff and laboratories and a justifiable research agenda is developed. It is far from clear that nutrient efficiencies in vegetable systems are declining with intensification, as has occurred in the case of intensive rice-wheat systems. Certainly there are environmental and health externalities, but these do not in themselves justify a basic research program in soils. On the other hand, managing soils as a solution to soil borne pests and diseases has shown results primarily in situations where nutrients are limiting. Movement into this research will require joint institutional partnerships with those who have developed research capacity in this area, and any initial work with research partners should begin with some scoping of potential lines of research and their expected outputs. If work were to be initiated in this area, the regional center in South Asia may be a more logical home for it, potentially in association with ICRISAT.

Recommendation 2.III.3.2 : While building capacity in soils research is justified in The World Vegetable Center, there is a range of choices between applied and strategic research and the location of that research. These choices should be governed by the development of research strategies in the regional centers.

Integrated Pest Management

Pest management in tropical vegetable systems is in many respects one of the more complex and intractable research problems. A wide array of pests attack tropical vegetables, some being species specific and others more general feeders. At the same time, plant breeding for resistance has been largely unsuccessful. There is a wide array of pesticides that give effective control, but bring with them attendant environmental and health risks if not managed well. For biological control to work as an option, there must be effective control for the whole pest complex, otherwise pesticides will be applied to the secondary pests and reduce the effectiveness of the biocontrol agent. This has led to two to three principal lines of work, namely safe management of pesticide application, biopesticides such as neem and purified Bt toxins, and organic agriculture. While there is a much research that can be done in the diagnostic and characterization area, there has been less research progress in developing effective control techniques for pests of the principal vegetable species.

The entomology research function at The World Vegetable Center operates more as a service function, reacting to demands from the breeding program, characterization demands from Africa, interaction with virology on virus transmission, and support to the on-farm production system research. Moreover, this work is distributed across a range of species, which gives the impression of relatively fragmented pieces of work, rather than consistent research toward developing IPM packages for priority insect pests. Since organic plots are being set up at HQ and the regional centers in South Asia and Southeast and East Asia—with potential in Africa-- these would provide an ideal context to develop and test biocontrol, biopesticide, and cultural practices, such as trap cropping. This would provide critical inputs into both organic agriculture for vegetables but also other production systems across a range of ecologies.

Recommendation 2.III.3.3: Entomological research at The World Vegetable Center needs to define clearer research targets across the different regions. Efficacy trials of potential interventions might be best coordinated with the expanding research on organic agriculture.

Seed Technology and Community Based Seed Systems

Community-based seed systems have been found to be critical for seed supply of open-pollinated varieties, particularly in conditions in Africa where seed companies are not so well developed as elsewhere —though this is changing. On the other hand, the sustainability of these systems has always been questionable, and this can only be resolved by moving to some type of private sector entity. Thus, there is a dual strategy of growing seed production capacity from the bottom up or relying on larger investments by companies that can put together the managerial expertise to produce and market improved seeds. There is a tendency for seed companies to

either specialize in field crops with large potential markets or in vegetable crops, with a large diversity of crops of high value. Because vegetable seed companies maintain a range of product lines mostly built around hybrids, there is an issue of whether they will also maintain a range of open pollinated varieties in their product line and what determines their willingness to do this. Alternately, the case for community-based seed production may be based on the lack of market development in more, non-commercial areas—with the prospect that, following initial vegetable production development via community systems, eventually seed companies will find it profitable to enter these regions.

These issues principally play out in sub-Saharan Africa and are integral to the vBSS program. With the liberalization of regional markets, particularly in East Africa, there has been a significant increase in seed companies, although these have tended to focus on field crops, particularly hybrid maize. Vegetable seed companies are very few and found mostly in East Africa. To meet the demand for vegetable seed, including indigenous vegetables, the vBSS program must adapt its strategy to the state of market development, with the objective over time—and that time frame becomes something of an issue with the 10 year horizon of the project—to move toward private sector capacity in vegetable seed production. Balancing the approach between public sector seed production, community based production, and increasing capacity in the private sector will be critical in meeting the other objectives of the project. This will involve development of seed production and seed quality procedures, particularly for the important indigenous vegetables. Within this balancing, there is probably not enough emphasis given in the early period to community based systems, and The World Vegetable Center should evaluate the experience of the other IARC's, including ICRISAT, CIAT, IITA, CIP, and ICRAF, in the development and scaling up of such capacities.

Recommendation 2.III.3.4: While maintaining the focus on private sector seed production capacity in Africa and the lagging areas of Asia, The World Vegetable Center should develop some capacity over the next five years in community-based seed production systems.

Dissemination Strategies for Managing Vegetable Production Systems

Developing technologies within the frame of multiple (economic, environmental and health) objectives is complex, but disseminating such technologies, especially as they rely on improved farmer knowledge and management, is also challenging. Since, except for home gardens, vegetable production systems are principally market driven, there is an inherent resource and knowledge base necessary for entry and competitive pressures to acquire new production technology. However, The World Vegetable Center is focused on improving the livelihoods of poorer households through horticulture, and this implies either poorer farmers diversifying

into horticulture from other crops—assuming of course access to market—or improving productivity of poorer farmers who already grow vegetables and who usually have higher costs of accessing markets, sell periodically to brokers or locally, and therefore face a number of constraints which limit their income potential from vegetables. Identifying this target group should be a prime focus for the regional centers, which will require identifying poorer regions with concentrations of households falling below the poverty line but with sufficient potential for market access, if not in terms of fresh vegetables, then in terms of processed—see discussion in Theme 4.

Currently, the work on dissemination strategies is tied to projects that test component technologies, eg integrated disease control or micro-irrigation technologies, except for the post-tsunami project. This work falls clearly within the Center's development activities. At this relatively early stage the focus is on developing participatory methods for technology testing and then dissemination. However, as an international center such work should also be driven by research hypotheses and carried out within research frameworks. For example, for the work on micro-irrigation, the potential adoption depends critically on the relative cost of water (see discussion above). The project had only two sites, one relatively wet and one with an extended dry season with costly watering. One of the principal conclusions was that productivity, net returns, and adoption depends on the relative availability and cost of water. To maximize learning, both in testing the participatory methods, but as well in understanding the potential for adoption, sites need to be selected more rigorously on the basis of criteria that strongly influence the performance of the technology. The objective is to understand the thresholds on the fixed factors governing adoption so as to more finely target those technologies in future work.

A critical issue is whether to focus dissemination research on technology components or on management systems. This runs the gamut from IPM, ISFM, home gardens, or organic agriculture. This requires the introduction of multiple technological components within the context of a significant shift in management, often with components that must be coordinated at a village level. For some systems farmer- appropriate diagnostics might be required. This makes the on-farm research much more difficult, with issues of whether to break the system down into individual components or to test various types of systems, potentially with intermediate system levels to that practiced by the farmer. However, potentially the more complicated task is introducing horticulture as a new crop within a crop diversification strategy. The argument here is that there are degrees of complexity in on-farm research in horticultural systems, each involving a range of hypotheses that condition the adoption process, and each with different degrees of collective action required at the community level. In sum, there should be a research agenda which guides this work, in addition to the testing of methods.

Nevertheless, on-farm testing is only the first phase in a dissemination strategy. Scaling up results from the on-farm testing is in many respects the research frontier of on-farm, participatory work. The dissemination approach that seems most appropriate for knowledge and management intensive techniques, particularly those that involve system changes, is farmer field schools. However, these are relatively resource intensive, although networks of FFS's are expanding rapidly in tropical Asia and sub-Saharan Africa. Combining these more intensive approaches with innovative communication and awareness raising through radio and other forms of mass communication—see the chapter on communications-- would potentially offer the best means for widespread dissemination. However, as with technological packages, the efficacy of the individual components need to be first understood. There is little systematic evaluation of alternative dissemination strategies, running from mass media through information supplied by input suppliers to farmer field schools. It is not evident that the Center is yet at the stage of taking on this research agenda. It needs clearer target sub-regions and populations, more systematic on-farm testing, and institutional partners who can manage a range of dissemination techniques. However, as The World Vegetable Center moves to expanding its dissemination strategies and activities, it should consider evaluation of the efficacy of these different components, which in turn would require overlaying a research design on selected dissemination projects.

Chapter 2.III.4

Research Theme 4: Post-Harvest Research

The post-harvest research theme is very much in an establishment phase, as this is a relatively new fields at The World Vegetable Center. It builds on market characterization and supply chain analysis that has been done by economists over recent years and incorporates relatively new work on post-harvest processing and packaging. The mission focuses on relieving constraints but the target is probably best defined by improving market efficiency within the value chain and ensuring access of smallholders, particularly those below the poverty line, to high value markets. This work will be of particular relevance in sub-Saharan Africa and in lagging areas of Asia, where domestic horticultural markets are in general not well developed and where there is particular potential to have beneficial impacts on the poor. As this is a relatively new area of work, the evaluation will focus on potential lines of development of the program.

Market Characterization and Analysis

Horticulture, unlike staple grains, faces a very elastic demand, with high rates of growth in production and consumption. The problem lies not in demand-side constraint but rather in ensuring consistent supplies of high quality produce at reasonable prices. As well understood by the post-harvest team, ensuring growth in supplies is due both to farmer investment in horticultural production, which is relatively large by comparison to other crops, and to improvements in the marketing chain that ensure quality, reduce losses, add value and improve market efficiency and thus reduce prices to the consumer—or increase prices to the farmer. It is not clear whether potential gains are higher from reducing marketing margins or from reducing production costs with new technology (including understanding when to produce), as little information is available on actual costs and gross margins at different stages in the value chain. Nevertheless, it is assumed that the potential gains are significant.

Market characterization studies in practice should provide the information base for design and testing of market interventions, whether in the area of post-harvest technologies or organizational innovations, such as when to undertake production and farmer collection points. In an appropriate phasing this area should be Output 1 in the log frame. As such, these are principally diagnostic studies, at the same time as adding to the broader understanding of the structure of horticultural markets. Rather, the studies to date are more stand-alone studies, focused on measuring such constraints as post-harvest losses. While this is useful, as statistics often are cited that losses are highly inflated, there is still little in the conclusions to suggest the critical interventions in the value chain that will lead to improved efficiency and some establishment of priorities. The Panel considers there is need to improve the

methods utilized in supply chain analysis. These methods in the literature are inherently highly descriptive, the focus is on market structure, and they have little analytical content. There is scope—for example, work at ILRI—to improve the analytical tools within value chain analysis. This is an area where The World Vegetable Center could make a significant contribution, drawing on the range of studies that have already been undertaken.

Moreover, besides improved analytical content, these studies could also be more hypothesis-driven. Thus, if the hypothesis is that post-harvest losses are principally due to high temperature conditions from harvest through to the retailer, then it is possible to construct a comparative study evaluating a range of value chains in which there were different forms of temperature management at critical points. The focus would also be on evaluating relative costs, potentially under different output price regimes. The object here is to understand what technologies are appropriate under various cost-price conditions. It is expected that there will be a step process in the deployment of improved post-harvest technologies—for example, from sacks to stackable crates in transporting vegetables—and this more dynamic process needs to be better understood.

Finally, supply chain characterization can be a costly exercise. As a diagnostic tool, more rapid appraisal techniques can also be developed, so that there is a range of diagnostic methods where survey costs can be traded off against analytical rigor, depending on the needs within the project. Horticultural value chains offer a wide range of variation in scale, number of transactions from farmer to consumer, in coordination, and in investment in post-harvest techniques including value addition. This characterization work could move from country studies to more comparative studies across countries and between export and domestic end markets. The need is to identify what works where and under what conditions.

The need for more standardized and rigorous methods was evident in the case of the survey of marketing chains of indigenous vegetables in sub-Saharan Africa. Large, multi-country surveys of this type involving over 2,000 interviews require attention to sampling design, questionnaire design, and analytical framework. This study could have benefited from tighter quality control in all three areas. It is particularly important in baseline surveys of this type that they yield valid results that can best help direct the research program.

Recommendation 2.III.4.1 : The Theme 4 team should critically review the methods employed in supply chain studies and develop a more standardized code of practice that maximizes the identification of key entry points to improve market efficiency.

Research on Post-Harvest Technologies

Research on post-harvest technologies is a potentially large area of work, given the range of crop species and the range of market intervention points that could be covered. This argues for a sound diagnostic capacity to guide the research in any particular country or market context. Criteria that would guide this process would include which market (particularly whether fresh or processed), what scale of operation, what investment costs and who bears the cost, and net benefit from the technical change. It would be expected that fresh markets would dominate in most cases, particularly as this also maximizes the nutritional benefit. In such cases maintaining quality and reducing losses are the principal objectives. This involves pre-harvest management, sorting, packaging, temperature control and efficient marketing arrangements.

There are two dominant factors governing investment in improved post-harvest management and handling of fresh vegetables. The first is significant price differentials for quality and the second is coordination within the marketing chain. The latter is reflected in supply chains organized for export or to serve supermarkets. Here there is usually scheduling, contracting, provision of collection and sorting points and other mechanisms to control quality at harvest and reduce time to the shelf. However, most fresh markets are served by the more traditional supply chain of assembly agent selling to wet or wholesale market and then on to either retailing outlet or the consumer. There is little coordination in the latter supply chain, quality is uncertain at each transaction point, and there is little incentive to invest in more appropriate handling and packaging. There is a major question of whether there are organizational innovations that would lead to improved efficiency and effectiveness in this type of supply chain.

The World Vegetable Center in many respects does not have the competitive advantage for involvement in processing research. There is significant capacity in food technology departments in universities throughout the region. Small scale processing of vegetables only has a comparative advantage in areas relatively remote from urban fresh markets. Research partnerships, either with universities or private companies, for development of micro-enterprises in lagging areas where fresh markets are constrained may have a role in regional center development plans. The current project in Southeast and East Asia is attempting to build such a network, but it is principally concerned with research trials without the important component of application in representative contexts. Such work should be relatively well targeted and be combined with complementary work on production systems and development of end markets. Markets for processed vegetables tend to be niche markets and a market diagnostic study should be done first before launching into work of this kind.

Recommendation 2.III.4.2 : The World Vegetable Center should prioritize its work on post-harvest management of fresh vegetables and link it closely with market characterization studies and market organizational innovations. The research work on processing and micro-enterprises requires further justification and targeting.

***Market Organizational Innovations for Improved Coordination*:**
This particular area of work is increasing in importance in market research done by many IARC's, particularly in sub-Saharan Africa. It involves such innovations as improvements in product assembly through collection points, contracting potentially combined with micro-credit, testing price differentials for quality, collective action involving cold or cool storage of varying capital investment, and a range of credit innovations such as factoring. This type of research moves more into the area of operations research, where interventions are tested through implementation of the innovation. A good example is the work in East Africa testing the development of a supply chain for indigenous vegetables marketed through supermarkets in principal urban centers. This type of research is both relatively cutting-edge but at the same time is done within a market development project mode.

The Panel encourages continued work in this particular area of market innovation and focused on sub-Saharan Africa, but with some potential in the poorer areas of South Asia that are not currently well-integrated into fresh vegetable markets.

***Quality Assurance and Certification*:**
Pesticide residues on horticultural products are a major concern for consumers worldwide. Much of the focus on alleviating this major health concern has been to develop safe practices at the production level through GAP recommendations. However, there is usually limited incentive for farmers to adopt these practices and in fact, significant counter-incentives to maintain pesticide spraying until harvest. In fact many small-scale farmers considered some of the quality requirements at the market place as a means to lock them out of the market. Export horticulture to the EU has resolved this issue through deliberate efforts to achieve compliance with diagnostics and traceability requirements. It is therefore a question whether there are mechanisms from the market side to ensure quality from farm-to-fork including hygiene and pesticide residues. As with export horticulture, this will have to involve a combination of heightened awareness among producers, good diagnostics, some level of certification of producers and some type of brand identification in the market place.

Theme four has not initiated much work in this area, although a project is planned in Vietnam. Quality assurance is in many respects a less rigorous form of certification and market management. Reaching clarity on what the Center might do in this

area should, like the CIMBAA project, be developed around a pilot scheme, possibly in Vietnam - although this might be assessed. It would be interesting to compare a quality assurance scheme with the organic alternative, particularly in terms of costs, effectiveness, and consumer acceptance. The World Vegetable Center needs to understand how such programs are implemented and their sustainability, but it is not an area that merits work across a range of countries.

Staffing and Deployment

The post-harvest theme is unusual in that all of the research has been and will continue to be done outside headquarters. This is both a particularly field-oriented research program as well as dependent on a significant complement of economists and social scientists. At this stage in the program's development, after a very productive initial framing, there is still a need for deepening the research strategy, sharpening the methods and maintaining quality control. At the same time, there is a need to differentiate the strategy between sub-Saharan Africa and Asia, particularly in terms of future work on market innovations, post harvest technologies and quality assurance. There is a particular need to deepen the strategy in South Asia, possibly in complement to the Sir Ratan Tata Trust project working in the poorer states. It is expected that most of the scientists in this theme will be deployed in the regional centers.

The one other issue arising in the research restructuring is the deployment of economists and social scientists across the research themes. All but one of the social scientists is in theme 4, which in the restructuring comprises largely the transition from the economics unit. There will be need to ensure balance of social science capacity across themes three, four and five. There is a large agenda for the production economist in theme 3 and if theme five develops the Community Nutrition Unit, there will be additional need for a social scientist in that unit. In this balancing, there will also be need to ensure that all of the social scientists are not deployed to the RCA, as some social science capacity is also needed in South Asia. This intersection of theme requirements, regional center requirements, and need for a critical mass of social scientists will be a fairly complex decision.

Chapter 2.III.5

Research Theme 5: Nutrition and Biostatistics

The fight against hunger and malnutrition is ranked number one within the Millennium Development Goals together with poverty alleviation. The 2006 UN report on MDG-achievements states regarding the hunger target:

> *Chronic hunger – measured by the proportion of people lacking the food needed to meet their daily needs – has declined in the developing world. But progress overall is not fast enough to reduce the number of people going hungry, which increased between 1995-1997 and 2001-2003. An estimated 824 million people in the developing world were affected by chronic hunger in 2003. The worst-affected regions – sub-Saharan Africa and Southern Asia – have made progress in recent years. But their advances have not kept pace with those of the early 1990s, and the number of people going hungry is increasing. Of particular concern is Eastern Asia: in the early 1990s, the number of hungry people declined; but again it is on the rise.* (UN, 2006)

Given this background, the fight against hunger and malnutrition needs to be taken up more vigorously in general and more specifically in research and development programs. The World Vegetable Center is the first international agricultural research center to have an explicit nutritional program recognising that the so-called 'food chain' starting at the farm does not end at the fork but continues to include human beings eating and digesting food and adsorbing and metabolizing nutrients. This also leads further than the focus on enhancing the micronutrient content of staple foods within the CGIAR Challenge Programme on Biofortification. The this Panel has been tasked to look into extending the scope of the Center's existing nutrition lab into nutrition research, addressing all ways of overcoming nutritional deficits and achieving other nutritional benefits through the consumption of vegetables.

Some challenges of improving nutrition and overcoming nutritional deficits have been addressed in the Africa section of this report. The main opportunity for The World Vegetable Center lies in helping to overcome three nutritional constraints with vegetables: first, the micronutrient deficits that can be met through consumption of vegetables containing iron and vitamin A so they can be easily digested and absorbed through meals; second, the ability of vegetables to supply a number of other vitamins, such as folic acid, within their natural environment, i.e. in adequate dose; and third, to explore those bioactive plant ingredients which exert metabolic changes, such as an increased general antioxidant activity or specific effects such as improved glucose tolerance.

The advantage of vegetables as a dietary intervention against micronutrient deficiencies (MND) is not only that more than one deficiency can be addressed with one dietary tool, but also that there is no dosage problem to be addressed. One

well established response to MND is supplementation of the respective nutrients. This approach is appropriate in overcoming an existing deficiency quickly but in terms of prevention it carries the risk of overdosing or exposing the consumer of the supplement to unexpected side effects. For example, it has recently been shown that children in Zanzibar and Southern Nepal who were on regular oral iron supplements have a higher risk of being hospitalized and eventually dying from more severe malaria and infectious diseases than children without that supplement. (Sazawal et al. Lancet, 2006; 367:133-43)

These findings led to a joint WHO-UNICEF statement cautioning against regular iron supplementation in high-endemic malaria and infectious disease areas. (WHO/UNICEF, 2007) This increased disease risk adds to the expense in procuring and distributing supplements on a regular schedule to populations in remote areas.

Vegetables can provide iron without these risks. Also vegetable consumption has huge advantages compared to food fortification. Fortification, i.e. the addition of a specific nutrient to a food, requires the procurement of large amounts of the isolated nutrient and a technology to homogenously mix it with the staple or oil. As this is too expensive for small mills or factories it is often restricted to larger food processing companies. Ensuring access to fortified foods for poor populations in remote areas is a challenge -whereas vegetables are mostly available and promoting their consumption is both more feasible and cost-effective.

Bio-fortification has not proven to be superior to consumption of e.g. dark green leafy vegetables. It commonly addresses only a single nutrient, whereas most people with micronutrient deficiency have more than one nutrient in insufficient supply. The costs of motivating farmers to buy a special bio-fortified seed are high, and they cannot be certain that their investment will be profitable for them. These considerations all point to the fact that vegetables are a sustainable and appropriate approach to overcome iron and vitamin A deficiency. At the same time this approach provides even greater nutritional benefits as vegetables contain vitamins, minerals and trace elements which not commonly addressed in anti-micronutrient-deficiency programs.

One of the additional benefits from vegetable consumption is a higher intake of folic acid which has been shown to play a role in preventing intrauterine formation of neural tube defects. Folic acid may also exert preventive effects on arteriosclerosis and certain types of cancer, even if the latter effects have not been fully ascertained yet.

In general, possibly the most significant role for vegetable consumption is to achieve 'healthy ageing'. As the Harvard School of public health puts it into their website: *"Eat your fruits and vegetables" is one of the tried and true recommendations for a healthy diet. And for good reason: Eating plenty of fruits and vegetables can help you ward off heart disease and stroke, control blood pressure and cholesterol,*

prevent some types of cancer, avoid a painful intestinal ailment called diverticulitis, and guard against cataract and macular degeneration, two common causes of vision loss. (http://www.hsph.harvard.edu/nutritionsource/fruits.html, 11/2007). The 2007 report on cancer prevention through diet, physical activity and healthy lifestyle also underlines the high priority for increased consumption of vegetables and fruits. (AICR 2007).

It is a common misunderstanding that the chronic diseases associated with low vegetable and fruit intake mostly affect people in the industrialized countries. This is to be corrected by WHO, as follows: "*The World Health Report 2002 already attributed at least 2.7 million deaths globally each year to low fruit and vegetable intake. Chronic diseases now make up 60% of deaths and 49% of the global disease burden. Already,* ***79% of these diseases are occurring in developing countries****. In addition, globally there are more than one billion adults overweight - at least 300 million of them obese. There are an estimated 171 million people with diabetes worldwide, a figure likely to double by 2030. In developing countries the number of people with diabetes is expected to increase by 150% in the next 25 years. High intake of fruit and vegetables as part of a healthy diet can make an important contribution to preventing chronic non-communicable diseases and their risk factors." (WHO 2004)*

The World Vegetable Center in the recent restructuring of its research programs made a conscious decision to extend its research and outreach work in horticulture into maximizing the nutritional benefit of increased consumption of fruit and vegetables in the developing world. Besides original vegetable research done at the Center, some nutrition issues can be addressed in cooperation with existing research groups in universities and research institutions. In terms of overall policy, one partner could be the International Food Policy and Research Institute (IFPRI) which stated in 2004: 'Nutritionists working in developing countries once thought that if people obtained enough energy in their diets, they would obtain enough minerals, vitamins, and other micronutrients. But that is clearly not the case. Malnutrition is not simply caused by a lack of food overall, but by a lack of high-quality foods such as whole grains, fiber, fruits, and vegetables."

Up to now, the nutrition lab in The World Vegetable Center has had the principal task of assisting the scientists in themes II (breeding) and I (collection and conservation of germplasm) by characterizing the micronutrient and carotenoid content of vegetables with the aim of breeding or selecting for high nutrient content. This took place from 1972-1989 under the term 'Chemistry', 1989-1996 'Analytical Laboratory', 1996-2002 'Nutrition and Analytical Lab' and since 2003 'Nutrition unit'. The target-oriented planning of theme V reflects the present scope of its mandate and its capacity within the Center.

The theme leader presented the issues to be addressed under the theme V at the IMPR 2007. The range of nutrition issues to be studied is as wide as nutrition security:

- horticultural factors,
- socioeconomic and educational factors, and
- nutritional and health factors.

It also comprises issues such as access to nutrient-rich foods, nutritional awareness, women's role in food decisions, food habits, quality of food/food safety, children, household economics, agricultural diversity, environmental aspects etc.

A full nutritional assessment needs to address the food, dietary and nutritional status of the individual as well as food habits, dietary recommendations, nutrition promotion, and dietary counseling. The nutritional status of the individual and of populations is an outcome variable of nutrition and health.

Assessing the potential of nutrition and health benefit from vegetables also includes nutrition at different life stages in general populations by location, during pregnancy and lactation, infant feeding, diet in childhood and adolescence, ageing and sports. Nutritional status also has a chemical and physical dimension beyond signs and symptoms, i.e. it directly affects the functional status of the organism, the bioavailability of nutrients and their metabolism,and indirectly the interaction between disease-guided clinical nutrition and nutrigenomics, the latter addressing the individual's capacity to digest food and to metabolise its components. All these aspects are highly relevant to vegetable consumption.

The theme V-team set as its goal improving the nutrition and health of rural and urban poor consumers through increased consumption of vegetables. The objective is to increase public awareness, accessibility and the utilization of nutritious, diverse and safe vegetables.

There are four outputs by which to assess the theme's achievements:

- Dietary diversity has been proposed as a candidate indicator for food security and a predictor of nutritional status. Information on consumption patterns and consumer behavior helps in identifying populations at risk and in prioritizing the Center's research efforts.
- Dietary modification is an economically feasible and culturally acceptable way to improve nutrient intake. This can be done through encouraging higher consumption of diverse and nutritious vegetables and improving nutrient retention and bioavailability in the traditional diets of populations at risk.
- The identification of bioactive compounds adds value to indigenous vegetables which economically justifies their promotion for increased consumption or for alternative uses in healthcare.
- Home gardens can provide households with direct, year-round and inexpensive access to nutritious vegetables. Among food-based interventions, home-garden programs have a high success rate in improving household nutrition.

- Distribution of indigenous vegetable seed kits, nutritional education and community-based activities with farmers' groups, women's groups, and school children are all mechanisms for encouraging and promoting the use of home gardens.

In the view of the present theme V coordinator future nutrition research and outreach could be established with the following additional objectives:

- Systematic evaluation of indigenous vegetables for their nutrient content and its bioavailability, as well as for bioactive substances and their activity;
- Systematic assessment of vegetable-based meals and diets on the bioavailability of nutrients and the non-nutritional bioactivity of plant ingredients;
- Assessing changes in the nutrient composition of vegetables during transport, storage, marketing and food processing as well as preparation; and
- Assessing 'nutriceutical' effects of bioactive plant ingredients, e.g. bitter gourd´s function in restoring impaired glucose tolerance, and others impacting on the prevention and management of dyslipidemia, arteriosclerosis, ischaemic heart disease, stroke, osteoporosis and some types of cancer.

Collaboration of theme V with themes I and II is a vital part of the Center's research strategy. This includes including adequate budgeting for lab services and their improvement, i.e. making it scientifically sound in a way that it leads to valid results acceptable for publication in high-impact journals of nutritional science (e.g. Nutr, J Nutr, Am J Clin Nutr, Eur J Clin Nutr). There are a number of ways to develop high-quality nutrition research in The World Vegetable Center, in its Regional Centers and in cooperation with national and international research institutions as well as with academia. The term nutrition research unit is used to describe the physical structures while the objectives, activities and milestones for the overall research program are defined under theme V.

Recommendations 2.III.5.1-4:

- **Improve the existing food science laboratory through upgrading of its equipment from Near-Red-Infrared-Spectroscopy (NIRS) to Gas-Chromatography-Mass-Spectrometry(GC-MS) and Atomic Absorption Spectroscopy(AAS) in order to achieve scientifically sound data on food composition.**
- **Create a Community Nutrition Unit under theme V but in affiliation with the socio-economic group in order to build capacity for nutritional assessment (food frequency questionnaires, recall- and protocol-techniques, anthropometry) in research and development projects. This unit should also be staffed to facilitate organoleptic research on vegetables.**

- **Create a nutrition research laboratory with facilities for cell culture, animal and human studies on bioavailability of nutrients and bioactivity of functional plant ingredients as well as fibre. Design this laboratory also as a linkage point for partners in health research who can carry out joint studies into health effects and safety of vegetable, vegetable-based meals and diets, as well as on nutriceutical effects of vegetables and vegetable extracts.**
- **Encourage all staff of the Nutrition Research Unit to cooperate in outreach activities on improving human nutrition that would be implemented by the Community Nutrition Unit in collaboration with the Communication Unit and the regional centers.**

Biostatistics Unit

In its quest to enhance scientific impact in all fields of breeding, germplasm selection, farming, pre- and post-harvest technologies, socioeconomic research, and food, nutrition and health aspects of vegetables, the World Vegetable Center needs a strong Biostatistics Unit.

This unit will not only qualify the staff and the research proposals, but it also makes the Center and its regional branches more capable scientifically of responding to requests from outside and to raise its profile.

A research institution such as The World Vegetable Center requires a Biostatistics Unit which goes well beyond buying in biostatistical expertise for individual projects.

The scope of tasks for a BU encompasses:

- Planning all types of research activities in order to secure the statistical significance of observations, representative results, sufficient power, i.e. validity of results, by calculating the necessary number of experiments to be performed with the same or varying material, e.g. seeds, plants, pests, chemicals, animals, machinery, markets, and others;
- Planning of mathematical modelling approaches to research questions;
- Statistical evaluation of observations from various types of experiments and studies;
- Organisation of databases for collections, e.g. seed banks; Developing and maintaining adequate computer capacity in response to the needs of the Center´s scientists;
- Ensuring data security and safety protection;
- Regular upgrading of statistical software; and
- Training junior scientists in statistical methods, including providing refresher courses.

In the era of internet expensive and sophisticated computing facilities do not necessarily have be established in all regional locations. An internal digital network may be appropriate for linking all scientists with adequate data storage and computing facilities.

Recommendation 2.III.5.5:

The World Vegetable Center should employ a short term specialist consultant to advise it on the best way to set up a Biostatistics Unit serving the needs of scientists in headquarters as well as in Regional Centers and offices.

Chapter 2.IV

KNOWLEDGE MANAGEMENT AND OUTREACH

The World Vegetable Center's mission is to alleviate poverty by increasing the production and consumption of vegetables. To achieve this in the time necessary to reduce the human toll from hunger and malnutrition indicates a much greater emphasis on mass methods of communication is needed in order to drive the Center's scientific outcomes farther and faster. Excellent science has to be coupled with effective management of the Center's knowledge base and stronger, wider outreach in order to deliver the mission.

The quality and output of staff in the communications area is high, and they manage to achieve a great deal on comparatively slender resources. However there is a clear opportunity to rethink the World Vegetable Center's outreach program and activity in order to:

- Reach poor farmers directly and quickly
- Improve the quality and quantity of scientific publications
- Inform and influence consumers in poor countries about more nutritious foods
- Raise global awareness of the Center's scientific achievements
- Raise the Center's profile with donors, existing and potential
- Increase the influence of Center scientific staff and leadership in the global food and poverty debate as a source of expert policy advice
- Couple it more closely with the development goal, as outlined in the Panel's findings.

The above is neither difficult nor very costly, and can largely be achieved through a realignment of present priorities and resources and through a higher focus on mass communication techniques.

Furthermore, the EPMR received comments from Center scientists, trainers, external partners (NARES, seed firms, NGOs and farmer bodies) and especially horticultural farmers themselves (at a field day at RCA Arusha) that an increased effort to reach farmers and consumers in large numbers is:

(a) of practical value and
(b) highly desirable (ie by creating consumer demand for new crops)
(c) complementary and helpful to outreach via partners (eg. would assist sales by seed companies and technology transfer by NARES or farmer groups).

Recommendation 2.IV.1. It is recommended that, in growing its communication activity, The World Vegetable Center focus an increasing proportion of effort and resources on reaching very large numbers of poor farmers and consumers as well as core audiences, via mass media.

Recommendation 2.IV.2. It is recommended that reaching poor farmers and consumers via mass media be made an explicit goal of the outreach plan, in line with the World Vegetable Center's mission. This priority should be reflected in the Center's strategic and medium-term plans, to align them more closely to the mission.

Reaching millions of small producers or consumers seems hitherto to have been regarded as a task too large, complex and costly for a research Center with limited resources to undertake. This is less true today in view of:

- Proliferation and penetration of mass media, especially electronic and digital, throughout the developing world but also newspapers, radio and TV
- Rising literacy among the poor even in the least developed countries
- Rapid growth in the World Vegetable Center itself and its desire to enhance the impact of its work
- The existence and generation by the Center of a substantial and growing stockpile of valuable material communicable to farmers or consumers
- The global spread of regional centers, nodes and partners, offering scope to overcome linguistic, cultural, delivery, resourcing and other barriers.
- The emphasis on neglected indigenous vegetables, where awareness raising is a primary task necessary to generate market demand for seed.

The objective is to enlarge the number of recipients of new horticultural information (and seeds) by using as many delivery channels as possible, within the limitations imposed by local conditions. A range of these delivery methods are discussed in the Appendix on Outreach Methods.

Managing the Center's Knowledge Flow

The Panel sees a need for greater clarity in how the World Vegetable Center manages its knowledge system for optimum results both in terms of scientific output and knowledge delivery to clients. At present these functions are bundled together in a way that makes for confused priorities and suboptimal delivery on all fronts.

We propose the following simple model:

Knowledge generation (research and scientific publication)-> knowledge collection, storage and categorisation for easy retrieval (internet, library, reference publications-> knowledge delivery (training, outreach, mass media, education, resource mobilisation).

This model implies:

- developing a dedicated scientific editing capability located close to the scientists and meeting their needs more fully – the "knowledge fount"

- fast-track re-development of the website as the central "knowledge well" for all World Vegetable Center outputs, scientific, general and industry or farmer-oriented, from which anyone may 'drink'

- refocusing communication activity away from paper publications and general PR towards mass methods of science communication, principally using electronic media and the internet – the "knowledge river".

The Knowledge Fount

Quality scientific publication is very important to the World Vegetable Center, its professional standing and ability to attract both talent and funding. However there appears to be a tension between scientific and other sorts of communication, especially in reaching poor farmers so as to fulfil the Mission, leading to conflicting priorities. This is neither desirable nor necessary.

A solution is to create a dedicated scientific editing unit within the research enterprise with the task not only of providing editing and publication services, but also of working closely with scientists to accelerate the rate and enhance the quality of publications and of identifying fresh opportunities and outlets to publish in. This unit would also liaise with the Outreach group to ensure the widest possible dissemination of fresh research results to farmers, media, NARES and other partners.

Every research project/proposal should have a dedicated (ie. unraidable) budget line for publication, scientific and lay, as well as the Center providing some core funding to ensure the necessary skills to prepare them.

Recommendation 2.IV.3. It is recommended that scientific editing be viewed as technical support for the scientific enterprise and housed, physically and in budget terms, within the World Vegetable Center research function. It should have its own dedicated staff. All research projects should have a budget allocation for publication of results.

The Knowledge Well

There is a clear need to fast-track redevelopment of the website as the central knowledge resource and repository of the World Vegetable Center, containing both scientific and general information for delivery to various target audiences.

This implies things such as content management (aiding researchers to upload their own data) a growing online library capability with fast links to horticultural science resources worldwide, and an expanded pool of information suitable for general audiences, including farmers, consumers, policymakers, donors, seed companies, mass media, NARES and NGOs.

The World Vegetable Center's web demand has grown 100-fold in recent times and growth will far exceed this in future as the developing world goes online. The current website, though attractive and relatively easy to use, will be swamped by the output of programs such as vBSS and ProNIVA and external demand for information about new and healthy vegetables and how to produce them. The need to grow this vital interface between the Center and the world, scientific and lay, is recognised by management but does not feature as a high priority in the current medium term plan.

The website is currently treated as a 'support service' rather than a spearhead in the World Vegetable Center's mission of delivering knowledge to increase vegetable production and consumption and alleviate poverty. It should be the central source of:

a. All World Vegetable Center scientific material and publications
b. All technical and outreach material for donors, partners, farmers and consumers
c. Media material including downloadable radio, video, images, graphics and print material
d. General publications for print-on-demand
e. A portal to the leading horticultural science and nutrition sites worldwide
f. Future Virtual horticulture outreach services (see Appendix).

It is essential for the World Vegetable Center not to fall behind global ICT technological trends and publishing standards on the internet. A defined budget is needed for web development.

The Center still produces far too many glossy publications, including the annual report, without closely assessing reader demand or need. Most documents can now be produced instead in e-format for print-on-demand only. Many can be a lot shorter. This would help clear the publications bottleneck, provide editorial flexibility, save money and demonstrate greater environmental awareness. There is an ongoing need to re-assess and further rationalise World Vegetable Center

publications output for audience need, moving as many as possible to e-format. All new publications should be required to demonstrate a *need* for paper format and proof of market demand (as distinct from institutional or personal demand). Funds saved in printing should be rechannelled to web development.

Recommendation 2.IV.4. It is recommended that the World Vegetable Center rapidly grow its website as a resource containing the total knowledge output of the institution, both scientific and plain-language, for researchers, farmers, consumers, policymakers and mass dissemination.

The Knowledge River

To achieve its mission objective of saving and improving millions of lives through safe, healthy vegetables, the World Vegetable Center needs to reach as many people as possible in the shortest time possible. It needs to turn the 'water' from its scientific well into a well-directed flood.

This can be achieved using inexpensive mass means of communication, and the EPMR urges a much greater focus in this area.

To deliver material to mass media (as well as partners and donors) low-cost electronic means such as email, RSS feed, web download, CD etc should be used. The expertise to do this can either be in-house or outsourced to one of several expert NGOs or private companies.

The Center should assemble or acquire a global database of key media most likely to reach poor farmers and consumers in key target regions, and influential media in key donor regions. This can be used selectively for regular e-dissemination of news and outreach material at low cost.

Recommendation 2.IV.5. It is recommended the World Vegetable Center give much greater emphasis to mass means of communication to reinforce messages to donors, stakeholders and partners, and to raise awareness of new varieties and technologies among farmers and consumers in poor regions.

In Africa in particular, where traditional extension channels are weak or fragmented, a range of low cost mass communication methods are desirable, such as those outlined in the Appendix on Outreach Methods, in particular a newspaper and radio. Africa and the other Regional Centers also need dedicated communication staff and expertise in order to maximise and accelerate delivery of World Vegetable Center science.

Recommendation 2.IV.6. It is recommended that energetic and qualified outreach professionals be progressively stationed in all Regional Centers, starting with Africa, with clean lines of reporting.

Other Outreach issues and opportunities

Policy impact

In order to carry greater weight in global discussion on ways to address poverty, hunger, malnutrition and food supplies under climate change, the World Vegetable Center needs to raise its international profile – and that of its leading scientists. This is as important, or more, to the Mission as it is to institutional standing.

The Center should aim to be *the* source of authoritative scientific advice, opinion and advocacy from a global perspective on vegetables, one of humanity's key food sources.

The Center can achieve this by pro-actively entering the leading international mass media in the form of news reports, expert opinion articles and contributions to current international debate on relevant issues such as poverty, hunger, nutrition, food supplies under climate change, horticulture and biosafety issues. There should be an explicit strategy of contact with the food and science writers in the most influential media in donor countries. This task should not be left to the Director General alone, so media skills training may be needed for senior scientists.

Reaching consumers

In view of the priority attached to reducing malnutrition in the Millennium Development Goals and in view of the Center's Mission to increase vegetable consumption, consumers need to be recognised as a key target audience, and catered for accordingly.

This has also been requested by poor farmers, who wish to be assured there is consumer awareness and market demand for any new crops or varieties they may produce. This uncertainty currently represents a serious obstacle to uptake.

This issue can be easily and economically addressed via mass media, in particular by including food, nutrition, health, women's' and cooking reporters and broadcasters, in the World Vegetable Center's short-course training program and supplying them regularly with information on diet and nutrition, new vegetables, cooking methods etc thereafter. Between them these journalists reach millions of consumers, making this form of outreach highly cost-effective.

Consumer outreach can also become a source of substantial revenue to the Center through the sale of commercial rights to leading global publishers and celebrity chefs to produce cookbooks and diet books on unusual and rare vegetables. In a world hungry for culinary novelty and searching to age in a healthier way, the World Vegetable Center's NIV work is the "mother lode" – a thousand new vegetables, flavours and nutritional opportunities most people have never even heard of.

It is the talking point which could make the World Vegetable Center a household name.

A plain language database on novel or unfamiliar vegetables should be assembled on the World Vegetable Center website, with information on the crop, how to grow it safely and easily, its nutritional features and handling, cooking or preservation advice. This basic information can then be reworked into:

- Cookbooks and nutritional guides for consumers
- Guides for poor farmers on new opportunities
- A world guide for nutritionists, supermarket buyers, cooks etc
- Continent, region or culture-specific guides in many languages
- Farmer, seed company, marketplace, NGO or NARES handouts.

Brand identity

The World Vegetable Center needs to accelerate the transition to its new brand identity (including adopting the acronym WVC) in order to exert greater influence on global food policies and the debate around them, and to mobilise more resources.

Listening capability

The World Vegetable Center takes a commendable research interest in the views of farmers and consumers about their needs and preferences. However there is opportunity to better co-ordinate and sharpen the Center's external listening capability in order to more closely couple its science to the needs of poor people, and so accelerate uptake.

Possibilities include:

- Farmer advisory groups, to enhance feedback and generate wide 'ownership' of The World Vegetable Center work
- Regional consumer panels to test unfamiliar vegetables, nutritional advice, new recipes and provide reactions to biotech innovations
- Vegieblog – a live chatroom on the Center website encouraging consumers, scientists, policymakers, farmers, staff and others to discuss global vegetable issues and comment on the Center's work.
- Web-based survey systems in real time for farmers and consumers, to track changes in demand and preference
- A central unit which consolidates all the various market and farmer research and feedback, and distils it into informative advice for scientific leaders planning requirements, staff and partners of The World Vegetable Center in order to enhance relevance and chances of success.

- A regular global scan of key diet and nutrition issues to ensure The World Vegetable Center is abreast of the largest and most urgent issues.
- A formal system for obtaining feedback from NARES, seed firms, NGOs and other partner organisations, to ensure customer relevance and communicate their views & needs across The World Vegetable Center.

An individual in head office should be assigned responsibility for collecting and co-ordinating various external inputs, global scans, advice from farmers and partners etc. into a simple clear form for- management and research leaders to use in their planning.

The Bill & Melinda Gates Foundation Program

At the end of the day, the success of the Bill & Melinda Gates Foundation project (vBSS) will be judged by how many lives it saved or improved, not by how many seeds it delivered. As the scientific spearhead for the World Vegetable Center in the years ahead, vBSS needs to have a well-planned approach to how it is going to deliver its outcomes to poor farmers and consumers. This does not receive sufficient emphasis in the current project. In the current phase this is necessary to:

- Prepare the ground for delivery of advanced new crops and varieties arising from vBSS by planning future outreach
- Make a strong and globally visible case for renewal of funding.

It will also be necessary to build adequate outreach funding into Phase 2 of the vBSS project.

Virtual farming

An outstanding opportunity exists for the World Vegetable Center to be a global leader in science delivery using 'virtual farming'.

It is suggested that the Center explore with the Bill & Melinda Gates Foundation in particular the scope to set up the world's first virtual farm in which participating farmers and extension workers can test new ideas, varieties and technology online in real time, and pioneer this as a new approach to technology awareness, delivery and training worldwide.

For details of this suggestion, see Appendix on Outreach Methods, p 7.

Chapter 2.V

DEVELOPMENT AND IMPACT

The World Vegetable Center is the only international agricultural research center that has development explicitly incorporated in its mission as well as in its original name - AVR**D**C.

This allows the Center to escape the inherent contradiction facing CGIAR centers, where their mission and accountability is framed within development objectives and yet they are limited to focusing on "research *for* development". This provides The World Vegetable Center with a clear opportunity to combine research with development in the pursuit of its mission to alleviate poverty and malnutrition through increased production and consumption of vegetables.

However, the Center has not previously set out clearly how this will be accomplished, particularly since the growth in horticulture has been private-sector driven and has focused principally on better-endowed regions and farmers. Many recent publications on development, notably the World Development Report for 2008, highlight the rural poverty reduction potential of what is termed the 'value revolution'. However, there has been little strategic thinking about how to link poor rural households to expanding urban consumption of vegetables, especially when retail systems are becoming increasingly dominated by supermarkets and where there are recognized constraints on smallholders accessing this marketing system. Equally, there is a need for greater strategic emphasis on widening the delivery of technology to meet the needs of the poor producers and consumers who are unable to participate to any great degree in the value chain.

The panel feels that The World Vegetable Center has the opportunity to play a leading role in developing a strategic approach to the question of how to link poor households to expanding, high value markets, and particularly those concentrated in areas of high density of poor households. The panel feels that this particular objective will help to focus what is currently a relatively diffuse approach to the development component of their mandate, especially in a context where management feels that the research-development balance is at the moment too far on the development side. What this balance should be, how development should be implemented within the Center, and the role of the expanding network of regional centers in this process are all implicitly defined, with the result that staff have a variety of understandings on what constitutes development within the institute. The Panel feels that the time is now right to address the development part of the Center's mandate more strategically and provide not only greater clarity to donors and to staff but also global leadership in an area of development critical to the alleviation of poverty.

Components of a Development Strategy

Although there is a gray area in defining what constitutes research and what constitutes development, the Panel's impression is that most of what the Center considers to come under the development rubric is what is termed adaptive research, home gardens, adoption and impact studies, and training. These areas are certainly part of a development agenda, but they are currently insufficient to set in motion with necessary national partners the objective of alleviating poverty through vegetable production and marketing.

The Panel considers that three principal capacities need to be fostered to contribute to an overall development strategy within the Center. In short, these are (i) research into development as it applies to the horticultural sector, (ii) awareness creation and dissemination of new technologies, and (iii) catalyzing impact pathways.

These capacities can be nurtured and grown at the same time, eventually complementing each other in fostering poverty alleviation through horticulture in the regions in which the Center works.

Research into development refers to the operational research to understanding how to overcome the constraints faced by poor households in adopting vegetable system technology. The World Vegetable Center has two development objectives, reducing poverty and malnutrition, which can be pursed either separately or jointly, depending on the population being targeted. Where the focus is on improved nutrition of vulnerable populations that do not have access to vegetable markets, then the focus is purely on the consumption and nutrition objective, highlighted in the discussion of the nutrition theme. However, often the focus is more on increased incomes of poor households by providing the systems that allow them to diversify into vegetable production, improved access of poor households to vegetable markets, and adoption of improved production technology. With the creation of the five research themes the Center is positioned to work on most of the necessary factors likely to govern improvement of the livelihoods of the poor through vegetable production and marketing. However, each theme at the moment works across a continuum of research-to-development activities, virtually all in different areas and with different systems. Bringing poor households into commercial vegetable production requires understanding how improved varieties, production systems, post-harvest and market access, and nutrition are integrated within regions with high poverty rates. The research on development agenda therefore encompasses first targeting poor areas and poor households, such as with the Sir Ratan Tata Trust project in India, then evaluating how to link these households to markets, adaptive production system research, evaluation of alternative extension and upscaling methods - including mass communication - and impact assessment.

Opportunities to enhance outreach and dissemination are discussed in the communications and outreach chapter and Appendix. At present, many of these

tasks are viewed as 'support services' of secondary importance to the scientific mission. Yet they represent the means by which the science is delivered to users, impact achieved and the mission fulfilled. They are the elements which give full value to the science and justify it. This needs to be fully acknowledged in the World Vegetable Center's structure and resource allocation.

At present the Center relies chiefly on NARES, NGOs, and seed companies to deliver its science to poor farmers. This approach has proved sound and should continue. However limitations include:

- The varying capacities of NARES in different countries to deliver new science to very large numbers of poor farmers in a short space of time
- The fact that seed companies have strong commercial orientation and while they can be relied on to sell seeds, they often will not disseminate other kinds of sustainable farming technology (eg IPM, organic systems, clean food, nutritional advice and postharvest systems). In addition seed companies will tend to deal with seeds for which there is a cash market and may have little or no interest in many of the yet-to-be-commercialised vegetable seeds, especially NIVs which have nutritional but little commercial value.
- Their market focus is on the small number of farmers who are successfully entering higher-value commercial production and may be expected to buy bulk seeds and not on the very poor and on the home gardens which provide much of their nutrition
- The likelihood that small local seed companies may be swallowed up or outcompeted by large national and multinational operations which have a high focus on mainstream and exotic crops, rather than on nutrition for the poor, and which promote hybrid varieties at the expense of local open-pollinated crops, landraces and indigenous vegetables.

For these reasons, as well as to reinforce the work of seed companies, NARES and NGO partners, we feel it is essential that the World Vegetable Center develop effective means of reaching large numbers of poor farmers and consumers, exploiting the full spread of modern low-cost mass communication technologies (see Appendix on Outreach).

The final area is developing impact pathways that combine what has been learned from the research into development with the outreach and dissemination programs. While The World Vegetable Center is not responsible for development *per se*, as that is vested with national institutions and policies, there is much it can do to make sure that it happens - such as building capacity and providing accurate and timely scientific information and advice.

To achieve its mission the Center must understand the pathways by which impacts on poverty are achieved. For example, does linking poor smallholders to markets require farmer groups and collective action, and in order to enter commercial vegetable production is farmer training or micro-credit necessary? If these are necessary, then which institutions can provide these services and what are their capacities? In turn can appropriate training and piloting build these necessary capacities? Defining such impact pathways makes most sense if it is explored in target sub-regions within the Regional Center mandate areas where poverty strategies are tested.

Finally, there is the issue of whether donors would fund such an agenda. In this regard, The World Vegetable Center has the potential to source funds from both research pockets and development pockets in donor agencies. For development projects these will be either region or country focused and will tend to integrate across different research themes. With a more coherent development strategy, there would be scope for testing the Center's approach to poverty alleviation through harnessing the value revolution.

Management Options

At the moment there is no organizational locus for creating and managing a development strategy within the Center. The panel feels that the lack of such a locus is reflected in the diffuse approach to development within the Center, thereby missing what could be one of The World Vegetable Center's greatest opportunities for delivering its science.

After considerable internal discussion the Panel feels that it is not in a position to recommend a particular approach to managing and coordinating a development program. However it wishes to put forward options for consideration, which are not necessarily mutually exclusive. The panel considers that there are at least five possible ways The World Vegetable Center can incorporate development more strongly into its strategy and program structure.

1. The first is to incorporate the development end of the continuum into each of the program themes. To a significant extent this is how the Center currently approaches the problem. This allows a more explicit overlay of research questions and hypotheses on what are principally development activities - for example, selecting the most effective approach to scaling up home gardens as a means of improving nutrition in targeted rural areas. However it militates against a more strategic and system-wide approach to the development issue or one that addresses specific regional needs systematically.

2. The second alternative is to explicitly incorporate development and impact as a research theme, either by reorganizing the current theme structure or

through the addition of a sixth theme. The rationale in this case is that a research structure can be imposed on the whole of development work at the center. Such a theme might incorporate work on dissemination and upscaling, pilot work on alternative market arrangements, impact assessment, and a significant part of the Center's socio-economic research. This approach has the advantage that development is acknowledged explicitly as a theme of equivalent importance with other research themes, and of attracting those donors with a development/delivery focus.

3. The third alternative is to bring together various components such as training, communication, social science and market research into a Development Division, with a defined budget, a plan and a senior manager - possibly a DDG - responsible for it.

4. The fourth is to make development operational through the Regional Centers through strategies that explicitly recognize and enable the RC to target its research and development activities to the poor and the malnourished. This strategy recognizes that development approaches through horticultural development must be targeted to the particular characteristics and needs of each region and than any development approach will need to integrate seed systems, production systems, post-harvest, market development, nutrition, and outreach. Moreover, this would also allow a more focused and strategic approach to developing survey and monitoring systems for impact assessment.

5. A fifth option is a synthesis of 4 with either 2 or 3 above, by developing a stronger development focus in headquarters through a development division or theme - but at the same time devolving authority and resources to the RCs to pursue the most productive approaches in their areas.

How The World Vegetable Center moves forward in this critical area will depend on decisions on some of the other organizational issues identified in this report. However, the 'Development' in AVRDC's long-standing acronym needs to gain expression in the organization itself.

Recommendation 2.V.1: The World Vegetable Center should formulate and implement a development strategy.

Chapter 2.VI

FUTURE ORGANIZATIONAL ISSUES

The World Vegetable Center is now well positioned to highlight the critical importance of horticulture in the agricultural economies of developing countries and to serve as a focal point for the increased funding available for agricultural research, and vegetable research in particular. The Center can consolidate the gains it has already made or it can position itself for renewed growth and leadership in international horticultural research and development. Being selected to lead the development of the Challenge Program for High Value Crops reflects both the increasing importance of horticulture in the agenda for international agricultural research and also the leadership which the World Vegetable Center is now being seen to offer.

The panel accepts that the Center must push ahead with its re-visioning and restructuring, although necessarily with significantly higher risk, to be better able to meet the projected increase in demand for international horticultural research. The conclusions and recommendations that follow are framed as suggestions for planning this growth and restructuring.

Overall Organizational Structure

Fundamental to this repositioning, and the restructuring associated with it, is a basic decision on the optimal structure for The World Vegetable Center. Currently, the Center is essentially organized around a principal capacity and critical mass at headquarters, on the one hand, and a set of regional centers that effectively serve as conduits for headquarters' research. This model will face two principal limitations in the medium-term.

The first of these is that future expansion of research at headquarters is highly constrained both by cost and infrastructure. In the past, the comparative advantage of building research programs at headquarters was based on the excellent skills and capacity of its national research staff, the quality of its analytical laboratories, and the ability to build breeding programs based around access to the extensive germplasm bank. The germplasm bank remains a core resource of the Center, as are the experience and skills of its national staff. However, the costs of basic field work and the availability of farm labor are rising. At the same time, the ability to maintain salary equivalence of senior, national research staff with other researchers in Taiwan is becoming problematic, especially with the continued devaluation of the US dollar. Finally, there is a growing shortage of laboratory space, especially for molecular science. The cost issue argues there should be some decentralisation of research programs to regional centers as the Center's overall research effort continues to grow. This raises the issue of whether to build new laboratory capacity at headquarters or in regional centers, which is influenced by

the most logical choice of site as well as the expertise required and issues to be addressed as research programs expand.

The second constraint is the increasing transactions cost of managing global research projects from a central headquarters. There is also the question of the relevance in conducting a significant part of the breeding, production systems, post-harvest, and nutrition research under Taiwanese eco-climatic conditions when the anticipated needs of the poor occur for the most part in different environments. When the focus was on Asia, there was capacity to manage projects either from headquarters, or where necessary, through the creation of temporary country offices, which were relevant to local needs. However, the growth in the Africa program has brought into sharp focus the need to develop dedicated research capabilities in the African regional center in order to meet the particular requirements of vegetable producers in that region.

The panel considers that this is a natural and necessary evolution as the center continues to grow and to deepen its research in the regions. This parallels the experience of other IARCs who have found it necessary to develop local breeding capacity for African conditions. However, the whole devolution and decentralization process highlights the issues of what programs and capacities should be devolved, what capacities should be developed and where and whether research is best coordinated through the theme structure or through the regional centers. There are phasing issues involved in how these decisions are made, but clarity is necessary in planning whether a centralized or more decentralized model is required for the future evolution of The World Vegetable Center. The idea is not necessarily to reduce existing research capacity at headquarters but rather to target future growth to the development of the regional centers and to develop a more rational distribution and coordination of program capacities.

Recommendation 2.VI.1: The panel recommends that The World Vegetable Center develops within its next strategic plan a framework for devolving and decentralizing its research activities across its growing network of regional centers.

Regional Center Priorities

The World Vegetable Center is currently developing four regional spheres of operation, namely sub-Saharan Africa (with the regional center in Tanzania and a sub-regional office in Mali), South Asia, South-East and East Asia, and Central Asia, the Middle East and North Africa (with the regional office in Syria and a sub-regional office in Uzbekistan). It would be highly risky to build infrastructural capacity across all these regional centers, and at the same time lose flexibility in program location. However, because the three regional centers outside sub-Saharan Africa are located in institutions with experimental farms and laboratory capacity, the issue of

significant investment in infrastructure does not arise - although there will inevitably be issues of negotiating costs and overheads, specialized equipment needs, and the question of joint appointments and cost sharing. This moves The World Vegetable Center into a much more flexible institutional mode in developing joint research programs which will be best explored in the development and implementation of the Challenge Program on High Value Crops. Such flexibility in how The World Development Centerdevelops research capacity in its regional programs applies to all except for the particular case of the Regional Center in Africa. In this case, The World Vegetable Center has few options other than to invest in continued development of the experimental farm, the germplasm unit, and office capacity. (ILRI and ICRAF do not have the experimental farm capacity of ICRISAT and ICARDA.) However, The World Vegetable Center will have to decide whether to develop analytical laboratory capacity at its Tanzania site or else develop joint arrangements with another institution, such as the BECA facility being developed at ILRI in Nairobi.

In terms of the phasing in the development of the regional centers, The World Vegetable Center should consider regional priorities, particularly in relation to its mission. In this regard, the panel considers that sub-Saharan Africa and South Asia are the highest priority, since world poverty is concentrated in these two areas. However, these two regions require significantly different strategies.

South Asia, particularly India and Bangladesh, are undergoing significant growth in horticultural production and consumption, rapid change in marketing structures, and expansion in private sector seed capacity. The commercial areas have undergone what might be termed a first or even second generation shift in varieties. Most commercial farmers are already growing hybrids and competition among the private sector seed companies is quickly expanding hybrids beyond tomatoes and chili to indigenous vegetables such as bitter gourd and other gourds within the cucurbits. However, there remain large areas of South Asia which have large numbers of poor and where the horticultural revolution has yet to reach. A strategic approach to these areas would bring The World Vegetable Center's research and development work more closely into alignment with its mandate.

In Africa, on the other hand, apart from the few areas of export horticulture, the horticultural revolution has yet to impact on smallholder incomes and the nutrition of the poor. There are significant potential returns to breeding, as even first generation varieties have yet to penetrate vegetable production systems. Private sector seed companies rarely produce their own seed, relying principally on imports from India, Europe or the US. However, this may change relatively quickly with the opening up of regional seed markets and companies, such as East African Seed and Kenya Seed in Kenya, responding by developing some initial breeding capacity for vegetable seed. These companies are also testing the potential market for African indigenous vegetables, in many cases working withThe World Vegetable Center.

The public sector research and development capacity in horticulture, on the other hand, remains weak and fragmented between national research systems and faculties of agriculture. The potential for a private-sector-led improvement in smallholder horticulture exists in Africa, but with the large question of who will invest in mobilizing smallholder productivity and market access, and with the attendant question of the role that The World Vegetable Center might play.

Recommendation 2.VI.2: In its next strategic plan, The World Vegetable Center needs to develop a strategy to bring the horticultural value revolution to the lagging areas of South Asia and the smallholder producing areas of sub-Saharan Africa.

This recommendation will require an integrated approach across the research themes and may involve the devolution of some of the thematic research programs to the regional centers, as discussed below.

The regional programs in CWANA and Southeast and East Asia can support the further expansion in horticulture production in these regions, but with a narrower focus than in South Asia and Africa. In Southeast and East Asia the regional program would build on a very strong private sector capacity in breeding and seed systems and The World Vegetable Center breeding programs would support continued deepening of breeding and a focus on more intractable problems that are beyond the capacity of private sector investment. The private sector is only in the early stages of development in Central Asia, but better developed in West Asia. Here, as well, much of the research work would be organized around support to introduction of new germplasm and varietal evaluation, leading to deepening of private sector breeding capacity. The projected development of an international varietal testing system would help to consolidate these programs.

A complex problem in The World Vegetable Center's establishment of a global program is the relationship with China. China is the world's largest producer of horticultural crops and is quickly developing a significant research capacity in horticulture. The relationship with China would be complementary, in that each partner stands to gain from the other's significant research capacity, particularly The World Vegetable Center's germplasm collection and international network and China's breeding and biotech capability. The panel notes the importance of developing this particular partnership but also appreciates the delicate balancing that The World Vegetable Center must pursue in developing a memorandum of understanding. While this must be a future objective, pursuing it will depend either on opportunities that open in the Taiwan government's relationship with China or in a more global positioning adopted by The World Vegetable Center.

Restructuring and Possible Devolution of Research Programs

IARCs have undergone a continual process of restructuring their research programs, primarily as a result of aggregating and regrouping projects funded by donors. However, some centers have been able to avoid this by having a research strategy and associated programs that clearly articulate how the Center plans to meet its development targets - and donors have responded by funding projects within the overall research program structure. The World Vegetable Center over the last year has moved away from a structure of disciplinary, research support units that could be flexibly built around projects to an integrated program structure that more clearly articulates how research will meet more complex development objectives through strengthening horticultural value chains, often with strategic partnerships with the private sector. The panel endorses this move to develop a strategic research program structure as essential to directing the growth process and to maintain leadership in global horticultural research.

Following consultation Center management defined the five themes within which the work of the research units and the ongoing projects is reassembled and organized into research objectives and strategies. These five themes will be referred to in shorthand as germplasm, breeding, production systems, post-harvest systems, and nutrition. Research units and principal scientists were in most cases assigned to each of the themes, although principal scientists were expected to allocate time across all the themes with a minimum of 15%. Theme coordinators have been nominated to lead the "visioning" process in developing strategies within each of the themes and to bring a more coherent framework for integrating the different unit and project components within each of the themes. This process has proceeded through two principal rounds of planning and as expected, the well established programs in germplasm and breeding have moved quite quickly to set up program strategies and identify core team members, while newer research areas such as post-harvest and nutrition are still in the process of defining the scope of their activities and identifying core research staff. On the other hand, the production system theme has the largest collection of research units and project components and has the opposite problem of finding a research framework that effectively integrates these disparate elements.

The restructuring has reached something of an impasse and some basic decisions are required for theme coordinators to attain a sense of completion and consensus with management that the strategy is appropriate and that their theme can move forward to develop its projects around core research areas. This is particularly difficult as there is no overall plan or framework that defines the theme strategy and the deployment of research within the regions. These decisions revolve around whether the theme structure is the optimal one, what components are most appropriate in each theme, and how to staff and fund the newer programs in post-harvest and nutrition.

Recommendation 2.VI.3: As a first step in the development of its next strategic plan, The World Vegetable Center needs to assess the restructuring of research programs in terms of optimal structure and optimal deployment in the regions. Clarity and agreement on the basic structure is required for the different themes to consolidate their individual strategies and programs.

Issues in Developing an Optimal Research Program Structure

The panel finds that the current thematic structure based on horticultural value chains or the production- -consumption chain addresses the key issues and commends it as a strategic framework.

The only issue that the panel finds unresolved is where and how development fits into this framework. Currently this is relatively diffuse—possibly too diffuse for bringing this key area into strategic focus and delivering on the Center's Mission. Development activities are found in the production systems and post-harvest systems themes and to a certain extent in the nutrition theme. Development activities are also found in the regional programs. The panel considers that to have significant impact in the horticultural sector, particularly where the focus is on poverty alleviation, there must be an integrated approach across varietal access and seed systems, production systems and post-harvest systems. Development work focused on improved nutrition through increased vegetable consumption, often of indigenous vegetables, may have a rationale for a separate approach, especially where the focus is on targeting particular vulnerable groups, such as vitamin-deficient children, HIV infected households, or pregnant or lactating women. Nevertheless, development activities need a strategic focus and this can be provided by either integrating it into the work of the regional centers, particularly RCA and RCSA, or in instituting a separate theme with development as its focus, or both. The panel saw no clear basis for choosing between these two options, and prefers to let management explore the most practical ways of embedding development more firmly into the Center's overall structure and strategy.

If a new development theme was created, it would most logically take the place of post-harvest systems, where social science, market studies were put into the development theme along with the on-farm production systems work and possibly seed systems, if these focused on OPV's and indigenous vegetables and were organized around community seed systems. Much of what is recommended in the communications section could also be incorporated into this theme. The more post-harvest technology component of the former theme would then be grouped as production and post-harvest systems. The development theme would then offer a framework for a more strategic approach to development activities, in which there would be a significant component of model and hypothesis testing and research into development. For example, this might include testing of different extension methodologies for complex horticultural IPM or production system technologies.

However, a key characteristic of this theme is that it would be implemented to a large extent through the regional center programs, and the particular development activities framed with a regionally-explicit development strategy for horticulture. A further advantage of having an explicit development theme is the ability of the Center to attract donors with a development focus or development budgets.

The other course is simply to devolve the management of development programs to the regional centers. This depends in part on how much management authority is granted to the regional centers and whether there is any loss in central coordination of this thematic work. If there is, then the choice moves in favour of a central theme. If there is not, and there is better scope for the regional centers both to define a coherent strategy and to link the output of the various research themes to an integrated development approach that takes advantage of the higher returns to horticultural production but as well links this potential to impact on poorer regions and poorer households, then there is a rationale for devolving the development projects to the regional centers. This would not preclude the idea of model and hypothesis testing and a more structured approach to pilot projects. An advantage of this approach is the closer links to national and regional partners and the potential to integrate capacity-building activities into joint research and development projects, where the impacts of training can be maximized through both mentorship and learning by doing. Given that training is essentially carried out by the regional centers, this offers the opportunity to deepen the impacts of training and extend the range of training activities, including integrating post-graduate degree research.

Recommendation - See 2.V.1, in the previous section dealing with Development and Impact.

Decentralization and Possible Devolution of Research Programs

If future growth at The World Vegetable Center is pursued through decentralization of activities to the regional centers, then the question arises of whether some of the research programs might as well be devolved from headquarters to the regional centers. This is not an easy issue, as there are significant advantages to close interaction between program coordinators themselves and between program coordinators and management. However, there is already a movement towards a more distributed approach to carrying out research within a theme - that is, research distributed across the regional centers. This is best seen in the breeding theme, in the development of breeding capacity in the Regional Center for Africa, and in the post-harvest theme and its similar focus on market studies and organizational innovations in markets in Africa as well. It is quite easy to see that both production systems and nutrition will also evolve along these lines. It therefore likely that virtually all the themes would develop research activities in the priority regional centers, as is happening in Africa but is also to be expected in South Asia. The question then

becomes whether the integrative glue that prevents fragmentation of the research program is provided through the research themes - or through the regional centers. It is really too early to speculate in the evolution of The World Vegetable Center as to which dimension will or should be the stronger. The alternative, of course, is a matrix approach, but the team feels that only very mature centers can make such management systems work and the Center should avoid organizing along these lines at this stage.

The factors driving this decision will be (i) the level of utility of each framework in strategic planning, (ii) the potential for developing appropriate projects, (iii) the potential for integration of activities and their associated synergies, and (iv) the ability to achieve impact. The most significant difference between the two approaches is whether to move to regional research that integrates research themes within the context of a regional strategy—supplemented by more basic research outputs from headquarters-- or whether global research themes can be developed that integrate research carried out under different agroecological, economic, and social contexts and where there may be potential for comparative work across these different contexts. Currently, this is a basic issue within the overall CGIAR system, driven in part by the relatively recent focus on producing international public goods but where there is an emerging gulf in the ability to achieve impact with global research strategies. Since The World Vegetable Center has a dual focus in its mandate on both research and development, this issue should not create the tension that it does in the CGIAR system. However, the question still remains of how the Center best organizes itself during a period of growth and devolution to deliver both its research and development mandate.

The Panel considers that the Center's research and development strategy will probably develop through two or three phases. It proposes the following approach to making this operational.

Recommendation 2.VI.5: The Panel recommends that initially there be a consolidation of the research theme structure with a view that its implementation should in the future be organized as a distributed set of activities across the regional centers. To balance this consolidation, regional centers should develop research and development strategies for their regions where there is clarity on targets, partnerships with regional public and private institutions in achieving those targets, and research priorities within the region developed within the frame of the consolidated research structure.

The panel envisages that project development will then follow a two-track approach along both regional and research theme dimensions. Based on experience over a two to three year period, it should become clearer whether to move to a system where the center of gravity ought to be at the regional level or at the research theme level.

Compared to the Center's current process this planning framework adds two additional elements, namely the development of regional strategies and the need for a more explicit delineation of The World Vegetable Center's development strategy for horticulture.

Project development within the two dimensions will determine the path that is chosen. Current experience suggests that regional projects are funded within a more integrative project framework, where activities encompass several themes, while the research projects at headquarters are funded essentially within the research theme. The test to a significant extent will be whether research projects with distributed activities across the regions can be funded, creating decentralization of activities within an overall research strategy.

Implications for Research Management

Currently, The World Vegetable Center has a very flat management structure, wholly consistent with its size. The research themes have not evolved into a program structure with program leaders that have management responsibilities—this was the previous model which was abandoned in 2002 with the reduction in the size of the overall research program. Virtually all the major management and coordination decisions go through the office of the Deputy Director General for Research (DDG-R). Day-to-day management decisions are essentially in the hands of the project coordinators and the directors of the regional centers. However, any further growth in research activities, particularly if these are as well to be coordinated across regional centers, will start to overwhelm the capacity of the DDG-R's office. Significant future growth, as is planned, will require another level of research management and the question will be when this should be instituted and what model would best fitThe World Vegetable Center's more decentralized program structure. Most of the scientific staff sense that the Center will be evolving toward a structure with this next level of management and at the moment feel that there is a lack of clarity about the respective roles and responsibilities of the research theme coordinators and the regional center directors.

The model chosen for research management will depend on the decision taken about whether to weight the center of gravity to the regional centers or to the research themes for research planning and management. At the moment, project development primarily goes through the research themes, although the vBBS project in Africa and the prospective Sir Ratan Tata Trust project in South Asia both illustrate the movement toward project development within regional centers. The locus of management authority depends critically on the directionality of the coordination task. This means deciding whether research is coordinated primarily by regional centers requesting research support from theme leaders based at headquarters or whether research theme coordinators request support and staff from regional centers. There is, of course, room for both, particularly depending on the type of research, but a clear management and coordination locus is necessary. There are

already areas of tension between regional center directors and research themes currently operated out of headquarters. This situation results in some research projects being carried out in particular regions without the necessary involvement of the regional center director. More coherence is needed between the regional centers and headquarters research at the moment, but this will only be achieved with a clearer vision of the future management structure of the Center.

The restructuring process is at a very early phase and there are a range of imponderables that will influence the future evolution of the institute, principal among them being the scope to generate of increased funding. For this reason, the panel does not wish to lock the Center into a future path. However, it does have a position on the issue that The World Vegetable Center should move toward a devolved management system with the second layer of management being invested in the regional center directors. The panel feels that the principal issue that will drive the center toward this course is the overall complexity and diversity inherent in the research task. First of all this consists of is just managing the number of species, particularly when indigenous vegetables are included, where crossing and selection for individual species must take place under quite different agroecological conditions. To this is added the great diversity in production systems—primarily irrigated in much Asia versus principally rainfed in much of sub-Saharan Africa--, seed systems, post-harvest systems, and market systems. Effectively managing this diversity within a global mandate is very difficult within a centralized, headquarters-based operation. The panel sees scope for greater research effectiveness and relevance in a devolved program structure, particularly where research can be fully integrated with a horticultural development strategy focused on poverty alleviation.

Recommendation 2.VI.6: Based on funding possibilities over the next couple years, the Panel recommends that The World Vegetable Center consider moving towards a devolved program and management structure where research coordination and management rests principally with the regional center directors and where research theme coordinators ensure the scientific quality of the research, linkage to advanced research, network information and product flows between regional centers, and when advantageous, develop comparative research across regions.

The intent of this recommendation is to ensure both the relevance and the quality of the research. However, this structure will depends on a sufficient critical mass of scientists being based at each of the regional centers (as, for example, is now possible in RCA with the Bill & Melinda Gates Foundation project). Moreover, for each of the research themes, the coordinator will probably (although not necessarily) be based in headquarters and the deputy should be based in one of the regional centers. Funding will, of course, be central to this but a consolidation of the Africa program and an expansion in the Regional Center for South Asia would be sufficient to move toward this proposed structure. Other regional centers could then follow. Regional center directors will have to be able to work closely with

research theme coordinators and defer to their judgment as regards scientific standard, methods, and research quality. The office of the DDG-R would then move to a focus on strategic planning, overall oversight of the research program, arbitration between directors, and ensuring quality within the overall research program. It would embrace the Knowledge Generation component of the knowledge management system proposed.

Chapter 3.

MANAGEMENT AND ADMINISTRATION

It is the Panel's view that The World Vegetable Center has been under very dynamic and effective management over the last five years. The Center first had to adjust to a significant shortfall in funding, which necessitated the move to a flat management structure, and in the last two to three years has had to adjust to rapid growth, which in turn has prompted further restructuring.

The Panel has found a very healthy institute, as reflected in its adaptive responses to changing and very contrasting external circumstances. This is in turn reflected in the very positive image that the Center has created in the international agricultural research community, the growing set of collaborative arrangements—the Challenge Program on High Value Crops and the Global Horticultural Initiative being the most prominent-- and the Center's expanding recognition in the developing world through the increasing set of regional centers. Management has positioned the Center well over the last few years to be a leader in global horticultural research, at a time when horticulture has become a more integral part of agricultural development efforts in the tropics.

The frame for the Panels' review of management is very much the same as that used in the evaluation of research, namely identifying areas of needed change as The World Vegetable Center proceeds with its growth and restructuring process. This is thus a positive and necessarily forward-looking evaluation of the Center's governance and management systems. It also reflects an evaluation at a point in time within a very dynamic change process. Some of the management systems, such as human resources, are already in a transition process. The focus of this review is to ensure that the research restructuring is best supported by appropriate management and financial systems.

The Board and Governance

The Board of Directors is the governing authority of the Center. It assumes final responsibility for the finances and overall management of the institute, particularly the appointment of the Director General as the executive officer of the organization. Good working relationships between the Board and the Director General are essential for the effective governance of the institution, but balanced by need for constructively critical oversight. In general, the working relationship between the board and management has been good, if not excellent, and is reflected in the excellent performance of the institution over the last five years. However, the basic argument in this review is thatThe World Vegetable Center, if it continues to grow as expected, will need to go through further significant restructuring requiring an overall vision of the institute and fundamental decisions on

how it is structured and managed. The board has an important advisory and oversight role in this process, and the issue to be addressed is whether the board is appropriately structured as a governance system to guide The World Vegetable Center into its expanding role as a global center of excellence and leader in horticultural research and development.

The structure of the Board of Directors of The World Vegetable Center reflects the history of the organization and the unique relationship with the Taiwanese government. Board membership consists of 5 representatives of institutions of member countries (of the seven founding members). These countries reflect the initial charter of the institution at a time when its geographical mandate was defined as Asia. Complementing the country representatives are nine other members, selected primarily for their scientific expertise and their relationship to donors of the Center. What is obviously missing in the current balance of board representation is the regional dimension, reflecting the global mandate of the institute. Member country representation is ostensibly there to reflect the interest of the country or region, namely Asia. With potentially difficult, future decisions in restructuring and decentralization, the issue of regional priorities may become more of an issue. As board restructuring has potential legal implications related to the Charter, the Panel only notes the issue, rather than making a recommendation.

The Panel notes the relatively recent creation of an Executive Committee and endorses this change. It particularly extends the approval authority of the board beyond the board meeting - especially in relation to budget approval - and provides the potential for more effective interaction between the board and management on issues affecting the Center. Similar thought could be given to clarifying the role of the Program Committee. At the moment PROCOM has essentially a reporting function to the board, particularly on issues arising in the internal program review. Yet research is the central function of the institute and there will be a clear oversight function as the research restructuring and decentralization proceeds. The Board approves such documents as the Medium Term Plan and will approve the prospective strategic plan. However, this comes at the end of the process, where relatively minor modifications are possible. Research planning should be a more interactive process with PROCOM. Many of the board members are selected for their scientific standing and to a certain extent this capacity is not being utilized to the extent possible.

A particular example of this underutilized potential is the lack of board input into this 7th EPMR. The Review is ostensibly commissioned by the Board and the findings are vetted by the Board. However, there was little input from the Board into the Review as to the salient questions that the board wanted addressed. The point to emphasize is that there is a very collegial interaction between board members and management pertaining to research, in a manner befitting a scientific institution and where peer review is an accepted standard. Mobilizing the scientific talent on the

board as input into research programs and research strategies makes use of an existing resource and ensures an engaged board. Lack of formal input from the board into the EPMR is an example of a missed opportunity.

Recommendation 3.1: Board and management should review the role of PROCOM with a view to improving Board interaction and input into research programs and strategies, particularly in the medium and strategic planning processes.

Organizational and Management Structure

The current organizational structure has served The World Vegetable Center well over the last five years, especially with the creation of the office of the DDG for Research. Befitting the size of the institute, this has been a relatively flat structure. However, with the expected continued growth in the research programs of the center, and especially with the deepening of capacity in the regional centers, there will eventually be the need for a third tier of management to coordinate the research programs, as the office of the DDG-R cannot sustain the increasing volume of reporting and authorization. This issue was discussed at some length in the chapter on research programs and options were set out and assessed. The resolution of whether to delegate management authority to the research theme coordinators or to the regional center directors will be decided in the medium term. However, the change process is underway with the current restructuring of research programs and expansion in the number of regional centers. The warranted flexibility at the beginning of this process must move through stages to resolution. Currently, there is an understandable lack of clarity on the roles and responsibilities of both the regional center directors and the theme coordinators. There is now need for some well defined phases in moving toward resolution of the organizational structure. This should be done either before the strategic plan is developed or as an extended process within the frame of developing the next plan. Compared to other IARC's, The World Vegetable Center is in the fortunate position of having to choose options but without having to eliminate existing structures.

Financial matters

The financial situation has remained robust over the last five years, due to the significant emphasis given to resource mobilization, and the diversification of funding sources that has followed. Financial stability is provided through core support from the Taiwanese Council of Agriculture, where the contribution has been about half of total resources, although this percentage has declined somewhat with the grant for vBSS. Core resources are used principally to fund personnel costs which, as with any research institution, are the principal component of the budget. About 80% of the core budget goes to personnel costs and about 20% is utilized for management overheads and capital. Virtually all the operational costs for research come from projects and restricted core funding. Moreover, almost all the core component is spent at headquarters—all of the 28 internationally-recruited staff at headquarters

are on core funding. Apart from core resources for the personnel costs of the regional center directors, most of the funding for staffing, operations, and research costs of the regional centers comes from project funding—25 internationally recruited staff are in the regional centers and are on project funding. Some core funds are used for start-up activities in the regional centers, but their future growth and development will come essentially from special project funding. This introduces a potential source of instability in the staffing and operations of the regional centers, which must be addressed if the regional centers are to deepen their activities.

If the work of the center is to progressively decentralize and devolve to regional centers and if it will depend on restricted core funding, then financial planning around this strategy must be instituted. This principally revolves around the issue of the overhead charges and where they are allocated. Currently all overheads on projects are allocated to the core budget at headquarters. This ties the hands of the regional center directors who are attempting to build research capacity in their centers. It can be posited that overhead costs are primarily covered in headquarters through the core grant from the Council on Agriculture, and that most, if not all, the overheads for projects, particularly those where staff are paid for in the project, should be retained by the regional centers. The costs of the project are principally spent within the regional center, drawing on the overhead costs of the regional center. If there are costs borne by headquarters, these should be explicitly budgeted for in the project, or these services purchased by the regional center. This need is particularly pressing at RCA, but also applies to the Asia and South Asia regional centers. Without some policy change on overhead allocation to the regional centers, there will be limited potential for them to build the capacities necessary to carry out the research that is being suggested by this report.

Recommendation 3.2: The World Vegetable Center should review its policy on overheads generated by projects in the regional centers with a view to allocating them to the regional center rather than to core, in order to cover normal operating and capital costs of the regional center.

Financial management systems over the last five years have been adequate to provide sufficient controls and oversight without being too burdensome. Moreover, they have met the demands of an increasing number of projects and donors, providing the financial reports required by the donor. Developing these control procedures and standardized practices, moreover, has been greatly aided by the addition of an internal auditor. However, the financial control and management system is being tested by the expansion in regional centers, and especially by the vBSS project, with its multiple locations, management through the Africa regional center, a dedicated project manager, and authority still vested primarily in headquarters. There is an important issue going forward of how much authority to delegate to the regional centers in terms of hiring, expenditure control, purchasing,

and overall project management. At the same the financial management system has had to adjust through virtually an imprest system. Quarterly financial reports are submitted to headquarters and accounts are replenished on the basis of semi-annual budgets. While this is functional, a more integrated financial management system that will adapt to the growing programs in the regions will be necessary.

Recommendation 3.3: To meet the financial management needs of The World Vegetable Center as it expands the number of regional centers and projects within them, a more robust financial management system is needed. It is recommended that a financial management consultant be contracted to review the needs of the Center and advise on the best options.

Resource Mobilization

Resource mobilization has been successfully pursued through three fronts, that is (i) a conscientious effort by the Director General to raise the visibility of The World Vegetable Center among donors, (ii) the development of a well functioning grants management office, and (iii) the incentive for scientists to develop projects if they are to have funds to pursue their research. Project funding is to a growing extent the life blood of the institute; however this area can be contentious at times due to competition for funds. In general, however, the area has been handled very well, although within a context of increasing resource availability. Probably the most sensitive area is in vetting project ideas and interacting with donors. For logical reasons this is done centrally, where the project idea or proposal is reviewed by the theme coordinator, grants office and DDG-R, and when approved, submission is through the grants management office. The Panel's impression was that this was a bit too centralized, there was not the potential for sufficient interaction between the principal investigator and the donor program officer, and that the incentive at the scientist level may be somewhat reduced. This is felt to be an area for nuance rather systematic change, and our suggestion is to assess the scope for scientist involvement at all steps of proposal development.

The grants management office handles a range of duties beyond purely the grant development process. In particular, it manages contracts both with donors and with collaborating partners. This often requires the development of MOUs with host country institutions, for which legal input is provided by the CGIAR legal office. This dual role of project development and managing external relations with institutional partners involves different reporting lines, namely to the DDG-R in the first instance and to the DG's office in the second. The grants management office originally reported to the DG's office and now reports to the DDG-R. Given that the bulk of the work in the office revolves around research proposals, this line of reporting makes sense. If the new Director General delegates more donor interaction to this office, then there may be a need to rethink its place in the organizational structure.

New sources of funding

While the global situation in agricultural research funding for the poor is easing, the issue for The World Vegetable Center is whether this will release sufficient resources (a) for the needs of the developing vegetable sector globally and (b) for the Center's own growth. There is opportunity to diversify into new sources of funding and support which do not depend on traditional donors or compete with other IARC activities. The following suggestions are offered for further investigation should they seem promising:

- Food firms and supermarkets. These have proved to be elusive to date, but that be because IARCS have not yet correctly identified the value proposition to appeal to investors from this sector. However all supermarkets have an interest in securing supplies of quality, safe and healthy produce. They have the further advantage over agribusiness that they are less likely to seek to dictate the research agenda so long as it addresses this broad goal. They can be approached through:
-
    - Employing a high profile 'ambassador', such as a former food company CEO who is well known to the global industry, has high standing and can 'open doors' not readily accessible to IARCs.
    - Approaching companies not as philanthropic donors (initially) but rather as investors who have something specific to gain from funding specific The World Vegetable Center research – eg bitter melons to address diabetes concerns in their consumers
    - Developing a value proposition that benefits investors and the poor. This means finding the argument that will improve the supermarket or food company's bottom line, but at the same time addresses a defined needs in the poor (eg indigenous vegetables which offer consumer novelty but also healthier diets for the poor)
    - Targeted approach: selecting one supermarket chain or food company with a strong interest in fresh fruit and vegetables (ie as part of their brand image) and working with them until the value proposition is clear.

- A strategic expansion into fruit research would enlarge the Center's R&D portfolio to embrace the major component in the world diet – fruit *and* vegetables. Given international fruit research is presently serviced in only a fragmentary way, there is a firm argument for consolidating it within one agency. This should be progressive and in line with the Center's existing scientific skills, funding and capacity for growth. The inclusion of fruit will significantly enhance the Center's global significance and the strength of its arguments for donor, investor or philanthropic funding. It will make it one of the most important players in preventative healthcare and healthy ageing in the world.

- Consider adopting a Cooperative Research Center structure in which partner institutions and companies contribute funds and resources to join the center overall or specific projects. This expands the range of funding and resources available to the Center to include those of universities and other research agencies around the world. Contributions could be as cash, scientific staff or equipment, or all three. The concept relies on the clear identification of an attractive scientific research opportunity with a potentially major payoff.
- Deliberate seek to raise the World Vegetable Center's international profile in the quality mass media through a strategic approach based on achievements and expert opinion, as a platform for attracting more donors/investors. This can be done by contributing articles and opinion from leading center scientists on international food issues, as they enter the media spotlight, on a timely basis.
- Open the germplasm collection on a commercial basis (fee+royalty) for biodiscovery of new pharmaceutical and industrial compounds, to fund the facility's future growth and preservation.
- Exploit the Center's indigenous vegetables work as a platform for commercial publishing (not by the Center itself) of food, cooking and health books, to generate a royalty stream which the it can use to fund other outreach activities. (See KM and Outreach section)
- Establish a Global Horticulture R&D Trust Fund to which farmers and seed companies can contribute as they rise in the value chain, enabling wealthier producers to contribute to future research which will benefiting both themselves and poorer farmers.

Recommendation 3.4: The Center should widen the scope of its search for new sources of funding, particularly from non-traditional sources. It should actively seek a higher global profile to underpin this.

Human Resources policy

Happy and productive staff members are essential to the scientific performance, reputation and achievements of any research center. The Panel found that, on the whole, World Vegetable Center staff were highly motivated - but that there are a number of opportunities for improvement in the relationship between the institution and its employees. Many of these have been identified by management in previous reviews and expressed in the Center's draft Human Resources policy. A new Human Resources Manager was hired last April, but has been fully committed in that time to recruiting for 43 unfilled positions.

The World Vegetable Center has very quickly increased its staff size, mostly in the regional centers. The need for recruitment has placed many other key tasks on hold. Particularly, there is need to review job profiles leading to clearer job

standardization and salary scales. This, however, is challenging in the context of further changes in the organizational structure. This particularly applies to the positions of theme coordinator and regional center director. Interim terms of reference have been developed but these are far too general for many of the theme coordinators. A similar situation surrounds the implementation of the draft human resources plan. This is made more difficult in terms of developing human resource policies in each of the regional centers and how and whether to move to some standardization—made more difficult where staff come under the policies of the host institution. The Panel feels that the Center's HR policy should be implemented as quickly as possible, even with the probability of further changes in the future.

Recommendation 3.5: The center should implement its current HR policy fully as a matter of priority.

Employment contracts

In order to be a competitive employer of highly skilled staff, whether these are senior scientists or research farm workers, the World Vegetable Center needs to review its policy on contracts.

For senior scientists, the option of 3-year contracts, rather than rolling one year contracts, should be considered. These would provide greater job security, motivation to pursue longer-term research goals and opportunity for personal growth and career development. It is not envisaged that 3-year contracts would be offered automatically, or in every case, but as a means of securing talent and rewarding performance over time. A benefit for management is that 3-year contracts for senior staff can be staggered to avoid too heavy a loss of key personnel in a single year, and greater retention of corporate memory and expertise.

The disparity in benefits and salaries between core and project staff is a source of potential disharmony and management should, as a matter of policy, seek to even it out over time - though this is never easy in the short run. Employment packages at all levels should reward outstanding performance through greater flexibility in provision of non-monetary benefits. These will vary in appeal according to location and type of staff: for example, health insurance may appeal more to some staff while educational opportunities will encourage others.

In the case of field staff hired at daily rates, the use of weekly, monthly and, in particular cases, yearly contracts would:

- reduce administrative overheads
- improve workforce morale

- increase the level of skills available to run an efficient research farm, as distinct from relying on unskilled agricultural labour
- Allow able individuals to develop into trained research assistants, leading to better research outcomes (ie fewer experiments lost through mismanagement).
-

Recommendation 3.6: The center should review its policy on staff contracts with a view to increasing motivation in existing staff, flexibility in management and employment, and the attractiveness to external applicants of working for the Center.

Career development

It is the impression of the Panel that more attention needs to be given to the career development of World Vegetable Center staff, that better systems of performance review and feedback need to be put in place, and that mentoring should become widespread and educational or training opportunities increased.

The aim is to send a stronger signal that the World Vegetable Center treasures and cherishes loyal and talented staff, and that they are seen as the backbone of its scientific success and ability to make a difference to poverty and hunger: "Our people are our most valuable asset" should be visible in deed as well as word. Praise and helpfully critical feedback should be more forthcoming.

To achieve this system of reviewing staff performance against agreed goals each year needs to be formalised and embedded. Self-assessment alone is not sufficient. Thought needs to be given to the career aspirations, especially of staff who will move elsewhere, and to ensuring they have the skills, attainments and achievements to do so. While this may seem counter-intuitive, it will pay off in higher motivation while at the Center and in the external reputation that attracts good staff.

A formal system of mentoring between senior and junior staff and between long-term 'living treasures' of the Center, and talented newcomers should be introduced. In particular cases mentoring can also take place outside the Center, with appropriately qualified mentors.

Recommendation 3.7: The Center should adopt a formal policy of reviewing staff performance annually and introduce a mentoring system to develop junior staff.

Health and safety

The World Vegetable Center needs to ensure it observes world best practice in OH&S for international agricultural research, especially in laboratories and in the field. Managing highly visible programs such as vBSS and being a global source of

information about safe food, it needs to ensure its internal standards and practices can withstand external scrutiny.

We recommend an audit of health and safety practices be carried out across The World Vegetable Center, with particular attention to fieldwork and the Regional Centers.

Recommendation 3.8: The Center should audit OHS standards and practices throughout the organization, especially in regional centers and around sensitive projects.

Planning

The World Vegetable Center has been moving quickly forward in terms of rethinking its research program and in establishing new regional centers. These decisions are cumulative but have not been made within the context of an overall planning framework. As noted throughout this report, the Center is not so much restructuring existing programs as developing a structure for future growth and program development. In such a case, it has relied primarily on the excellent leadership and management skills in its three senior positions rather than providing a blueprint and developing a more flexible process, particularly in the development of the research themes and the positioning and prospective role of the research units. With the advent of a new Director General, the opportunity arises to move directly to the development of the next long-term, strategic plan. The Panel has through the course of this report provided prospective thinking and suggestions for the development of that plan. At this point in the review, there is little more to add to this particular aspect of planning within the center.

Medium-term planning has been the principal vehicle for guiding research at the institute. The previous MTP in 2005-2007 focused more on promoting the work of the institute than providing a coherent research plan. The most recent MTP for 2007-2009 marked a significant advance in developing a research planning framework, built around the formative strategy development within each of the five themes. This MTP provides a clear planning framework in which research priorities and strategies within the theme can be assessed—if somewhat skeletally, as the MTP is set out in a log frame format. However, the future research outputs are framed in terms of existing projects, which in some cases leads to a very fragmentary view of the research being caring out. What the planning frame should also provide is a sense of forward priorities in terms of new projects that are considered essential to advance the research agenda. In sum, it should a sufficient framework for justifying new projects that are considered to be of the highest priority.

The upcoming strategic plan, should provide both justification for the research theme but, more importantly, how the theme might vary its work by region. As strongly argued in this report, the regional centers also need to develop strategies,

particularly framed in terms of how The World Vegetable Center is to achieve its mission of alleviating poverty in the region, and with its finer targeting of where it will work in the region. The intersection of theme strategies and region strategies will then begin to determine overall priorities for the Center. In the current MTP, regional strategies are defined purely in terms of the activities they have in each of the research themes, which does not give the impression of a coherent research plan.

CONCLUSION

In the period under review The World Vegetable Center has not only put in place the structures to pursue its global mandate but has become a focal point for global horticultural research and development, as exemplified in its leadership in the CGIAR's challenge program on high value crops.

This growth process coincides with increased interest by the development community in vegetables as a means of alleviating poverty and growing the rural economies, reflecting very closely the Center's own mission to alleviate poverty and malnutrition in the developing world.

The restructuring of its research programs provides a strong strategic element in the pursuit of its mission, integrating from production to consumption and nutrition in a large and complex research field.

The Review Panel has thus found a vibrant, dynamic and inspirational institution, one that is well managed, and one that is positioning itself to take on even greater challenges in improving vegetable production and consumption in developing countries.

The Review Panel has focused this evaluation on the next phase of The World Vegetable Center's growth and development. The last five years have been a process of putting in place the skeletal structure of the institution, while at the same time maintaining and evolving its research programs.

The task that lies ahead is to deepen the strategies and programs of both the research themes and the regional centers and to couple them more strongly to development. This growth and deepening process will require some balancing across the institution in order for the whole to function synergistically. This in turn will require growth characterized by decentralization of management and devolution of capacities and programs.

The Review Panel is sure that this will be an exciting stage in the Center's development and in the end will lead to an institution fully capable of fulfilling its mission ***to alleviate poverty and malnutrition in the developing world through the increased production and consumption of safe vegetables.***

Appendix 1

IMPACT & OUTREACH METHODS

To illustrate that the task of reaching poor farmers and consumers need be neither costly nor difficult, various methods for reaching The World Vegetable Center's target audiences that have been mostly explored and tested by NGOs are discussed below.

Rural & regional media

90% of the human population gets 100% of its information about new science and technology from the media. Only those in science or education get it direct. This makes the media, and in poor countries that means local newspapers and radio primarily, of critical importance to farmers in learning of the existence of new methods, technologies and crop varieties.

If The World Vegetable Center science outcomes are not to take many years to reach the hundreds of millions of poor people who need them, greater use of the mass media is essential.

This hinges on effective dissemination of the information to the media most likely to be used by the poor. Nowadays, with email, web, RSS feeds and other techniques, this process can be low cost and significantly automated.

It is suggested that The World Vegetable Center establish a global database of key media most likely to reach poor farmers and horticultural growers in target regions, and use this for regular selective dissemination of news and extension material.

This material can consist of stories about new technologies, varieties, farming methods, farmers who are trialling them, regular columns or comment by The World Vegetable Center or partner staff on current local and global issues and other material relevant to the regional audience. Its purpose is to establish The World Vegetable Center in farmers' (and others') minds as a primary source of new ideas, technology, expert advice and opinion.

Radio broadcast

Radio is an excellent extension tool for reaching poor farmers, especially where literacy levels are not high or other means of communication sparse. Information can be pre-packaged as stories, interviews, opinion and discussion involving scientists, farmers and extension workers onto CDs. These can be distributed to local radio stations at low cost. The stations are generally pleased to broadcast it as it helps "fill the silence".

Alternatively packaged programs can be distributed to established radio discussion groups such as the ones below, or else placed on the web as MP3s for download by broadcasters.

Many agencies now combine extension broadcasts with village discussion groups to develop the ideas they have just heard. This is a powerful way of communicating new R&D and ensuring local relevance and interest.

Radio can be used on its own or to reinforce other methods of outreach such as print media, fact sheets, field days, video, email, mobile phones and the web. This is known as multichannel learning.

Farmers in Tanzania advise that a short bulletin on vegetable market prices would be eagerly received, and The World Vegetable Center news and technical advice could be attached to this, ensuring a high audience. The market prices could be provided by a partner, seed company or grower association (eg TAHA).

Case study 1: Radio is recognized as the most appropriate communications technology in Africa, since it is cheap and easy to operate, and reaches the majority of the population, especially women and farmers, who can listen to programmes while working.

Development through Radio (DTR) is a unique rural radio project in Zimbabwe. This project provides training for women, to encourage and develop their leadership skills so that they become more self-reliant. It also promotes interactions among communities so that they can exchange information and share experiences. It links rural people with policy makers and non-governmental organizations (NGOs) that can offer solutions and resources. Using participatory methods, the project encourages members to engage in dialogue and debate on critical issues that affect them and their communities. By sharing experiences and ideas, DTR clubs are strengthened.

The project encourages and helps communities to mobilize their resources to launch income-generating activities. It provides a platform via which they can to obtain information on how to start up and run sustainable projects, and expert advice on problems encountered by individual community groups. The DTR training programmes encourage women to become agents of change, and equip them with skills to help alleviate poverty, as well as to address issues such as the marginalization of and discrimination against women. The DTR is a project of the Federation of African Media Women (FAMW). The project has now been replicated in Angola, Ghana, Malawi, Namibia, Nigeria, Sierra Leone, South Africa and Zambia.

Case study 2*:* In the village of Itokama, in eastern Papua New Guinea, representatives of a dozen local clans gather for a strategy meeting to discuss how to manage and conserve their part of the rainforest, which is under threat from loggers and land developers. The members of this tribal 'land group' are gathered around a radio, listening attentively to a programme in Pidgin English. The programme and meeting's guiding principle is 'kuae-fie-nami' ('speak and understand each other'), meaning that the answers to land development problems lie in dialogue rather than in one-way initiatives.

The project brings critical technical information and skills-building support to local farmers through an innovative, ICT-supported learning approach called Multichannel Learning.

Based on research that shows that people learn in various ways and through various means, and that the chances for successful learning are improved *when more than one learning channel is used,* Multichannel Learning reinforces its messages over and over through multiple media and in different settings. At the core of the project is a series of 'interactive radio instruction' programmes that are broadcast during scheduled meetings of the land group forum. In an entertaining serial drama, actors portray colourful characters representing a variety of viewpoints on land development, forest conservation, family planning and other issues. Points of audience participation are built into the radio scripts – listeners are invited to answer questions posed by the actors. Most importantly, the broadcasts serve as launching points for facilitated discussions. The content of the radio programmes is repeated and reinforced in a variety of printed materials. These use simple vocabulary, with clear explanations and plenty of graphic symbols and illustrations that can be understood by the semi-literate audience. The materials are also distributed to students in schools, women's groups, and literacy and reading clubs.

World Vegetable Center newspaper

Newsprint is still one of the cheapest mass means of communication in the world. A paper can reach half a million or even a million readers for the same price as a glossy book or brochure reaching a few hundred or thousand only. The World Vegetable Center should give close thought to producing fewer "glossies" and more newsprint outreach material for distribution to poor farmers and women in markets. Distribution can also be achieved through NARES, seed firms, NGOs and other partners, at field days and even in local shops.

World Vegetable Center research indicates that literacy levels among poor farmers are rising quickly in Africa, with up to- half of poor farmers in most country have a primary school-education and someone in most families who can read. This makes a cheap, high circulation vegetable newspaper an extremely promising option.

Costs of production can be met in several ways:

- through advertising sold to commercial companies
- through sponsorship or donation
- through budget allocation, eg in Phase 2 of vBSS
- by reducing output of high-cost glossy publications
- a combination of these methods.

Farmer video

Video is a valuable medium for farmers to learn from one another and from scientists. It enables the 'early adopters' to share their knowledge and experience of new technologies with fellow farmers in a highly visual (and entertaining) way. Farmers trust other farmers ahead scientists or extension officers. They are curious about how other farmers do the things they do.

For select projects in target countries farmer video groups offer a cheap, practical and realistic way to extend new R&D. Locally made videos can be coupled with extension material prepared by The World Vegetable Center and NARES. Video is a very useful tool where literacy rates may be low.

With today's cheap cameras video can be readily produced in a research or trial context, with the great advantage that it can show a full cropping cycle in a matter of minutes. It can also be used to display current and new horticultural practices across a district, or the world. It can combine the latest technology from R&D with on-farm realities. It can be compiled by farmers themselves, giving ownership of the technology in the process.

Case study: In Ghana, cocoa farmers are learning to produce videos that teach improved cultivation principles and pest management to their fellow farmers in order to tackle black pod disease, which can result in major crop losses. Research conducted on similar cocoa farming areas in Cameroon shows that if left untreated, this disease can result in crop losses of up to 90%. Farmers are being trained in the production of video films that communicate the principles of improved cocoa cultivation to other farmers.

Specialists from the Cocoa Research Institute Ghana, the Sustainable Tree Crops Programme (STCP) farmer field schools, and CABI worked together with FFS graduate cocoa farmers to pioneer participatory video production. They developed a training programme that involves farmers in all stages of video production, including the acting, editing, pre-testing and refining video episodes.

After training, the farmers directed a 12-minute digital video about pruning old cocoa trees as a way to improve yields. The farmers 'test-drove' a rough version of the film for comprehensibility, cultural appropriateness, and relevance of information content in a review process in their home village. Cocoa researchers and FFS programme advisers also checked the video.

The group produced a second, two-part, 20-minute video about control of black pod disease and ways to control it. Both videos were edited in a commercial studio, but under the direction of the farmer video team with facilitation by the media trainer. At the end of 2005, the group completed the videos and delivered copies to various local participating and other organizations to be used in farmer education.

The initial response of the farmers who took part in the review of the rough versions of the videos was very encouraging. There are plans to extend the video series to include other aspects of cocoa cultivation. These will include selecting the best planting materials, nursery practices, pest recognition and control, and post-harvest operations.

Email extension

A long-time precursor to the web, email is a more appropriate tool for sending and receiving information, especially in poor countries where access to the Internet can be unreliable and expensive. Unlike the web, which requires your presence as you download information to your computer screen, information requested by email can travel at night, when rates are low, and comparatively slowly, yet it still arrives in your mailbox for you to read at leisure.

In spite of poor phone connections and unreliable electricity supplies, people in poor countries are using the Internet in greater numbers than ever before. We were told the internet is now available in most West African villages, for example. However it can be slow and expensive for people in poor countries to search online databases or find and download documents from the web.

Email delivery tools like www4mail can help fill the gap. Organizations such as Bellanet, Kabissa and the University of Trieste offer, as a public service, web access to email users through www4mail. Thanks to their services, people in poor countries are able to retrieve web pages using only email.

Web-to-email technology uses servers that fetch documents from the web, and send them to you as email messages, either in plain text or HTML. To use the system, simply send an email message addressed to one of the web-to-email servers listed below. Leave the subject line blank. In the body of the email message, type the web address of the page you want to read.

The email addresses of some popular web-to-email servers are:
www4mail@kabissa.org
www4mail@access.bellanet.org
www4mail@wm.ictp.trieste.it

Web groups

Web discussion groups are spreading even in very poor countries, as illustrated below. For The World Vegetable Center in particular they offer the opportunity to speed the growth and adoption of new farming methods, neglected vegetable crops, organic or low-input farming techniques, sustainable farming and complex concepts such as integrated pest management.

Existing women's discussion groups can also be used to raise consumer awareness of new or unfamiliar crops, better ways to prepare and cook vegetables, new recipes, nutritional information etc, all of which is essential to creating the market demand for novel or higher value horticultural products grown by poor farmers. These will not catch on unless consumers are also made aware of them.

Case study: The Women of Uganda Network (WOUGNET) is a non-governmental organization established in May 2000. WOUGNET promotes the use of ICTs by women to enhance their capacities and opportunities for sharing and exchanging information and collaboration.

WOUGNET operates online, so that most members are based in Kampala where it is relatively easy to gain Internet access. For members in rural areas who lack Internet access, WOUGNET puts them in contact with women who do have access and are willing to serve as 'information conduits'. Its activities include:

a mailing list via which women and women's organisations can exchange and disseminate information;

a website profiling women's organisations and their activities.

a monthly Update Newsletter highlighting the activities of women's organisations throughout Uganda;

a 'TechTips' programme to address members' queries related to computers or IT;

a website design programme.

Mobile phones

Even in countries where the internet is still poor or nonexistent and computer literacy low, mobile phones are becoming ubiquitous. In Africa, most farmers attending an The World Vegetable Center field day had one, and many women in the market used them for business.

Several agencies are now using mobiles to deliver extension information to farmers, as the following example illustrates.

The World Vegetable Center could provide short, simple advice and tips on production or announcements of new varieties and technologies for use on mobile phones either in recorded voice or text format.

Case study: The central Chinese province of Henan are launching a programme that will give farmers access to information on the Internet without needing a computer. According to Feng Fengju of the Science and Technological Service Center of Puyang City, Henan, farmers can access information through their telephones, by requesting information using their keypads and listening to answers to their enquiries through their earpieces.

"In our poor regions, it is impossible for the average farmer to afford a computer, let alone access the Internet," Feng told SciDev.Net "Even if they could afford a computer, they would not know how to use it."

However, many rural families have installed telephones, which they seldom use. In 2000, Feng and her colleagues established a database of information on agricultural technologies, health guidelines and employment opportunities that could be used to help answer telephone enquiries. They then developed a set of codes, representing various common enquiries that users would be able to input through their telephone keypads.

A farmer wanting to know how to raise a new breed of cow, for example, would, following the automatic operator's instructions, have to first press a code for 'agricultural technology', then enter a code in the sub-menu for 'animal husbandry', and then a code in third level menu for 'cow', and finally a code for the breed of cow they want information on.

Software would then relay relevant information from the database using a pre-recorded voice. About 30,000 farmers used the service and their positive response prompted Feng and her colleagues to enhance the system in late 2003 by adding real-time information from the Internet.

With funding from the local government, they hired a Beijing-based software company to develop a more advanced system able to interpret telephone keypad enquiries orders and, in response, relay up-to-date Internet information to enquirers.

They also redesigned their code system and selected as sources some authoritative websites such as the national agricultural information network operated by the Ministry of Agriculture.

The new system which now has thousands of users includes the original computer database and at least a dozen authoritative websites. The new system cost just 150,000 yuan (US$18,000) to set up. Its running costs are also low both for operators and for users. By using the telephone to access the Internet, farmers need only to pay the cost of telephone calls — 0.1 yuan (less than US$0.02) per minute.

Podcasts

Podcasts – recorded audio or video information which can be downloaded by the user at will - offer a powerful new way to communicate science and technology to farmers and other users.

The information can be made available at a central site, such as the The World Vegetable Center website, and downloaded by anyone in the world with an iPod or personal recording device, or a PC. In countries where music is an important part of life, as in Africa, iPod use is growing and is expected to accelerate significantly.

Its advantage is that the user can download items automatically for playback at a time that suits them. Any item made for radio or video can be offered by this means. For example vision of a new The World Vegetable Center advance can be distributed worldwide, with commentary added in local languages.

Case study: Rural communities in the Cajamarca region of Peru are taking part in a podcasting experiment. Farmers can now get relevant information on the specific crops they grow in a language they understand.

Radio has been used to reach the farmers here but broadcasting projects can be expensive to set up and there are often regulatory problems to be overcome. Radio remains popular, however, among the rural communities, indicating that people preferred to listen to important information rather than read it in leaflets or other written material. But a lower cost solution was needed, especially as the state no longer provided local agricultural extension services. After a two-year research project conducted by Practical Action and Cranfield University, it was decided that podcasting could provide such a solution.

Targeted messages, in simple, easy-to-understand language, are produced and made available on the Internet. Users subscribe for free to the service and automatically receive regular updates. To make each podcast more accessible to the wider farming community, local information centers with Internet connections make audio CDs or copy the files onto

digital audio players which can then be listened to by farmers at a time convenient to themselves. They are also able to rewind and replay the parts of the information they might at first not understand. The podcasts are also broadcast on radio, offering the opportunity for people with traditional receivers to hear the same information. In fact, it was this mix of old and new technology that contributed largely to the success of this project.

In rural centers it was noticed that there were often queues of people waiting to use the telephone but nobody was using the computer based Internet services. People in the market would be listening to radio. It was obvious then that voice was the most important communications medium. Voice had long been the method of sharing knowledge through story telling in the evenings. Information was spread simply by talking, but one person's voice can only reach a limited number of people.

The project in Cajamarca was set up to test the technology in terms of finding out the benefits to local people and the value it could add to their livelihoods. Future plans from Practical Action include adding audio information to their "Janathakshan" portal in Sri Lanka, and providing audio information to rural communities in Zimbabwe. These will be recorded in a variety of local languages, for example Tamil and Sinhala, to make them more accessible to the target audiences and therefore help to connect that important "first mile".

CDs

CDs are a useful and cheap way to combine text, audio, images, video and presentation information for distribution to nodes reaching producers, such as NARES, seed companies, mass media, NGOs and farmer groups. However the same material should also be issued in other forms and downloadable from the The World Vegetable Center website.

An advantage of the CVD format is that it can encompass all the information from a particular project into one package. A disadvantage is that CDs are often not used by busy recipients. It is important to monitor user response to information sent out in this way and not just assume it has got through.

Case studies: there are many examples of use of CDs, mostly failures for the above reason. It is of critical importance to ensure information on the CD is producer-relevant and not just scientific information dumped on a CD. It must be edited into simple farmer language.

Children

With UNICEF or appropriate NGOs and government departments, The World Vegetable Center can employ children of poor families to educate their parents (farmers and consumers) through a sponsored Seeds for Schools project delivering simple, cheap and informative seed packs to all primary schools in key target countries determined by nutritional need and poverty level.

Child nutrition is the most urgent task of all. Children can be teachers as well as students. This would be a valuable dissemination vehicle for vBSS outputs to poor families not reached by seed companies. It will also help to train the next generation of farmers in vegetable production techniques and the next generation of mothers in the nutritional qualities of vegetables.

The World Vegetable Center already distributes seeds on a small scale to farmers. By producing a smaller, cheaper kit and with some sponsorship, this program could potentially reach 100,000s of families via several thousand primary schools which will grow the seeds as a class exercise and then send the resulting seed crop home with

the pupils. Chidren thus act as a "mass medium" for disseminating The World Vegetable Center science.

It is suggested that a pilot Seeds for Schools trial be conducted in Tanzania.

Virtual farms

Imagine if a farmer, anywhere in the world, could sow a crop, harvest it 10 minutes later and understand exactly what factors contributed to its being a success or a failure – and could then sow the crop again, correcting for whatever went wrong the first time, and see the results in her or his income.

This is the farm outreach tool of the future, and The World Vegetable Center can help pioneer it.

Technology for people to perform actions in real time and interact with one another in a virtual world already exists on the internet on sites such as Second Life and games like Ultima and Warcraft. In these people from all over the world work and play together, discuss things, hold meetings, create buildings, design clothes or equipment and buy and sell virtual objects, often for real money.

Nobody has ever done this in agriculture before, and The World Vegetable Center could be the world leader in using this powerful new way to allow farmers to explore the use of new technology. It would involve combining virtual world technology, which is now well-tested, with farming software that models crop production and other farm activities. In theory, anything you do on a real farm can be done on a virtual farm.

The strong connection between The World Vegetable Center and Bill & Melinda Gates Foundation through vBSS offers great potential to bring world IT expertise to the task of building a virtual farming world where farmers can test out new ideas and technologies and discuss them among themselves and with experts.

Its drawback is the need for a reliable and fast internet connection, but as the internet spreads globally these are becoming more available even in poorer regions like West Africa. Within 10 years they will be widely available.

In a virtual world, language is less a barrier than elsewhere as groups tend to form in which members can communicate with each other. For wider communication the internet itself is generating its own shorthand language, much as kids have developed a new global language for mobile phone texting.

A virtual farm offers the enticing possibility of farmers from Asia and Africa trying out new farming methods together and discussing them, in real time, with experts from The World Vegetable Center or its partners in NARES or seed companies. It allows different farming scenarios to be modelled, and farmers to quickly see the income and cost consequences of a new crop or farming method. Farmers could participate as individuals or as groups.

The World Vegetable Center could, for example, hold a virtual field day, explaining new crops or methods, at which farmers from 50 different countries attend in real time, then go back to their virtual farms and try it out a few minutes later!

It may be argued this technique will not work among farmers with low computer literacy. However it would be wrong to assume that, because a rural community is illiterate today, its children will always remain computer illiterate. In particular the virtual farm offers a means to communicate new technologies to the rising generation of young farmers who are more flexible in outlook and interested in using new technology, both IT and farming.

It is suggested that The World Vegetable Center explore with the Bill & Melinda Gates Foundation the scope for setting up a global virtual farm in which participating farmers can test new ideas and technology in real time, and pioneer this as a new approach to agricultural extension, communication and training worldwide.

Further it should be noted the virtual farm can be used for any form of crop or livestock production, can reflect different farming regions and systems, be for mixed farmers or specialists and can involve agroforestry and conservation farming systems.

The virtual farm could thus be used by: the entire CG system, national agriculture departments worldwide, seed or agrichemical companies, organic and other farmer groups.

It is an opportunity for The World Vegetable Center to be a world leader in both research *and development* combined, to ensure the fastest possible uptake of new farming techniques globally in order to address world food, hunger and poverty problems.

This is a big idea but it need not be difficult or expensive to implement. All it needs is a little vision.

Consumers

If The World Vegetable Center wants its technologies to have the biggest impact and to really improve the lives of the poor, it must also consider ways to reach consumers in poor countries.

The reason can be simply illustrated by GM technology, where tens of millions of dollars and thousands of scientific careers have so far been wasted through the failure by the scientific community to consult with consumers about the acceptability of the new technology. For this reason, in many countries, consumers have refused the technology and governments have restricted or banned its use.

Working with consumers, and gathering their feedback, is essential to the uptake of new technologies by farmers, who will not be inclined to grow things which people cannot eat and for which there is thus no market.

The World Vegetable Center can easily reach consumers via the mass media and by training food writers in the media.

When promoting things like neglected or new vegetables, more nutritious vegetables or better ways to prepare them, the development of consumer awareness is essential, along with farmer awareness and- adoption.

This is not just a suggestion of the EPMR. It is also an explicit request by farmers who attended The World Vegetable Center field day at Arusha, who wish to be assured there is a paying market for the new varieties they are being offered by the Center.

It is recommended The World Vegetable Center develop a consumer outreach program to bring information about new vegetables, nutrition and preparation to consumers globally – but especially in poor countries – via the mass media. This can be delivered via short training/information courses for food writers in the media who influence dietary trends.

These recommendations are of particular significance toThe World Vegetable Center's biotech programs, which could fail to be adopted by farmers unless they are convinced consumers are also accepting of the new varieties and the technology used to produce them. No matter how great the potential benefits of GM varieties, they will not be realised without consumer acceptance.

Panel Recommendations and Management Responses

For Section 1 Highlighted bullet points from the text are specifically favoured or noted. *Italic additions are extra-commentary*

EXTERNAL ENVIRONMENT AND MISSION

8. Food demand

Working closely with and through the Global Horticultural Initiative it should seek to expand its influence on policy formation and the public debate.

AVRDC - The World Vegetable Center also needs to develop high skills in listening to farmers and consumers needs and requirements in charting its programmes.

The Center may consider commissioning a study into *strategic* expansion into fruit research over the coming decade, due to:

- gaps in fruit research at the international level
- the complementary nature of fruits and vegetables in a nutritional sense, providing micronutrients, bioactive plant ingredients and fibre
- compatibility with its existing R&D capabilities
- the lack of distinction between fruits and vegetables at farm or consumer level and the scope for synergies in both production and nutrition
- to build its profile as the world's leading horticultural institute and source of policy advice on food and nutritional issues
- opportunity to increase resource mobilisation, R&D synergies and efficiencies; better use of infrastructure and skills.

9. Dieting the rich, feeding the poor

AVRDC - The World Vegetable Center may be able to mobilise greater research resources to solve the problems of the poor. One opportunity is to persuade major international food companies and supermarket chains that they should invest in R&D which will assist both their wealthy customers and at the same time address the needs of poor farmers and consumers. AVRDC - The World Vegetable Center will need to develop a *value proposition* likely to influence these potential new sources of funding capable of achieving a win-win for poor and well-off alike. (See Funding Environment, below)

"Prosperity for the Poor – Health for All"

10. Water scarcity

Possible implications for AVRDC - The World Vegetable Center include:

- Rising external pressure (and funding) for greater emphasis on water use efficiency in crop types and farming systems
- Substitution from grains and meat to horticultural (fruit and vegetable) crops as more water efficient per unit of nutritional intake
- Growing consumer demand for 'low water' foodstuffs
- Greater emphasis on rainfed systems and the harvesting of rainwater for use during dry spells.
- Shifting of vegetable production into new areas and climatic zones as the climate warms and/or local rainfall increases
- Need for low cost (eg plant-based) systems for cleansing groundwater used for irrigation and drinking of toxic materials
- Development of saline and brackish water farming systems
- Demand for intensive urban horticultural systems using recycled water or stormwater where these sources can be made sufficiently clean
- Expanded interest in marine algae culture
- Use of plants for phytoremediation of contaminated urban water to purify it for reuse (eg in horticulture)
- New demand for low-water vegetable protein production in bioreactors.

11. Energy costs

To insure against this AVRDC - The World Vegetable Center needs to review, or give greater emphasis to, its research effort into:

- Low-input farming systems, including organics, which reduce reliance on mechanical tillage, industrial fertilisers and high energy inputs
- Expanded urban/periurban horticulture to reduce food miles
- Reducing food chain losses (i.e. reducing transport costs/unit of nutrition)
- Reducing energy demand in high-value cropping systems
- Use of vegetable wastes in biofuels or composts for local on-farm use
- The future role of vegetables as food for the poor in substituting for crops now being burnt as biofuels or diverted to meat production. (400mt of grain is forecast to be burnt as fuel by 2020, equal to the world rice crop)

12. Global environmental change

Possible implications for horticultural research from current climate change scenarios include demand for:

- Rising demand for varieties and systems able to cope with greater climate extremes and variability, notably drought, heat, salinity and desertification
- agricultural adaptation and mitigation pathways that are both pro-poor and minimise deleterious feedbacks to the Earth System
- novel ways to reduce or negate the contribution of vegetable production to greenhouse gas emissions (e.g. plantstone carbon lockup)
- early warning detection of pest and disease responses to climatic signals

- crop-types that signal biotic and abiotic stresses
- vegetable cropping systems which reduce soil erosion and desertification
- scope for nutrient recycling within vegetable production systems
- spillover effects on vegetable production of global demand for grain to be burnt as fuel in response to demand by public concern over climate change.

13. Urbanisation of the poor

Implications for AVRDC - The World Vegetable Center may include:

- Shifting emphasis from high value to low-cost foods
- Shift in production emphasis from rural to urban & periurban settings
- Demand for alternative cheap food sources, eg industrial scale vegetable protein culture
- Intensive vegetable production systems that minimise land use (eg rooftop culture)
- Challenge of promoting novel vegetables with high nutrition/low cost to populations unfamiliar with them.
- Loss of young, innovative farmers from rural areas
- Popularisation and education in vegetable growing as a source of employment, income generation and entrepreneurship in rural areas as a social strategy to slow urban migration and slum development
- Role of vegetable production in reducing urban unemployment and the social dislocation which accompanies it.

14. Food globalisation

AVRDC - The World Vegetable Center needs to consider both the wider benefits and the downsides of new high-value farming systems and crops before committing significant research resources to them, and to ensure it maintains a pro-poor balance in its choice of research projects.

Globalisation of the seed trade carries several implications including:

- Growing importation of international hybrid varieties will replace indigenous varieties and landraces, causing loss in local genetic and agricultural diversity which AVRDC - The World Vegetable Center breeding strategies may have to compensate for
- Large companies may supplant smaller local seed companies on whom AVRDC - The World Vegetable Center relies to deliver seeds to the poor
- Seed prices to the poor may rise too rapidly. As most farmers will want to plant improved varieties for higher yields, the challenge will be to ensure the availability of enough good quality seed at prices poor farmers can afford.
- Driven by supermarket buying practices, market demand for vegetables may favour imported ‘exotic’ varieties over indigenous vegetables with more desirable nutritional profiles. *The opposite could also occur with assistance*

8. Health constraints

AVRDC - The World Vegetable Center may wish to consider an emphasis on vegetable varieties and technologies which require lower labour inputs, which help protect the health of rural workers and which integrating food safety aspects into postharvest considerations in order to reduce food-borne and food-transmitted disease loads.

Also the importance aspect of labour creation

10. Funding environment

The following are offered as suggestions for further investigation, should they seem promising to the Board:

- Food firms and supermarkets. Hitherto elusive, these may be addressed through
  - Use of a high profile former food company CEO as 'ambassador'
  - Approaching companies not as donors but as investors
  - Development of a value proposition that benefits investors and the poor
  - Targeted approach.

- Strategic expansion into fruit research would enlarge the Center's R&D portfolio to the major portion of the world diet, significantly enhancing its global significance, stature and its overall case for donor, investor or philanthropic funding.

- Consider adopting a 'Cooperative Research Center' structure in which partner research institutions and companies contribute both funds and scientific resources to join, or for specific projects.

- Significantly increase international profile in the quality mass media through a planned approach based on the Center's achievements and expert opinion, as a platform for attracting more donors/investors.

- Open the germplasm collection on a commercial basis (e.g. fee+royalty) for the biodiscovery of new pharmaceutical and industrial compounds, in order to fund the facility's long-term expansion and preservation.

- Use the indigenous vegetables research as a platform for commercial publishing (not by the Center itself) of food, cooking and health books, generating a royalty stream to underwrite its other outreach activities. (See Outreach section)

- Establish a Vegetable R&D Trust Fund to which farmers and seed companies can donate as they rise in the value chain, enabling wealthier producers to contribute to work which benefits both them and poorer farmers. *Example of Suri Sehgal Foundation*

Panel Recommendations and Management Responses

Recommendations	*Responses*
Regional Center for Africa	
Regional Center for Africa	*There is a severe imbalance in the recommendations for RCA when compared with ARC (South-east Asia) and with RCSA (south Asia).* *In most cases recommendations for RCA should be generic for all regional centers and the issue of Asian continentality is not addressed. Or should we consider the reverse case of whether Africa should be sub-divided into ESA and WCA regions? Preference to retain Africa as a single unit at least in the short term*
Recommendation 2. II.1: Should no immediate solution be forthcoming, proceed with option (i): Register a not-for-profit company as a subsidiary of RCA, to import equipment tax free, as a temporary measure until the larger status issue is resolved with the Tanzanian Govt., , and, in order to avoid such problems in future, give consideration to option (ix): Restructure The World Vegetable Center as an international research network with a federated or cooperative research center structure, registered in a neutral location OR with each of its nodes registered in the continent of residence.	Be more patient and if necessary accept option 1. NGO status recently approved, efforts continuing on attempt to register as an intergovernmental agency.
RCA Research Management: **Recommendation 2.II.2**: a. Prepare clear job descriptions and worksheets for scientists clearly indicating their assignment to individual research projects and training activities. Review these worksheets annually in order to adjust them to the achievements, goals and career aspirations of individual staff (acc. to Human Resources Policy). b. Define the role of scientists in the RCA, providing them with time for self-initiated research projects including proposal writing and preparing research reports, scientific conferences and publication in peer-reviewed journals.	Accepted Accepted

Recommendations	*Responses*
Regional Center for Africa	
RCA Research Management	
c. In order to attract the most capable scientists for its research the World Vegetable Center should assist the career aspirations of its scientific staff after they leave the Center (as it does not and should not offer tenured appointments).	Accepted
d. Clarify reporting lines for scientists, going straight to the scientific coordinators of the projects and through these to the Director of the Regional Center, who then reports to the Deputy Director General - Research.	Accepted in principle but prefer Global Theme Leaders (or nominee coordinators) then Regional Directors (or regional managerial nominees) and then if need of arbitration DDG Research. Appraisal path should be identical. Establish regional research coordination committees.
e. Extend the working contracts for senior scientific staff to a basic three year minimum with the option of one or two renewals.	It is proposed to extend all contracts of IRS to 3 years but with no limit to renewals. Notice period to remain 6 months for regular practice but only 3 months for dismissal with cause or financial "force majeure". This latter reflects current operational reserves availability.
RCA Research Farm **Recommendation 2.II.3**:	
• As all research projects in RCA - including those initiated at HQ - need the farm as an essential research tool it should receive funding from the core budget or project overhead funds. Individual projects can contribute to the farm budget in proportion to their use of it.	All projects should seek to incorporate farm costs as a direct line item which should allow the farm to be essentially self-sustaining. It is probably unrealistic to expect such chargebacks to include major capital re-investment items such as building upgrades and very expensive farm and laboratory machinery. For these costs core capital should have a strategic renewal or upgrading plan at an institute wide level.
• The farm manager should be given a clear definition of her/his responsibilities. The farm manager should report to the Director of RCA.	Accepted
• Instead of daily appointments the farm labourers should be offered weekly or monthly contracts including a benefit package. This will motivate them more, ensure a steadier and more experienced workforce to support the scientific experiments, and allow the farm manager to attend more closely to infrastructure issues.	A judicious mixture of Regular Work Force (RWF) with contracts and a cadre of daily paid labourers --- DPLs (without contracts) would be required. DPL handling is probably a job to be delegated by the farm manager to the HR function.

Recommendations	*Responses*
Regional Center for Africa	
• The better educated and more experienced farm labourers should be offered annual contracts including a benefit package. They should have opportunity to qualify as field officers. This will help address a perceived shortage of experienced field research assistants.	As above. All grades of employee should be offered the chance to better themselves through training and education
• As for the whole The World Vegetable Center, RCA should accelerate the introduction of a Human Resources Policy for its staff, including field workers.	Accepted
• Occupational health and safety (OH&S) need to be strengthened to avoid potential health hazards in farm work. This includes awareness, procurement of and training in use of safety equipment, regular monitoring and supervision of occupational health and safety standards.	Accepted. The Center requires establishment of global and regional risk management committees incorporating OH&S dimensions to report to DDG Research at global level and Regional Directors at regional level. Provide annual statement to Executive Committee for specific donors viz. DFID. This goes beyond the existing Health and Safety committee to include all forms of risk such as to knowledge, reputation etc.
RCA Research Themes **Recommendation 2.II.4**: Establish a 'Nutrition Research Unit' within RCA facilitating dietary assessment, and database-founded nutritional analyses in close collaboration with the Nutrition Section in The World Vegetable Center-HQ. The NRU should include space for the scientifically sound performance of organoleptic investigations into vegetables and vegetable-based meals.	Should be part of the Global Theme 5 **Nutritional security, diet diversification and human health** which should be represented where possible at all regional research hubs. However, must be done in a scientific and rigorous manner. NRU activities can be undertaken at the regional level through partnerships with local labs and/or when specific funding becomes available. All routine analytical labs should be self-funded through chargeback mechanisms
RCA Training, Development & Outreach **Recommendation 2.11.5** A. Training: the Center should develop a more strategic approach to training based on the potential to achieve maximum impact. B. Outreach: set up an Africa node for communication and outreach, staffed by at least one full-time professional science communicator reporting to the Director RCA but also working closely with the Communication Manager in Taiwan.	Accepted. A Center-wide approach is justified and, since few donors will currently provide training specific grants, specialized trainee funded programs or project-based programs will be considered. Accepted in principle. Budgetary considerations to be examined and reporting lines determined internally

Recommendations	*Responses*
Asian Regional Center	
Recommendation 2.II.6: The Panel recommends that ARC be given the same status and managed in the same manner as the other regional centers	Accepted but see initial comment re: continentality question addressed at the beginning of 2.II. ARC must demonstrate that it can successfully generate a large funding base. A critical mass of scientists is presently lacking to make ARC truly effective.
Regional Center for South Asia	
Recommendation 2.II.7: A strategic plan for horticultural research and development within South Asia should be formulated to guide the development of RCSA.	Accepted but only as part of institutional strategic formulation (Recommendations in Section 2 V. A strategic planning exercise was undertaken when RCSA was created, with representatives from all South Asian nations and a report was released.
Research Theme 1: Germplasm	
Recommendation 2.III.1.1-12 :	
1. The Panel recommends the Center strengthen and expand the scope of its Material Transfer Agreement (MTA) both for the public and private sectors, to obtain feedback for impact assessment.	Accepted within bounds of legal dimensions but objectives of recommendation probably unrealistic. The value of voluntary feedback mechanisms of this type for impact assessment is often limited.
2. Completion of the nutritional audit of accessions to facilitate the Center's nutritional research needs.	Accepted. No timeline is agreed to as this is a very large job and will require specific fund raising.
3. Exploration of the scope to generate funds through involvement of the biotech sector or large food companies.	On hold at present while funding environment status quo remains favourable
4. An increased focus in collection policy on tackling and solving key human health issues with new kind of vegetables and also on documenting the possible toxic effects of the Indigenous Vegetables (IV) .	A review of assumptions by existing contributing partners is a prerequisite step.
5. Priority be given to completing the characterization, evaluation and documentation of existing accessions, their inclusion in AVGRIS and availability via the web.	Accepted using special project funding. NB anti-nutritional factors in IV may be overall more insidious than dramatic toxins.
6. A special initiative should be considered to explore the Collection for sources of resistance to drought, heat, salinity, acidity and other abiotic stresses.	Accepted but increasing importance of molecular biology level characterization must also be addressed

Recommendations	*Responses*
Research Theme 1: Germplasm	
7. The collection and evaluation of local and indigenous vegetables by the Regional Centers in South East Asia, South Asia, Central Asia, and Africa should be regarded as a priority as open-pollinated varieties, land races and local indigenous varieties in these regions are being rapidly swamped by improved varieties, hybrids and exotics.	Accepted Desirable in principle but may now be inhibited by ITPGRFA legal considerations. Crop Diversity Trust may be able to assist in this process.
8. Careful consideration should be given to the protocols and documentation for the storage, handling and distribution, import and export of GM brassica material expected to emerge from the CIMBAA project. (Such documentation will also assist in impact assessment)	Accepted
9. The bilateral agreement for collections between HQ and the regional centers should be reviewed and strengthened to further advance the collection and exchange of vegetable germplasm worldwide.	Accepted. Special arrangements may need to be negotiated with unusually restrictive countries.
10. The online data base information and AVGRIS system needs to be fully implemented and put into widespread use.	Accepted
11. Greater emphasis be placed on utilisation vis-a-vis collection, evaluation and characterisation.	Accepted as funding permits
12. Duplicate storage of germplasm, especially the elite lines, should be prioritised. The 'Black Box' arrangement with Norway should form the basis for similar agreements with gene banks like Tsukuba Gene Bank in Japan and Taiwan Gene Bank, as is currently being negotiated with Korea.	Accepted within the limitation of cost considerations
Research Theme 2: Breeding	
Recommendation 2.III.2.1: The Center should continue to re-focus its breeding programs in a regionally appropriate way,	Accepted
with elite level science and breeding concentrated at headquarters and downstream breeding of locally-relevant varieties in the regional centers	Accepted, but with possibility of critical mass for MAS etc. established in some regions where conditions are appropriate.

Recommendations	*Responses*
Research Theme 2: Breeding	
Recommendation 2.III.2.2: The Center should ensure it maintains an explicitly pro-poor balance in its efforts to develop commercial crop varieties and developing indigenous vegetables and open-pollinated varieties more suited to the needs of poor farmers and households.	Accepted in principle. In some cases with exotic varieties, hybrids may be more suitable to the needs of poor farmers especially if they sell to local or regional markets.
Recommendation 2.III.2.3: The Center should continue to pursue its cautious approach to biotechnology	Cautionary advice accepted. The Center should adopt biotechnological solutions that are cost and time effective, tried and tested approaches due to the large number of vegetable crops but it is vital that all dimensions of the institute from Theme 1-5 firmly embrace modern scientific methods whether biotechnological, ICT etc.
and transgenics, building its core scientific expertise but at the same time tuning its listening ability to the wishes and needs of consumers in target countries, as this offers the best prospects for rapid adoption.	Accepted. Yet, no over-commitment to GMOs until food crop flood gates are opened. World Vegetable Center must nevertheless stand and be counted in pro-GMO community while the issue is germane globally
Research Theme 3: Production Systems	
Overview of the Research Theme: **Recommendation 2.III.3.1**: Theme 3 should focus its research objectives further and develop a research strategy that exploits synergies in component research across different systems and develops system targets in the principal regions in which The World Vegetable Center is working.	Accepted but planning needs to be done in an institutionally inclusive manner from regional up to global levels and not necessarily Theme specific.
Integrated Soil and Water Management Strategies: **Recommendation 2.III.3.2** : While building capacity in soils research is justified in The World Vegetable Center, there is a range of choices between applied and strategic research and the location of that research. These choices should be governed by the development of research strategies in the regional centers.	Accepted
Integrated Pest Management: **Recommendation 2.III.3.3**: Entomological research at The World Vegetable Center needs to define clearer research targets across the different regions.	Accepted
Efficacy trials of potential interventions might be best coordinated with the expanding research on organic agriculture.	Rejected: Unsound suggestion as IPM is most often utilized in more conventional, disturbed, production systems so the results from organic could be misleading and there should be no restriction in trials to organic interventions only

Recommendations	*Responses*
Research Theme 4: Post-Harvest Research	
Seed Technology and Community Based Seed Systems: **Recommendation 2.III.3.4**: While maintaining the focus on private sector seed production capacity in Africa and the lagging areas of Asia, The World Vegetable Center should develop some capacity over the next five years in community-based seed production systems.	Accepted in principle. Absorb lessons on community-based seed production systems and how they might be scaled-out and up from partners such as ICRISAT first before commitment
Market Characterization and Analysis: **Recommendation 2.III.4.1** : The Theme 4 team should critically review the methods employed in supply chain studies and develop a more standardized code of practice that maximizes the identification of key entry points to improve market efficiency.	Accepted
Research on Post-Harvest Technologies: **Recommendation 2.III.4.2** : The World Vegetable Center should prioritize its work on post-harvest management of fresh vegetables and link it closely with market characterization studies and market organizational innovations. The research work on processing and micro-enterprises requires further justification and targeting.	Accepted especially in the context of currently limited human, laboratory and project financial resources in this area
Market Organizational Innovations for Improved Coordination: The Panel encourages continued work in this particular area of market innovation and focused on sub-Saharan Africa, but with some potential in the poorer areas of South Asia that are not currently well-integrated into fresh vegetable markets.	Accepted
Research Theme 5: Nutrition and Biostatistics	
Recommendations 2.III.5.1-4: • Improve the existing food science laboratory through upgrading of its equipment from Near-Red-Infrared-Spectroscopy (NIRS) to Gas-Chromatography-Mass-Spectrometry(GC-MS) and Atomic Absorption Spectroscopy(AAS) in order to achieve scientifically sound data on food composition.	Accepted in principle….cost considerations may influence timing and careful consideration must be given to technological options in relation to strategic demands

Recommendations	*Responses*
Research Theme 5: Nutrition and Biostatistics	
• Create a Community Nutrition Unit under theme V but in affiliation with the socio-economic group in order to build capacity for nutritional assessment (food frequency questionnaires, recall- and protocol-techniques, anthropometry) in research and development projects. This unit should also be staffed to facilitate organoleptic research on vegetables.	Accepted in principle that community nutrition is an area of importance for Global Themes 4 and 5 but recommendation has substantive cost and partnership implications which must be carefully addressed at institutional strategic capability level before implementation
• Create a nutrition research laboratory with facilities for cell culture, animal and human studies on bioavailability of nutrients and bioactivity of functional plant ingredients as well as fibre. Design this laboratory also as a linkage point for partners in health research who can carry out joint studies into health effects and safety of vegetable, vegetable-based meals and diets, as well as on nutriceutical effects of vegetables and vegetable extracts.	See previous response. No commitment to laboratory upgradation is accepted until strategic tasks are clearly defined in relation to institutional priorities. Expansion and upgrading in these aspects of human nutrition must be linked with research partnerships and projects funded by the health sector.
• Encourage all staff of the Nutrition Research Unit to cooperate in outreach activities on improving human nutrition that would be implemented by the Community Nutrition Unit in collaboration with the Communication Unit and the regional centers.	The dimension of this recommendation to encourage attention to human nutritional issues institution-wide is accepted. Its proposed managerial dimensions to activate this enhanced attention are untimely. However, it is recognized the NRU must improve its global prospective and engagement.
Biostatistics Unit **Recommendation 2.III.5.5**: The World Vegetable Center should employ a short term specialist consultant to advise it on the best way to set up a Biostatistics Unit serving the needs of scientists in headquarters as well as in Regional Centers and offices.	Accepted in principle but larger aspects of need for support not only in statistics but also bioinformatics needs to be considered institution-wide and the substantive cost implications of the recommendations that such a study might generate. Consultation with partners (ICRAF, IRRI, ICARDA, CIP, ICRISAT, Bioversity etc.) and explore opportunities for outsourcing or joint resources would be first step.
Knowledge Management and Outreach	
Recommendation 2.IV.1. It is recommended that, in growing its communication activity, The World Vegetable Center focus an increasing proportion of effort and resources on reaching very large numbers of poor farmers and consumers as well as core audiences, via mass media.	Accepted within current limitations of budget feasibility

Recommendations	*Responses*
Knowledge Management and Outreach	
Recommendation 2.IV.2. It is recommended that reaching poor farmers and consumers via mass media be made an explicit goal of the outreach plan, in line with the World Vegetable Center's mission. This priority should be reflected in the Center's strategic and medium-term plans, to align them more closely to the mission.	Accepted but following a strategic planning exercise
The Knowledge Fount **Recommendation 2.IV.3**. It is recommended that scientific editing be viewed as technical support for the scientific enterprise and housed, physically and in budget terms, within the World Vegetable Center research function. It should have its own dedicated staff.	Oversimplistic recommendation. Managerial study required before decision implemented.
All research projects should have a budget allocation for publication of results.	Accepted
The Knowledge Well **Recommendation 2.IV.4**. It is recommended that the World Vegetable Center rapidly grow its website as a resource containing the total knowledge output of the institution, both scientific and plain-language, for researchers, farmers, consumers, policymakers and mass dissemination.	Accepted
The Knowledge River **Recommendation 2.IV.5**. It is recommended the World Vegetable Center give much greater emphasis to mass means of communication to reinforce messages to donors, stakeholders and partners, and to raise awareness of new varieties and technologies among farmers and consumers in poor regions.	Accepted
Recommendation 2.IV.6. It is recommended that energetic and qualified outreach professionals be progressively stationed in all Regional Centers, starting with Africa, with clean lines of reporting.	Accepted within existing budgetary strictures and prioritization of appointments for new staff

Recommendations	*Responses*
Development and Impact	
Recommendation 2.V.1: The World Vegetable Center should formulate and implement a development strategy. *(The panel considers that there are at least five possible ways The World Vegetable Center can incorporate development more strongly into its strategy and program structure –please read in the report)*	Accepted (items 1. and 4. are more attractive but all alternatives will be considered) but only as an element of a greater strategic plan which needs to be grown bottom up from the regions and only when they are sufficiently developed and stable to look with confidence into the future
Future Organizational Issues	
Overall Organizational Structure: **Recommendation 2.VI.1**: The panel recommends that The World Vegetable Center develops within its next strategic plan a framework for devolving and decentralizing its research activities across its growing network of regional centers.	Accepted
Regional Center Priorities: **Recommendation 2.VI.2**: In its next strategic plan, The World Vegetable Center needs to develop a strategy to bring the horticultural value revolution to the lagging areas of South Asia and the smallholder producing areas of sub-Saharan Africa.	Accepted, with the understanding that the scientists should be based in research situations where they are not isolated
Restructuring and Possible Devolution of Research Programs: **Recommendation 2.VI.3**: As a first step in the development of its next strategic plan, The World Vegetable Center needs to assess the restructuring of research programs in terms of optimal structure and optimal deployment in the regions. Clarity and agreement on the basic structure is required for the different themes to consolidate their individual strategies and programs.	No action on theme structure until institutional strategy is determined and priority research foci are determined. Form will then follow function. Linked to 2.VI.1 above.
Issues in Developing an Optimal Research Program Structure: **Recommendation 2.VI.4 - See 2.V.1**, in the previous section dealing with Development and Impact.	Repeating answer for 2.V.1 Accepted (items 1. and 4.) but only as an element of a greater strategic plan which needs to be grown bottom up from the regions and only when they are sufficiently developed and stable to look with confidence into the future

Recommendations	*Responses*
Future Organizational Issues	
Decentralization and Possible Devolution of Research Programs: **Recommendation 2.VI.5**: The Panel recommends that initially there be a consolidation of the research theme structure with a view that its implementation should in the future be organized as a distributed set of activities across the regional centers. To balance this consolidation, regional centers should develop research and development strategies for their regions where there is clarity on targets, partnerships with regional public and private institutions in achieving those targets, and research priorities within the region developed within the frame of the consolidated research structure.	Rejected as it appears to be in conflict with acceptance of 2.VI. 6
Implications for Research Management: **Recommendation 2.VI.6**: Based on funding possibilities over the next couple years, the Panel recommends that The World Vegetable Center consider moving towards a devolved program and management structure where research coordination and management rests principally with the regional center directors and where research theme coordinators ensure the scientific quality of the research, linkage to advanced research, network information and product flows between regional centers, and when advantageous, develop comparative research across regions.	Accepted. Managerial staff training will be required in consequence
Management and Administration	
The Board and Governance: **Recommendation 3.1**: Board and management should review the role of PROCOM with a view to improving Board interaction and input into research programs and strategies, particularly in the medium and strategic planning processes.	Accepted. Advice at strategic level is welcomed.
Financial matters: **Recommendation 3.2**: The World Vegetable Center should review its policy on overheads generated by projects in the regional centers with a view to allocating them to the regional center rather than to core, in order to cover normal operating and capital costs of the regional center.	Rejected: Recommendation could severely weaken the integrity of the institution and prevent core investment as and where needed most.

Recommendations	*Responses*
Management and Administration	
Recommendation 3.3: To meet the financial management needs of The World Vegetable Center as it expands the number of regional centers and projects within them, a more robust financial management system is needed. It is recommended that a financial management consultant be contracted to review the needs of the Center and advise on the best options.	Accepted and already initiated
New sources of funding:: **Recommendation 3.4**: The Center should widen the scope of its search for new sources of funding, particularly from non-traditional sources.	Accepted with caution for institutional reputation
It should actively seek a higher global profile to underpin this.	Accepted
Human Resources policy: **Recommendation 3.5:** The center should implement its current HR policy fully as a matter of priority.	Accepted but also must now be adapted to be functional for a decentralized structure and the financial and managerial implications must also be digested to ensure equity
Employment contracts: **Recommendation 3.6**: The center should review its policy on staff contracts with a view to increasing motivation in existing staff, flexibility in management and employment, and the attractiveness to external applicants of working for the Center.	Accepted, but implies retention of considerable prerogative at the Director General level.
Career development: **Recommendation 3.7**: The Center should adopt a formal policy of reviewing staff performance annually and introduce a mentoring system to develop junior staff.	Accepted
Health and safety: **Recommendation 3.8:** The Center should audit OHS standards and practices throughout the organization, especially in regional centers and around sensitive projects.	Accepted but see answer to recommendation 2 II. 3 bullet 6 Center-wide need for establishment of global and regional risk management committees incorporating OH&S dimensions to report to DDG Research at global level and Regional Directors at regional level. Provide annual statement to Executive Committee for specific donors viz. DFID