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Symposium on 'Wild-gathered plants: basic nutrition, health and survival'

Linking biodiversity, diet and health in policy and practice

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Simplification of human diets associated with increased accessibility of inexpensive agricultural commodities and erosion of agrobiodiversity leads to nutrient deficiencies and excess energy consumption. Non-communicable diseases are growing causes of death and disability worldwide. Successful food systems in transition effectively draw on locally-available foods, food variety and traditional food cultures. In practice this process involves empirical research, public policy, promotion and applied action in support of multi-sectoral, community-based strategies linking rural producers and urban consumers, subsistence and market economies, and traditional and modern food systems. Implementation of the International Plant Genetic Resources Institute's Global Nutrition Strategy in Sub-Saharan Africa offers a useful case study. Relevant policy platforms, in which biodiversity conservation and nutrition are and should be linked, include the Millennium Development Goals, Millennium Ecosystem Assessment, Convention on Biological Diversity, Global Strategy on Diet, Physical Activity and Health, Food-Based Dietary Guidelines, Right to Adequate Food and UN Human Rights Commission's Permanent Forum on Indigenous Issues. The largely unexplored health benefits of cultivated and wild plants include micronutrient intake and functions related to energy density, glycaemic control, oxidative stress and immuno-stimulation. Research on the properties of neglected and underutilized species and local varieties deserves higher priority. In tests of the hypothesis that biodiversity is essential for dietary diversity and health, quantitative indicators of dietary and biological diversity can be combined with nutrition and health outcomes at the population level. That traditional systems once lost are hard to recreate underlines the imperative for timely documentation, compilation and dissemination of eroding knowledge of biodiversity and the use of food culture for promoting positive behaviours.

Dietary diversity: Food-based approaches: Agrobiodiversity

Globalization of food production and supply poses unprecedented challenges to the health and well-being of populations of developing countries. While levels of hunger have decreased and *per capita* energy consumption has risen consistently in most countries (Rosegrant *et al.* 2005), inexpensive foodstuffs produced by large-scale agriculture can have adverse affects on diet quality, undermine the self-sufficiency of small-scale farmers and threaten environmental sustainability. Malnutrition and poverty remain at unconscionable levels in many regions, and in Africa are increasing (UN Millennium Project, 2005). Both food insecurity and the so-called 'nutrition transition' are characterized by the simplification of diets leading to a reduction in the consumption of diverse, nutritionally-rich and functionally-healthy plant foods. The 800 million of the world's population whose diets are still insufficient in energy and the approximately two billion suffering from micronutrient deficiencies all have inadequate access to products of biodiversity that would improve their dietary options. For growing numbers of the population reliance on a limited number of energy-rich foods contributes to the emerging epidemic of non-communicable disease (Popkin, 2002).

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The consumption of living organisms is essential to nutrition and health. Plants, animals and micro-organisms make up most of what is eaten by man and are the source of many medicines, while biodiversity more generally provides key components of healthy environments and sustainable livelihoods. Agrobiodiversity comprises the cultivated plants and animals that form the raw material of agriculture, the wild foods and other products that are gathered by rural populations within traditional subsistence systems, as well as organisms such as pollinators and soil biota that are key to sustainable agroecosystems (Jarvis *et al*. 2006). Degradation of ecosystems, simplification of diets and loss of species, and of the knowledge of them, expose man to new health challenges and undermine the adaptive resilience inherent in diversity. Thus, the contributions of plant and animal diversity to food security and dietary quality offer an important rationale for the sustainable use of biodiversity.

While the links among agrobiodiversity, dietary diversity and health appear logical in principle, in practice making a case with an impact on international policy and on the well-being of vulnerable populations depends on both a clear conceptual framework and strong empirical support. The International Plant Genetic Resources Institute in its Biodiversity for Nutrition, Dietary Diversity and Health Project contributes to this agenda through research, practical interventions and policy development. The present paper draws on the specific case of east Africa in outlining relevant aspects of concept, evidence base, practice and policy more broadly.

Conceptual framework

Biodiversity as the foundation for healthy diets and livelihoods

Traditional farming and hunter–gatherer societies typically draw on a defined suite of resources within a local environment in a manner that is both self-sufficient and nutritionally balanced. A range of cereals, roots and tubers, legumes, other seeds, fruits, vegetables and animal-source foods are the source of essential energy, lipids, protein, vitamins and minerals. Individual crops, many of which are locally important but neglected and underutilized globally, vary in their nutritional and health properties (Johns & Sthapit, 2004).

The elimination of most essential nutrient deficiencies requires only small increases in the variety of food items an individual consumes (Ruel, 2003). Nonetheless, many underutilized species are rich in nutrient quality. For example, millets, which are important in traditional diets in both south Asia and Sahelian Africa are a good source of dietary Fe (Antony & Chandra, 1998; Lestienne, 2005). It has been observed (Spigelski, 2004) that reduced consumption of pearl millet (*Pennisetum glaucum*) couscous in Senegal in favour of less-expensive imported rice leads to reduced Fe intake in a population that already suffers high rates of Fe-deficiency anaemia. Buriti (*Mauritia flexuosa* L.) and some other palm fruits from Brazil are excellent sources of β-carotene (Rodriquez-Amaya, 1999). Among leafy vegetables *Moringa oleifera* offers an example of a fast-growing multi-purpose tree, the leaves of which contain exceptional nutrient quality in vitamins A and C, Ca, Fe and protein (Gidamis *et al*. 2004). It has been promoted successfully to reduce malnutrition in several sub-Saharan African countries.

Although concern for the functional properties of foods that prevent chronic disease has emerged primarily in relation to the health of populations in industrial societies, many insights on the benefits of dietary constituents, such as *n*-3 fatty acids from marine sources, fibre and antioxidants, derive from studies of traditional diets (Johns & Sthapit, 2004). A diversity of fruits, vegetables and other plant foods generally contributes to lower rates of morbidity and mortality, and particular foods reduce risk of specific diseases (Tucker, 2001). Important functional examples among underutilized crops include buckwheat (*Fagopyrum esculentum* Moench; Li & Zhang, 2001) and finger millet (*Eleusine coracana* L.; Kurup & Krishnamurthy, 1993), foods that reduce the risk of heart disease and diabetes. In addition, they have blood glucose-lowering effects attributable to soluble- and insoluble-fibre components. The benefits of antioxidant phenolics, or carotenoids such as lycopene and lutein, may exceed those attributable to β-carotene or other nutrients. Evidence suggests that lycopene from tomatoes and various fruits prevents prostate cancer in men and possibly other conditions (Hasler, 2002). Lutein, which is high in most green leafy vegetables and mostly absent from other foods, and zeaxanthin, which occurs in large amounts in yellow maize, appear to be important for preventing cataracts, the leading cause of blindness worldwide, and other forms of age-related eye disease (Mares-Perlman *et al*. 2002).

In addition to providing basic subsistence, cultivated and wild-gathered biodiversity is an important source of income generation for small-scale farmers around the world. Poverty reduction as it increases options for purchasing food and diversifying diet is critical to overcoming malnutrition and improving health.

Contemporary changes in food systems

Forces of globalization, commercialization, industrialization, population increase and urbanization change patterns of food production and consumption in ways that profoundly affect human diets. High-input high-yield agriculture and long-distance transport increase the availability and affordability of refined carbohydrates (wheat, rice, sugar) and edible oils (World Health Organization, 2002). While making greater numbers of the population secure in terms of energy, modern food systems also underpin the nutrition transition (Popkin, 2002; Popkin *et al*. 2001). Where high rates of infectious illness persist, undernutrition and overnutrition combine to produce a double burden of communicable and non-communicable disease. In addition, the globalization of culture and commerce fosters a Westernization of food systems and diets in developing countries.

Chronic diseases, including diabetes, heart disease and obesity, poses a staggering cost, particularly for developing countries and economies in transition. The recent report by the World Health Organization (2005) calculates the

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lost national income associated with heart disease, stroke and diabetes over the next 10 years for key developing countries. The accumulated losses (US$\$ \times 10^9$) that will be suffered are for Brazil 49·2, for China 557·7, for India 236·6 and for Russia 303·2, while for smaller developing economies such as Nigeria, Pakistan and Tanzania the losses will be 7·6, 30·7 and 2·5 respectively. The costs in human lives and on economic growth and development are not acceptable. All resources, particularly the accessible, sustainable and locally-adapted resources such as biodiversity for dietary diversity need to be mobilized to reverse this trend. The challenge is to address a problem for which the causes and consequences span culture, health, agriculture, markets and environment.

Major changes that affect local systems of production include a shift away from subsistence agriculture in the classic sense and an increasing orientation to markets for both income and food purchase (Johns & Sthapit, 2004). Market factors alter traditional cropping patterns in ways that contribute to the erosion of local crops and varieties that underpin traditional dietary diversity. While intensive commercial agriculture can offer economic benefits to rural populations and reduced food costs for consumers, it has mixed impacts on nutritional status (Von Braun, 1995), in part because of reduction in traditional dietary diversity (Dewey, 1989). Changes in land use diminish opportunities for gathering and hunting the essential wild components of many traditional food systems. In addition, some niches or farming practices such as home gardens that provide complementary resources for diet and medicine (Marsh, 1998) and also serve as repositories of biodiversity, assume less importance. As supermarkets take a larger market share in developing countries (Reardon *et al*. 2003) opportunities for small-scale farmers to sell diverse products are potentially reduced. Contamination from industrial and agricultural activities further undermines traditional and indigenous food systems and health (Johns & Sthapit, 2004; Johns, 2006), while climatic change is likely to adversely affect crop production and nutritional status in Africa (International Food Policy Research Institute, 2002).

Promising models of food systems in transition

While the impacts of rapid socio-cultural changes can be seen throughout the world, those countries that retain a strong traditional food system in which diet has recognized health, cultural and ecological roles are better able to avoid the concomitant increases in chronic non-communicable diseases (Popkin *et al*. 2001; Johns & Sthapit, 2004). Asian and Mediterranean diets (Trichopoulou & Vasilopoulou, 2000) provide the clearest examples. Kim *et al*. (2000) offer socio-cultural explanations for the lower-than-expected rates of chronic non-communicable diseases in South Korea. Physiological, cultural and ecological functions are promoted in a strong social marketing approach that emphasizes the higher quality of traditional dishes. Okinawan food that has been strongly influenced by Chinese ideas of longevity through a traditional diet offers a further example (Cockerham & Yamori, 2001).

Traditional systems often see food, medicine and health as interrelated (Johns & Sthapit, 2004), with food typically associated with cultural identity and social well-being. The foods of indigenous populations form part of rich knowledge systems. They typically draw on local biodiversity and are based on local production and management of land and distinctive environments. Knowledge and practice on the value and uses of agrobiodiversity in food systems is gendered, with women often having a greater knowledge about nutritional benefits and food uses of traditional species.

Most of the world's poorest households live in countries harbouring the largest amounts of biodiversity and, as a consequence, conservation and poverty cannot be addressed independently. In contemporary circumstances in which a majority of the world's population depends at least in part on purchased foods, improving accessibility to a range of crops offers nutritional benefits to the rural and urban poor. This improvement can be best achieved within a model (Fig. 1) linking local producers and consumers in which agrobiobiodiversity contributes to poverty reduction and viable economies within a supportive socio-cultural context. The approach put forward here assumes that small-scale farmers can manage and use traditional agricultural and wild biodiversity to improve their livelihoods by developing products that can be marketed to meet the demands of local food cultures and offer nutritional and cultural benefits to (increasingly urban) consumers. Thus, linking biodiversity and health is both a response to the consequences of economic growth and a way to direct growth in a positive manner.

East African food systems

East African food systems are based on a rich diversity of traditional cereals, legumes, leafy vegetables, indigenous fruits and animal-source foods that are cultivated and gathered from the wild. Economic and cultural changes leading to the erosion of resources and food knowledge that began during the period of European colonialization has been accelerated by agricultural technology, urbanization, commercialization and globalization. These changes exacerbate the problems of undernutrition, food insecurity, communicable disease (including HIV/AIDS and malaria) that characterize African poverty. Nonetheless, east African communities continue to value traditional foods and retain knowledge of their use and cultural importance (Johns, 2003).

Building the evidence base

Empirical data demonstrating the relationship between biodiversity and nutrition are essential to convince decision-makers of the validity of food-based approaches to health. They also support the implementation of strategies that promote the conservation of plant genetic resources by enhancing their use and value to producers and consumers in developing countries. Most importantly, empirical and participatory research on the links between dietary diversity, health and biodiversity can provide the foundation for programmes that enable developing countries to respond

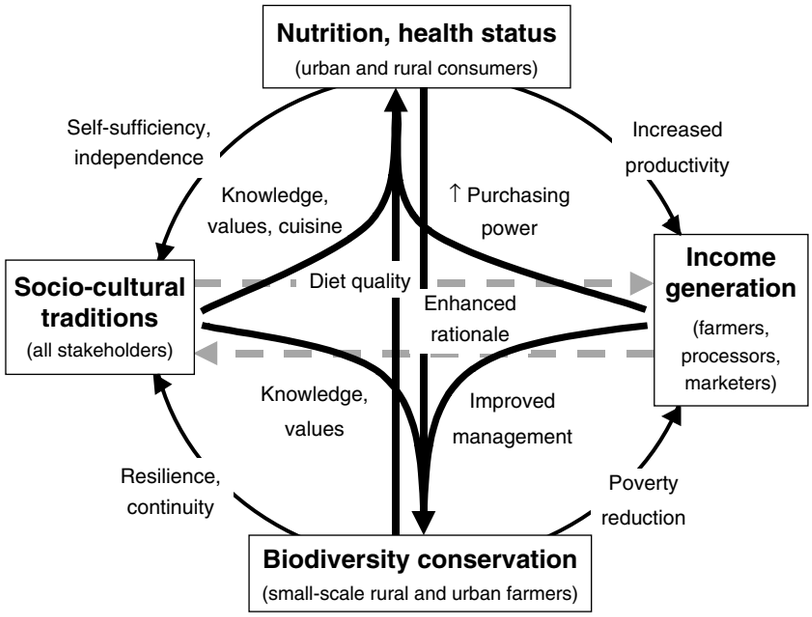

Fig. 1. Population-level synergies linking biodiversity conservation and human nutrition in developing countries. (From Johns & Sthapit, 2004.)

effectively to current problems and future changes in food systems, environment and patterns of disease.

A strong case for the contributions of biodiversity to nutrition and health emerges from existing data on food composition, including increasing information on the nutrient variability present within species. The biomedical literature on the mechanisms of action of particular plants or their value in clinical trials gives a perspective on the contribution to the health of individuals. Nonetheless, these data are minimal or non-existent for a large number of species and analysis of food function, composition, digestibility and safety takes high priority. Wild foods that are typically understudied deserve particular attention both for basic characterization (Burlingame, 2000) and for ecological, agronomic and marketing research (Leakey, 1999).

A small number of studies demonstrate the contribution of dietary diversity to population-level nutrient adequacy in developing countries (Ruel, 2003), with fewer studies considering the value of cultivated and wild biodiversity. It has recently been shown (Spigelski, 2004) that in a peri-urban area of Dakar, Senegal (in west Africa), dietary diversity is positively correlated with intakes of several key nutrients, specifically Ca, Fe, Zn, vitamin A, vitamin C, thiamin, riboflavin and vitamin B_6. Specific tests of the hypothesis that dietary diversity contributes to health and that biodiversity equates with dietary diversity can combine quantitative indicators of dietary and biological diversity with nutrition and health outcomes at the population level (Johns & Sthapit, 2004). In addition to nutritional indicators such as child development, anaemia, infection and obesity, this undertaking might also draw on the disease-risk reduction activities presented earlier within the framework of dietary quality indices (Stookey *et al*. 2000). Intake assessments could consider a measure of traditional foods or sustainability of the diet. In a pilot study in southern Madagascar the relationship between dietary diversity indices and the incidence of respiratory and gastrointestinal infection has been examined (N Wilson and T Johns, unpublished results). Wild-gathered foods, most importantly animal-source food, provide the strongest correlation. Similarly, unpublished data from Papua New Guinea (P Owen and T Johns, unpublished results) demonstrate an inverse relationship between indicators of diversity in traditional diets and risk factors for CVD and diabetes.

Policy-oriented research can define and direct the manner through which socio-economic, technological and political factors affect human and ecosystem health. Research at the local, national and international levels might explore socio-cultural and agronomic aspects of small-scale agriculture, farmer transaction costs and the pricing, institutional, technological, information, socio-cultural and organizational factors that affect homestead production of non-staple crops. Evaluation of the impact of biotechnology on biodiversity and the well-being of vulnerable populations is also essential. Biotechnology as part of a balanced approach to development and improved food security can contribute to the improvement of local crops that benefit and enhance local self-sufficiency, but approaches need to explicitly complement and maintain physiological and socio-cultural diversity and livelihood options within sustainable food systems (Johns & Eyzaguirre, 2006).

Practical steps: towards rebuilding the east African food systems

Successful interventions to support the use of biodiversity for the health objectives are likely to be multi-sectoral, multidisciplinary and problem-focused. The programme coordinated by the International Plant Genetic Resources

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Institute in sub-Saharan Africa brings together key partners to address the fundamental problem of dietary simplification. It recognizes dietary diversity as a fundamental, cost-effective and sustainable way of resolving health problems related to malnutrition, but also that diversity-based approaches to improving nutrition and health depend on the maintenance and use of agrobiodiversity. An additional premise is that the sustainability of healthy environments and of improved health for the world's disadvantaged is best achieved in a context that addresses the economic and socio-cultural needs and aspirations of farmers and consumers (Friis-Hansen & Sthapit, 2000).

A programme of research, promotion and policy on urban and rural dietary diversity seeks to address nutrition and health consequences of socio-economic change in sub-Saharan food systems. An East African Dietary Diversity Working Group began in 2002, with activities since then having advanced most in Kenya. Case studies underway in Kenya, Tanzania and Uganda as well as in one west African country, Senegal, will provide a comparison of the potential of traditional agrobiodiversity and food culture, including the use of leafy vegetables, cereals, legumes, fruits and animal-based foods, to counter increased intake of energy-rich staples and commercial cuisine. Their specific objectives include:

1. documentation of links between agrobiodiversity and dietary diversity within traditional food systems; survey of uses and erosion of traditional knowledge of food-crop diversity among population subgroups related to age, gender and economic status; study of factors that contribute to food choices of small-scale farmers and urban dwellers;
2. test of hypotheses on the relationship between agrobiodiversity and dietary diversity and health using comparable methodologies in representative case studies; development and test of methods for measuring dietary diversity of small-scale farmers and urban consumers, and its association with nutritional and health status;
3. analysis of production, marketing and other factors that contribute to the availability and accessibility of a diverse diet;
4. a programme of promotion of dietary diversity at local, national and regional levels including the transfer and sharing of information and successful experiences in defending and enhancing the use of plant diversity for dietary diversity.

The formulation and implementation involves the participation and integration of the expertise of multiple stakeholders from the scientific, health, government and private sectors. Key to the development and potential success of the project is to raise the issues within public forums, with policy-makers and with decision-makers through concerted and reinforcing efforts from various sectors. The project consciously builds on the stakeholders' cultural linkages to the issues and their common commitment to addressing an issue of national and regional social, economic and health importance.

The East African Working Group has defined the priorities and direction for the project in this region in two coordination meetings. In each country data compilation and initial situation analysis and workshops provide a foundation for further activities. In Kenya specific promotional, research and policy activities are planned and implemented by meetings involving smaller subsets of the participants.

The Baseline Study on Status of Utilization of Traditional Plant Foods among the Urban and Peri-Urban Populations of Nairobi, Kenya carried out by the Department of Food, Nutrition and Dietetics, Kenyatta University (project coordinator J Kimiywe) involved 800 urban and peri-urban households in thirty-two representative enumeration areas of Nairobi. It employed food-frequency questionnaires and 24 h recalls, with attention to intra-specific diversity of traditional food, plus focus groups. Preliminary results suggest that ethnic origin and occupation, but not household income or education level, strongly influence choice and consumption of traditional foods; lack of availability and price, particularly of fruits and vegetables, also determine consumption. The surveys conducted in Nairobi provide a first level of documentation of the links between agrobiodiversity and dietary diversity and include information on uses and erosion of traditional knowledge of food-crop diversity among population subgroups related to age, gender and economic status.

Kenyan promotional activities focus on traditional foods, nutrition and health. An African Traditional Food Week was organized by over ten institutions, activities at the Kenyatta University Culture Week were organized by the University, those at the Nairobi International Show by a national board and a Nutrition Week by the Kenyatta National Hospital. Two of the events included walks along the streets of Nairobi, while two other events involved major performances. In all events education and awareness materials including T-shirts, six brochures, five leaflets, five banners and two posters were printed and distributed to an estimated 40 000 individuals. Leaflets, posters and brochures were distributed to schools, hospitals, research institutions, media centres and parliamentarians, and to members of the public. The same messages were delivered through radio, TV and the print media.

The main policy activity undertaken to date was a symposium for health professionals and decision-makers in conjunction with the African Food, Nutrition and Health Week. Ongoing efforts to engage the health and other sectors are progressing in Kenya, and this process is a component of the formation of working groups in the other three countries.

An ongoing qualitative survey of Nairobi markets conducted by the National Museums of Kenya to guide the household survey has documented over 800 traditional crop species or varieties. Marketing of traditional leafy vegetables through major Kenyan supermarkets since 2003 under the guidance of the partner non-governmental organization Family Concerns continues to increase the distribution of these foods. Demand continues to increase in both the contracted supermarkets, in other supermarkets that are now selling these products for the first time and in the informal markets. Concerns have been raised

that supply cannot meet demand in the short term, with potential adverse consequences if consumer expectations cannot be met. A survey to analyse in Kenya the production, marketing and other factors that contribute to the availability and accessibility of a diverse diet will be coordinated jointly by Family Concerns and the Kenya Agricultural Research Institute.

Policy opportunities

The Millennium Development Goals (United Nations, 2000) specifically call for ensuring environmental sustainability, including a reverse in the loss of environmental resources (goal 7); biodiversity in turn has an important role in addressing goal 1 (eradicate extreme poverty and hunger) and others that relate to health. These relationships are emphasized in the action plan of a consultation meeting organized in Chennai, India in April 2005 by the International Plant Genetic Resources Institute, the Global Facilitation Unit for Underutilized Species and the MS Swaminathan Research Foundation. The contribution of agrobiodiversity, food and nutrition to address goal 1 and other Millennium Development Goals is the basis for the Convention on Biological Diversity COP7 Decision VII/32 (Parties to the Convention on Biological Diversity (COP 7), 2004), which calls for a cross-cutting initiative with implementation drawing on collaboration among the Secretariat of the Convention on Biological Diversity, the FAO, the International Plant Genetic Resources Institute and other parties. In addition, the relationship between biodiversity and nutrition is highlighted in the Millennium Ecosystem Assessment (Wood *et al*. 2006).

Within the sub-Saharan Africa region the sharing of common experiences to make a link between policy and research and promotional activities can reinforce understanding of the determinants of dietary simplification and foster solutions based on common African values and strong evidence-based science. From the Kenyan experience two areas of limitation, specifically in bringing the objectives of the project to Members of Parliament and in engaging key decision-makers in the Ministry of Health and among health professionals, have been identified. The presence of two Members of Parliament at the symposium in July 2004 provided an insight into developing a strategy to reach Members of Parliament, and planning for specific activities in this area was a focus of a meeting of the East African Working Group in April 2005. A slowness of satisfactory engagement of the health sector in these activities probably reflects the varied and complex responsibilities of health and the clinical orientation of key individuals.

Progress at the national level has been made by situating the project relative to international efforts addressing non-communicable disease, specifically the World Health Organization (2004) Global Strategy on Diet, Physical Activity and Health, and through the efforts of senior members of the project team to develop linkages with key personnel in the WHO and through the UN System Standing Committee on Nutrition, which can then assist in forging a national level consensus on multi-sectoral approaches. The food-based dietary guidelines are a specific policy instrument that potentially brings together the WHO Global Strategy and sustainable use of biodiversity (World Health Organization, 1999; Johns & Sthapit, 2004).

As an important component of traditional food systems, biodiversity is implicit in policy instruments that consider cultural rights and contributions of traditional practices to health. The World Health Organization (2004) Global Strategy on Diet, Physical Activity and Health specifically recognizes the 'socioeconomic importance and the potential health benefits of traditional dietary and physical activity practices, including those of indigenous peoples' and reaffirms the place of 'cultural traditions, and national dietary habits and practices' in establishing dietary guidelines. The voluntary guidelines on the right to adequate food (Food and Agriculture Organization, 2005) more explicitly recognize the importance of conserving biodiversity and make links between biodiversity and traditional knowledge and local and indigenous customs and traditions. Also relevant to such policy discussions is the UN Human Rights Commission's Permanent Forum on Indigenous Issues. A recent publication addresses the rights-based approach to food (Eide & Kracht, 2005).

Conclusions

Profound changes in developing food systems affect both human health and the health of ecosystems. While sustainable use of natural resources holds the promise of self-sufficiency, for large numbers of the populations of developing countries a downward spiral of environment degradation and poverty presents the likelihood of continued dependence and malnutrition. The emerging nutrition transition and double burden of non-communicable and infectious disease is a manifestation of the simplification of ecosystems and diets. Forestalling this trend demands concerted and proactive interventions in policy and practice. Global perspectives such as those expressed in the Millennium Development Goals (United Nations, 2000) or the The Indaba Declaration on Food, Nutrition, Health and Sustainable Development from the World Summit on Sustainable Development (Johannesburg, 2002; Stakeholders' Forum for Our Common Future, 2002) recognize the interactions among economic development, social development and environmental protection and the interrelation among the themes of water, energy, health, agriculture and biodiversity. Active interventions are called for that increase the understanding of these relationships in specific situations and provide a way forward in practice.

While a strong case can be made in general that nutrients and medicinal agents in biodiversity improve health, basic research on the contributions of traditional foods to health will reinforce the usefulness of biodiversity. Scientists in developing countries with knowledge of local resources, customs and cultural values must play a fundamental role in identifying sustainable approaches to diet; external interventions must respect local qualification, insight and commitment. A growing body of peer-reviewed data generated in developing countries addresses the health properties of indigenous foods. Although large developing

nations can support extensive research and development programmes, in general progress depends on improvements in the scientific resources, opportunities and infrastructure available (Johns & Sthapit, 2004).

While considerable data supports the contribution of diversity of quality foods to the health of individuals, epidemiological studies can demonstrate contributions of biodiversity to human health at the population level. Conceptual differences in how health is defined, as well as lack of dialogue between environmentalists concerned with underlying processes and health professionals focused on providing essential healthcare, impede progress. While the importance of health or of environmental sustainability would generally not be in dispute, different sectors have different priorities.

Within this framework food systems and nutrition offers a common ground. Biodiversity and traditional food culture have key synergies for human health and for biodiversity conservation. Likely solutions depend on sound global policies but will be country specific. In a theoretical sense solutions might be found in concepts of wellness that consider individual health within a social and environment context. Traditional and modern values can be mutually enforcing as health consciousness involves a combination of health, environment and culture. In east Africa, where nutrition transition coexists with the pandemic of HIV/AIDS and other social concerns, linking traditional food culture and health is likely to translate into an attachment to rural and ethnic origins coupled with social and spiritual values within the context of formal religion. In other regions connections among socio-cultural, health and environmental factors take other forms.

Greater consumption of diversity among urban dwellers depends on affordability and accessibility of the products of biodiversity. Viable markets depend on demand from consumers that can be driven through education and promotion and by reinforcing traditional food culture. Demand translates into opportunities for income generation and improved livelihoods when rural farmers are linked with consumers. Reduction in poverty has a crucial indirect impact on health. In practice contemporary food systems exist within an increasingly commercial context. In developing countries supermarkets and other commercial entities can be persuaded to combine economic and social rationales in support of traditional biodiversity. International policies and regulation related to trade and to cultural, food and other forms of human rights must ensure the viability of food systems rooted in local ecology and cultural tradition. Greater diversity within production systems and natural ecosystems strengthens the opportunities for diversity in all diets and the prospect of a sustainable future.

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