

Ensuring Future Food and Nutritional Security in the Context of a Warming World with More Limited Natural Resources

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Abstract

Malnutrition is worst in sub-Saharan Africa and South Asia, but over the next 40 years food production in these regions will need to more than double to meet the needs of population growth. In both regions smallholder farmers will continue to provide the bulk of food production as climate change brings more extremes of drought and flooding, making crop production more risky. Malnutrition is primarily a “hidden hunger” that severely stunts human potential due to a lack of vital protein and micronutrients such as vitamins or minerals. Starvation and obesity are extreme expressions of malnutrition. A past focus on increasing production of staple crops has exacerbated the problem of imbalanced diets and malnutrition, and decreased diversity in cropping systems. Vegetables are our most important source of micronutrients and a vital source of protein, but production in most countries is well below the minimum to provide a basic balanced diet for all. Hardy vegetables produced by smallholder farmers should have a vital role to play in overcoming malnutrition, particularly in South Asia, Africa, and the Pacific. Although often seen as undervalued weeds in the past, easily grown indigenous vegetables are an extremely important source of nutrition for the poorest. Wider use of improved lines can significantly increase nutritional security. Improved varieties of globally important vegetables and new production systems that permit production under extremes of drought or flooding also are needed. All people are interested in their food, but a professional disconnect has developed between agriculturalists and health professionals who view the human food chain from the opposite ends of production or consumption. A common focus on nutritional security provides a professional meeting point and an opportunity to market horticulture to a generation of students who may have little background in food production, but are certainly interested in its consumption.

INTRODUCTION

Horticulturalists play a crucial role in ensuring future food and nutritional security for those most vulnerable to stresses imposed by climate change and resource scarcity, but they cannot do it alone or by continuing to apply old forms of thinking about their profession.

The future regions and communities most vulnerable to climate stress and resource shortages will be those currently most disadvantaged in sub-Saharan Africa and South Asia, where agricultural production is dominated by smallholders and past food policies favored self-sufficiency in staples. Smallholders have highly diverse cropping systems and the vegetables they supply to their communities provide essential micronutrients for balanced diets that staples cannot. Ensuring future nutritional security

means providing balanced diets, not just self-sufficiency in staples; thus, horticulturalists have a central role in making it happen.

Vegetable crops of predominantly temperate origin that are popular in the West have come to dominate world production, aided by their spread to all continents during colonial times. Far less emphasis has been placed on tropical indigenous vegetables from sub-Saharan Africa and Asia that in many cases may be better adapted to future warmer climate scenarios than the crops the world more commonly views as “vegetables.” Horticulturalists need to rethink which vegetables a warmer world will need to rely on.

High value vegetables preferentially receive more inputs than other crops to help them cope with unfavorable weather and nutritional deficiencies, but extremes of heat, drought, salinity, and flooding will be unavoidable in a warming world. Some vegetable cultural practices to cope with these stressors already exist, but the development of well-adapted varieties will take longer. Little work has been done to assess the genetic variability of most vegetables to cope with less than optimum growing conditions. Horticulturalists will need to develop cultural practices and breed vegetables to cope with harsher climate conditions and lower inputs than they have come to expect.

Food and nutritional security involves securing the whole food chain from production through to consumption. Horticulturalists traditionally have focused on production, but issues such as equitable access to food and ensuring a balanced diet increasingly demand attention. Those with the least power and already substantially imbalanced diets are most affected by climate change and limited resources. Horticulturalists need to build greater connections with health professionals who have more experience with aspects of consumption. We are all concerned by what we eat, and securing the food chain to provide a balanced diet—particularly for the most vulnerable—can point us toward an alternative way of viewing the role of horticulturalists in a warming world.

DISCUSSION

Overcoming Malnutrition Will Largely Depend on Smallholder Farmers

Climate change is expected to have the most negative impacts on crop production in sub-Saharan Africa and to a lesser extent in South Asia, but without major economic growth to pay for imports, the burden of providing food in these regions will fall primarily on their smallholder farmers.

Climate change could lead to yield reductions of up to 50% in some countries in Africa by 2020, and net crop revenues could fall by as much as 90% by 2100, hitting smallholder farmers hardest (Boko et al., 2007). Crop yields in Asia are expected to decline by 2.5–10% from 2020 onward, and by 5–30% after 2050, with declines worst in South and Central Asia (Cruz et al., 2007). Climate change is expected to increase the variability of agricultural production due to increasing incidence of extreme climatic events. Droughts and floods that are now the major causes of food shortages in sub-Saharan Africa and South Asia will increase. The regions of the world that currently have the highest levels of poverty and chronic undernourishment are also those most likely to be adversely affected by climate change (FAO, 2009a).

A recent major review of future world food production predicted that the world’s population will increase by a third, or 2.3 billion people, by 2050 (FAO, 2009b). Most of this growth will be in developing countries; greatest in sub-Saharan Africa (+114%), and least in East and Southeast Asia (+13%). A projected average global economic growth of

2.9% would mean a major reduction in extreme poverty in developing countries by 2050 and a decreased inequality of incomes and less widespread chronic undernutrition, but global food production will still need to increase by 70%, and in developing countries it will need to almost double.

With sufficient national growth in incomes, food imports may make up for some food shortages in regions likely to be detrimentally affected by climate change, but most local food supplies will continue to be provided by smallholder farmers. Surveys of farm productivity in developing countries often show that small farms produce more per hectare than large farms. This is particularly so when labor is a major component of production and capital is costly, as is often the case in Africa. However the average performance of smallholder agriculture in Africa over the last 50 years has been lackluster, with per capita production declining marginally since the early 1960s (Wiggins, 2009).

The average agricultural productivity performance across Africa hides many significant regional and national success stories that suggest that smallholder agriculture is quite capable of major increases in the production of a range of commodities under the right circumstances. Northern and Western Africa did much better than other parts of the continent over this period, and land-locked Burkina Faso raised its grain output from smallholder farms over the period at an even higher rate than Vietnam, one of the major success stories of the Green Revolution. Smallholder farmers are likely to be most successful when there is a favorable investment climate for farming, good investment in agricultural research and extension, protection of property rights, and the existence of demand that is transmitted to the farm gate (Wiggins, 2009).

Malnutrition Is Often Hidden and Overcoming It Depends on More than Staples

A well-balanced diet is essential to good health and human development, and malnutrition occurs when this is not the case. Malnutrition is a problem affecting primarily the poor in both developing and developed countries and is more widespread than hunger, affecting an estimated one in three people worldwide (WHO, 2001). But most malnutrition is hidden and is primarily due to a lack of vital micronutrients, including vitamins and minerals. Extreme malnourishment can lead to death from starvation or chronic diseases from obesity. Mostly its results are insidious more than spectacular, and rich and poor alike suffer from imbalanced diets. There are no news images of starving children to raise public awareness of the problem. The “hidden hunger” of micronutrient and vitamin deficiencies increases the risk of illness or death from infectious diseases and children do not develop to their full physical or mental potential.

A monotonous and imbalanced diet of cheap staples is the norm for much of the world’s population. One measure of this is how much dietary energy is provided by a staple food. A high percentage of total energy consumption provided by starchy staple food as a proportion of all foods consumed indicates low diversity in the diet. Table 1 shows the percentage of total energy consumed that is provided by starchy cereals, roots or tubers for food-insecure countries in Africa and south Asia that have rates of undernourishment and undernutrition exceeding 30%. Diets in Ethiopia, Madagascar, Mozambique, Tanzania, Zambia, Burkina Faso, Bangladesh, and Nepal are very monotonous with more than 70% of energy consumed from starchy staples. The table also shows that food diversity in most of these countries has not improved over the past ten years.

Table 1. Contribution of starchy foods to total dietary energy consumption in countries with high rates of undernourishment and undernutrition in Africa and South Asia.

Region	Country	Under-nourishment (%) ¹	Under-nutrition (%) ²	Dietary energy from starchy staple (%) ³		
				1990–1992	1995–1997	2003–2005
Central Africa	Angola	44	31	59	65	63
	Cent. African Rep	41		57	56	54
	Chad	38	37	65	61	62
Eastern Africa	Burundi	63	39	46	47	53
	Comoros	51	25	57	58	53
	Djibouti	31	33	52	50	53
	Eritrea	66	40	-	77	71
	Ethiopia	44	38	-	81	80
	Kenya	30	21	55	57	57
	Madagascar	35	42	75	75	79
	Mozambique	37	18	76	77	79
	Rwanda	40	23	48	44	56
	Tanzania	35	22	71	70	71
	Zambia	45	19	77	79	76
	Zimbabwe	39	17	64	63	58
Western Africa	Burkina Faso	9	32	76	74	73
	Guinea-Bissau	31	19	69	69	69
	Liberia	38	24	68	59	65
	Mali	10	32	70	70	69
	Mauritania	8	31	56	53	47
	Niger	28	43	78	74	68
	Sierra Leone	46	30	60	60	60
	Togo	37	21	76	75	74
South Asia	Bangladesh	26	46	85	84	82
	India	22	48	66	64	60
	Maldives	7	30	51	45	40
	Nepal	16	45	79	77	73
	Pakistan	23	38	56	53	51

Data source: FAOSTAT 2010a.

¹ Undernourishment: prevalence of undernourishment in total population (%). Source: FAOSTAT. Food security statistics: Food deprivation: Prevalence of undernourishment in total population (20.11.2009)

² Undernutrition: prevalence of underweight (moderate, less than - 2 s.d) in children under the age of five years. Source: FAOSTAT. Food security statistics: Nutritional status: Children (14.12.2009)

³ Share of starchy foods in total dietary energy consumption adapted from FAOSTAT Food security statistics: Diet composition, Diet diversification index, Dietary energy (07.08.2008)

A continued dietary deficit in micronutrients and vitamins may be a more important nutritional problem in sub-Saharan Africa and South Asia over the coming decades than a lack of energy. Grain production is expected to increase sufficiently to meet the energy demands of population growth, and daily energy availability is expected to increase from around 2770 kcal in 2003-2005 to an average of 2970 kcal in developing countries by 2050 (FAO, 2009a).

It is not just the poor in developing countries who have imbalanced diets dominated by staples. A global epidemic of excess weight and obesity is linked to less physical activity and overconsumption of poor quality food with diluted nutrients and dense energy. Obesity is now a major public health issue in most developed countries, predisposing individuals to serious chronic diseases, including type II diabetes, cardiovascular disease, hypertension and stroke, as well as certain forms of cancer. It is also a particularly serious problem in countries in transition including China and India, where type II diabetes in children is increasing at an alarming rate (Hossain et al., 2007; Chan et al., 2009).

Good health depends on dietary diversity, and as poverty increases, human diets become less diverse. In impoverished countries the poor have little choice and are forced to rely on the cheapest available staples and dietary diversity and health suffer. In richer countries, changes in the food systems have made poor quality processed foods high in carbohydrates and fats more affordable, available, and accessible; this has most impact on the diets of the poor (Monteiro et al., 2004; Friel and Baker, 2009).

A long term global focus on ensuring supplies of staple crops has come at the expense of dietary diversity. The emphasis has been on ensuring supplies of macronutrients while putting less emphasis on major sources of micronutrients—a focus on survival rather than on health. Continuing to focus on increasing the production of staples will only exacerbate the real food problem, which is one of imbalanced diets.

Vegetable Production Is Well Below the Minimum for Good Health

Vegetables can be a major source of protein for the poor, and they provide our most important dietary source of essential micronutrients, including vitamins and minerals such as calcium, iron, zinc, folate, and pro-vitamin A, as well as antioxidants that can help prevent cancers. World vegetable production does not meet even the basic nutritional needs of most countries, and the resulting imbalanced diets are one of the world's most serious health problems. Smallholder vegetable production has a vital role to play in overcoming this gap.

In much of South Asia and sub-Saharan Africa, dietary deficiencies of iron and vitamin A are major health problems, resulting in millions of deaths each year. Iron deficiency anemia is one of the world's most prevalent dietary deficiencies. In a recent report on the world nutrition situation, the UN estimated that 4 to 5 billion people are affected, with the most severe incidence in South Asia and sub-Saharan Africa. Its effects on cognitive development, fatigue and mortality have significant economic impacts, estimated at 7.9% of GDP in the case of Bangladesh (ACC/SCN, 2004). Vitamin A deficiency also is widespread and an estimated 190 million preschool children and 19 million pregnant women are affected. More than half of these are found in South and East Asia and under a third in Africa (WHO, 2009). Vitamin A deficiency is a major cause of blindness and weakened resistance to disease, resulting in the deaths of up to 3 million children each year (ACC/SCN, 2004).

Populations in developing countries with more diverse diets have better nutrition (Johns and Eyzaguirre, 2007), but the production of vegetables is often well below the minimum needed for good health. The situation is particularly dire in countries that are already food insecure. Figure 1 shows those countries in Africa and South Asia classified as severely food insecure, either because of undernourishment rates above 30%, or child underweight rates above 30% (FAOSTAT, 2010a), and overlays this with information on fruit and vegetable consumption. The bars show average fruit and vegetable consumption, (FAOSTAT, 2010b) while the blue line shows the minimum annual recommended intake of 150 kg per capita of fruit and vegetables (WHO, 2003). Only three of the 28 countries meet or exceed recommended intake. Ten countries, or over a third, fall short of meeting even 30% of the recommended intake levels, as shown by the red line. These are Angola, Chad, Eritrea, Ethiopia, Mozambique, Zambia, Zimbabwe, Burkina Faso, Togo, and Bangladesh.

A lack of local supplies is a major cause of low consumption. Supplies of fruits and vegetables for sub-Saharan Africa and South Asia are well below those of most other regions in the world, and cannot supply the WHO recommended minimum annual per capita consumption of 150 kg per annum (Fig. 2). Without the income to supplement local supplies with imports, per capita consumption in these regions suffers.

A lack of local fruit and vegetable supplies can hit the urban poor hardest, particularly when combined with increases in the price of staples. When poor households are under financial stress they have little capacity to adapt, and dietary quality suffers. Food accounts for 50–70% of total household expenditures in South and Southeast Asia, and most of that is spent on staple foods rather than meat or vegetables. When such households are under financial stress they first cut down on non-staples, then on the total number of meals (SCN, 2009). An increase in staple prices combined with a lack of fruit and vegetable supplies shifts diets to less nutritious food and the deficit of dietary micronutrients worsens. Increasing malnutrition produces a greater risk of illness or death

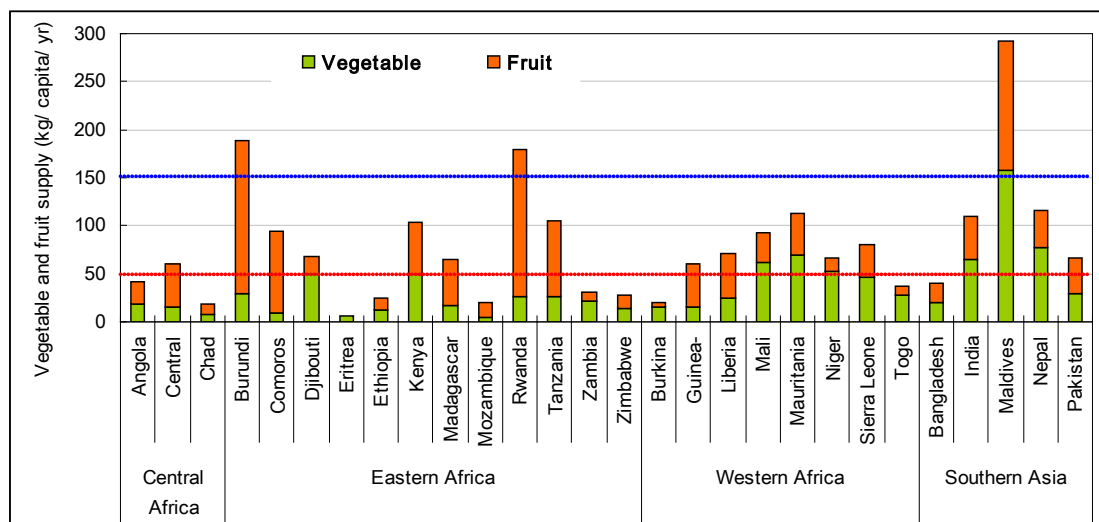


Fig. 1. Fruit and vegetable consumption compared to WHO minimum recommended intake.

Top dotted line: WHO minimum recommended intake

Bottom dotted line: 30% of recommended intake

from infectious diseases and children may not develop to their full physical or mental potential.

Smallholder farmers growing hardy vegetables must be at the forefront of tackling this nutritional problem. Vegetables are generally highly perishable, and most national supplies of vegetables are produced locally or regionally. Local producers will need to fill local needs. Given the right varieties, input technologies, and market signals, local vegetable production in developing countries can be dramatically increased. This can include both peri-urban as well as rural production. Over the last 20 years world vegetable production has more than doubled and most of this increase has been due to increased production by smallholder farmers in China (FAOSTAT, 2010c).

Improved Production under More Stressful Conditions Is Needed

If smallholder farmers in South Asia and sub-Saharan Africa are to meet the nutritional challenges posed by imbalanced diets and the agronomic challenges posed by changing climate, they need improved vegetable production systems, well-adapted varieties, and strong market signals. The most appropriate crops to grow may not necessarily be those that are currently globally important, but may be those of regional importance.

Vegetables generally are sensitive to environmental extremes. High temperatures and moisture stress are already major causes of low yields in the tropics and these are likely to be exacerbated by climate change. Tomato (*Solanum lycopersicum*) is the world's most important vegetable crop, grown on over 5.2 million ha (FAOSTAT, 2010c). In addition to cabbage (*Brassica oleracea* var. *capitata*), onion (*Allium cepa*), hot pepper (*Capsicum annuum*) and eggplant (*Solanum melongena*), tomato is a globally

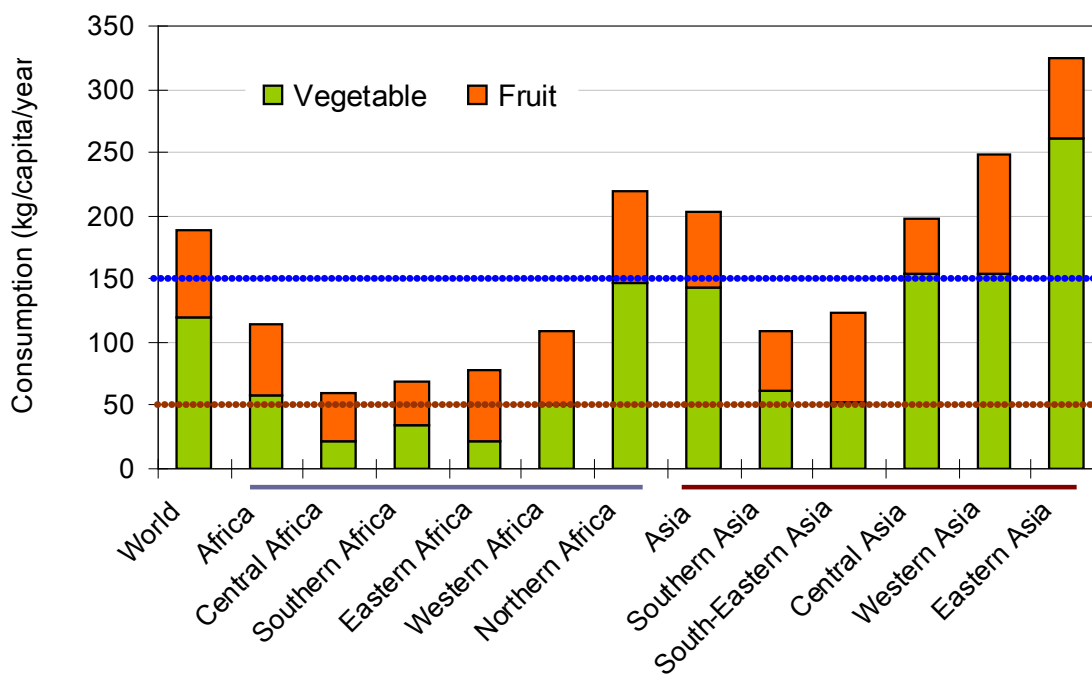


Fig. 2. Fruit and vegetable supplies per capita by regions.
 Top dotted line: WHO minimum recommended intake
 Bottom dotted line: 50% of recommended intake

significant crop important to smallholder production in Asia and sub-Saharan Africa (Brown et al., 2005). Most vegetables prefer cooler temperatures, and productivity is lowest in the hot and humid lowlands (Ali, 2000). For instance, in sub-Saharan Africa (excluding South Africa) average tomato yields are only about 7–12 t/ha, while those in tropical Asia are about 15–20 t/ha; both well below the average yields in temperate regions (FAOSTAT, 2010c).

Improved production systems that can cope with climate extremes must allow vegetables to produce under high temperatures, greater drought stress, increased soil salinity, and periodic flooding. This will involve a combination of improved varieties and modified production systems. Most research on the effect of environmental stress has been done on tomato and there is a great need for more research on other vegetables (de la Pena and Hughes, 2007). High temperatures decrease pollen productivity and viability (Porch and Jann, 2001), and inhibit photosynthesis in tomato (Hazra et al., 2007) resulting in reduced fruit set, smaller and lower quality fruits, and ultimately a reduction in yield. Drought is the single biggest cause of crop failures worldwide (CGIAR, 2003) and vegetables are particularly susceptible as most are succulent plants consisting of generally more than 90% water (AVRDC, 1990). Soil salinity is an increasing threat; high soil salinity afflicts about 20% of cultivated land and 33% of irrigated land worldwide (Foolad, 2004). Many globally important vegetables, including onion, are sensitive to soil salinity while cucumbers (*Cucumis sativus*), eggplants, crucifers, peppers and tomatoes are only moderately sensitive (Shannon and Grieve, 1999). Vegetable production in the tropics is often limited during the rainy season as most vegetables are highly susceptible to flooding. Genetic variation in this characteristic is limited, particularly in tomatoes, which rapidly wilt and die following a short period of flooding, particularly at high temperatures (Kuo et al., 1982).

Simple, affordable, and accessible technologies must be used to increase the resilience of smallholder vegetable farmers to cope with increased problems due to high temperatures, drought, salinity, and flooding (de la Pena and Hughes, 2007). These include water-saving drip irrigation as well as mulching and the use of shelters and raised beds help to conserve soil moisture, prevent soil degradation, and protect vegetables from heavy rains, high temperatures, and flooding. Work carried out at AVRDC–The World Vegetable Center has been particularly successful in grafting tomato scions onto eggplant rootstocks to provide improved flooding tolerance (Black et al., 2003).

In many cases such technologies can affordably improve smallholder production under climatic extremes, but greater varietal tolerance to these factors is the most cost-effective option. This is more likely to be achieved in species that are native to climates with marked seasonality and able to acclimatize to highly variable environments (Pereira and Chavez, 1995).

Breeding for heat tolerance has proved easier than breeding for drought, salinity, or flooding tolerance (de la Pena and Hughes, 2007). AVRDC–The World Vegetable Center has developed cultivars of tomato and Chinese cabbage (*Brassica rapa* subsp. *pekinensis* and *chinensis*) with good adaptation to hot and humid tropical environments since the early 1970s. These improved lines initiated the successful cultivation of tomato and Chinese cabbage in the lowland tropics. The heat tolerant lines of tomato show no reduction in pollen viability from heat stress and produce a fruit set 15% higher than heat sensitive cultivars under the same conditions.

More improved lines are needed for future climatic scenarios, and these must be able to match the yields of conventional varieties under favorable growing conditions.

New cultivars must be developed from both existing tomato lines and from the relatively unexploited wild relatives of tomato. It is particularly challenging to breed for drought and salinity tolerance as this is controlled by multiple genes. It also varies with crop developmental stage (Foolad, 1999). Some wild relatives of tomato have good drought and salinity tolerance (Rick, 1979), but this is often genetically linked to undesirable fruit characteristics such as small fruit size and low fruit set and yield.

Only limited molecular marker analysis of the characters underlying stress tolerance in vegetables has been done but work is currently underway at AVRDC–The World Vegetable Center to identify quantitative trait loci (QTLs) underlying tolerance to heat, flooding, and drought tolerance in tomato. Mapping populations have been produced and characterized using simple sequence repeat (SSR) markers to identify both the single major genes and QTL loci involved in heat tolerance. Mapping populations containing drought tolerant material from a wild relative of tomato (*Solanum pimpinellifolium*), and a cultivated tomato also have been produced to identify QTLs involved in drought tolerance. The Center is developing easy and reliable screening methods for characterizing new sources of heat, drought, flooding, and salinity tolerant germplasm from both wild relatives and cultivated lines. Simple physiological screening methods complement the molecular characterization that is underway.

Developing vegetables that are more tolerant of environmental extremes should not be limited to only those of global importance. Many indigenous vegetables from the tropics already are well adapted to the climatic conditions likely to be more widespread in the future. Many are highly nutritious and familiar to smallholder farmers, and can provide excellent opportunities to help farmers cope with climate change.

Improving Indigenous Vegetables Is Particularly Important for the Poorest

Vegetable production in sub-Saharan Africa has underemphasized the continent's rich heritage of hardy indigenous vegetables. Exotic vegetables introduced by settler communities historically shifted the production and consumption emphasis from indigenous to globally important, exotic species. Yet indigenous vegetables are easy to grow, require minimal external inputs, and are highly suited to resource-poor farmers in Africa (Opole et al., 1991). The number of species involved is large and poorly known. Many are cultivated in small patches in home gardens or found growing as weeds in marginal areas within farms or growing wild in forest areas; they do not have sufficient visibility as commodities, so the aggregated value of their contribution to rural diets and food security often has been underappreciated and they have been neglected by researchers, policy makers, the development sector, and funding agencies.

Indigenous vegetables are an important part of farming systems and diets. They are crucial for nutrition, poverty alleviation, and food security, particularly during famine and natural disasters. They are very diverse. More than 100 traditional vegetables have been identified by farmers in just four districts in Tanzania (Keller et al., 2005), and the total number of species of food crops cultivated in sub-Saharan Africa is among the highest for any region of the world (Leakey and Wills, 1977; Tindall, 1977; Martin, 1984). In Tanzania, Uganda, Rwanda, and Malawi, a socioeconomic study indicated that rural households rely on indigenous vegetables as a major source of micronutrients, and this is particularly important for the poorest (Weinberger and Msuya, 2004). In Tanzania, indigenous vegetables comprised 40% of the total vegetables consumed by the poorest households compared with 11% of the wealthiest. Indigenous vegetables also provided

approximately half of the vitamin A requirements for the poorest households and slightly less than one-third of their iron requirements.

Indigenous vegetables form a significant part of African rural economies, comprising more than 70% of the traded vegetables in rural markets, and about 10% in bigger towns. They are an important source of employment, income generation, and improved household food security (Schipper and Budd, 1997; Onyango, 2002). Their sale and processing are particularly important for women who usually manage home and community vegetable gardens. Women, particularly the more elderly, often have the knowledge of how to prepare indigenous vegetables, conserve seeds and grow them. Most vegetable vendors in local markets are women, and in many cases low input indigenous vegetables are their only source of cash income for the welfare of their families. Supply is often a bigger problem than demand. While there is a particularly high demand in urban markets for indigenous leafy vegetables, supplies are often limited by the amount of seed available to farmers. More than 70% of seed is kept by farmers themselves from previous crops or obtained from neighbors, and private seed companies are only slowly entering the market for seed for indigenous vegetables (Weinberger and Msuya, 2004).

AVRDC–The World Vegetable Center places particular importance on developing greater use of indigenous vegetables throughout the tropics. Of more than 57,000 accessions in its genebank about 13,000 are indigenous to Africa, South Asia or Southeast Asia. Selection and breeding programs are underway to expand the production of the most popular species. Indigenous vegetable seed kits with more than 50 species have been developed for distribution to research institutions, school gardens, and home gardens in Southeast Asia, and commercial seed production of improved lines is now well established in some African countries.

Nutritional Security Provides a Meeting Point for Agriculture and Health

Ensuring future food and nutritional security in the context of both a warming world and one with more limited natural resources will not happen unless horticulture and health professionals collaborate in solving the diverse problems involved. It requires different thinking about the target audiences, the crops and production methods involved as well as issues of consumption and nutrition.

Horticulturalists are good at working with the production end of the human food chain, but generally not so familiar with the opposite end concerned with consumption, which is more the preserve of health professionals. Ensuring food and nutritional security depends on food's (i) availability, the total supply provided from local and other sources; (ii) accessibility, the distribution of food and the power that people have to obtain it; (iii) affordability, the relative cost of different foods compared to other basics of life; and (iv) acceptability, which includes the capacity of individuals to utilize the nutrients in their food, and its safety, quality, and cultural acceptance (Friel and Baker, 2009)

The number of horticultural farmers is declining in developed countries; consequently there are fewer students coming to horticulture or agriculture with a family background in farming. For example, in the United Kingdom, the University of Reading—the country's most noted agricultural university—has had a significant erosion over the last decade of at least 10 master's level agricultural/horticultural courses owing to lack of sufficient student demand. This erosion has been concentrated in what historically have been viewed as vital disciplines such as plant breeding, agronomy,

pathology, and entomology. Similar reductions in student demand have been seen in many European, US, and Australian universities.

But yet we all eat, and the problem of imbalanced diets is just as critical in developed as in developing countries. Obesity may be more familiar to most students than starvation as an exemplar of the global problem of imbalanced diets. Thus we need to reconfigure this issue to see that solving the problem of imbalanced diets and providing nutritional security is as much an issue of producing the right crops as it is of consuming the right foods. Horticulture must redefine and expand its role to ensure quality diets in addition to the production of specific crops.

The professional disconnect that has developed between agriculturalists concerned with food production and health professionals concerned with food consumption has marginalized the importance of horticulture as essential to a balanced diet and human nutritional security. If the key issue is a well managed food chain that ensures both the health of production systems and consumers, then increasing staple production no longer becomes the sole priority. Horticulture becomes a key component in ensuring nutritional security through balanced diets, and particularly the welfare of those most likely to be affected by future climate change and resource constraints.

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