Biodiversity, nutrition and health: making a difference to hunger and conservation in the developing world.

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Abstract

The world has made great strides in reducing hunger, yet the problem of malnutrition, particularly the "hidden hunger" caused by missing micronutrients, constitutes a formidable challenge for the future. Biodiversity has a crucial role to play in mitigating the effects of micronutrient deficiencies, which are debilitating hundreds of millions of people in developing countries, particularly children and women. It is also becoming increasingly recognized that a diet rich in energy but lacking other essential components can lead to heart disease, diabetes, cancer and obesity. These conditions are no longer associated only with affluence; they are on the increase among poorer people in developing countries, especially urban dwellers. A more diverse diet is one key to combat this trend and to healthier lives, with biodiversity, nutrition and conservation coming together in mutually-reinforcing virtuous circles to the ultimate benefit of all people. Small-scale farmers, especially women, who grow and use diverse crops improve their own health and that of their families, and at the same time improve their incomes by supplying diversity to the market. As healthier, well-nourished people growing a range of appropriate crops, they will better conserve the natural landscapes around them. And when people perceive that agricultural biodiversity has greater value through positive impacts on both income and health, they are more likely to maintain and protect it. Well-nourished people are more productive and will make a greater contribution to the development of their communities.

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Introduction

The world has made great strides in reducing hunger. The proportion of the world's people in developing countries who are hungry declined from about 25% in 1970 to about 16% in 1995. Nevertheless, that still means that some 800 million people in developing countries remain chronically underfed.[1] Looking specifically at children, the number of malnourished children has dropped from 203.8 million in 1970 to 166.3 million in 1997.[2] The average, however, hides the fact that in Sub-Saharan Africa the number of malnourished children has grown from 18.5 million to 32.7 million over the same period, while in West Asia and North Africa it has remained static at 5.9 million. If those areas are to match the experience of East Asia, which has seen the number of malnourished children more than halve, from 77.6 million to 37.6 million, it is going to take new kinds of approach.

The Convention on Biological Diversity is of enormous relevance to nutrition, which in turn is relevant to improving the lives and health of poor people. In its preamble, the Convention states that "conservation and sustainable use of biological diversity is of critical importance for meeting the food, health and other needs of the growing world population." That makes it clear that biodiversity has an important role to play in fulfilling people's nutritional needs. The obverse of the coin is that healthy, well-nourished people are more likely to conserve the biodiversity that surrounds them.

Despite these apparent links, a recent document on biodiversity and human health[3] makes no mention of nutrition. It discusses the role of biodiversity as a source of therapeutics and medicines, and the spread of infectious diseases as a result of ecosystem changes that impact biodiversity, but is silent on the links that bind biodiversity to nutrition and health.

Consequences

The reduction in hunger that has been achieved so far is no small accomplishment. But it conceals important needs that have not yet been addressed. One is hidden hunger; the lack of micronutrients, vitamins and other important components of a diet otherwise adequate in energy. The consequences of this are many and complex. Some, for example the xerophthalmia associated with vitamin A deficiency and other forms of blindness, are linked to poverty.

Other consequences of a poor diet include many diseases more often associated in peoples' minds with affluence than poverty, for example cardiovascular disease, type 2 diabetes, and cancers. Poor nutrition is also associated with a generally weakened immune system and thus with increased susceptibility to a wide range of infectious diseases.

The non-communicable disease consequences of malnutrition are to a large extent linked to a shift in diet that has been called the nutrition transition. This is a particularly urban phenomenon whereby diets, especially of the poor, have become much simpler. High-input agriculture, reduced transportation costs and agricultural subsidies have combined to make refined carbohydrates (wheat, rice, sugar) cheaper than ever in the cities of the developing world, where fried 'street foods' are often the most important dietary item for many poor people.

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[1] The State of Food Insecurity in the World. FAO. 2003.

[2] M.W: Rosegrant et al (2001) Global food projections to 2020, IFPRI, Washington DC, Table 2.1

[3] Biodiversity: Its Importance to Human Health, Ed. Eric Chivian, Harvard Medical School, Boston, 2002.

Evidence for this nutrition transition is somewhat sporadic, but can be seen in snapshots of national dietary patterns. In Kenya, for example, there has been a drop in the average intake of pulses and legumes that almost exactly mirrors the increase in daily energy requirements obtained from fats and oils. In Senegal, oils and fats contributed 20% of daily energy requirements in 1998, up from 8% in 1963. There has also been a shift away from locally important cereals, such as millets, which are better at regulating blood glucose levels and also are higher in iron.

These refined foods provide adequate energy, but are bereft of other vital nutritional elements, and this lack is associated with ill health. For example, diabetes, cardiovascular disease and cancers have all been linked to oxidative stress and the presence of free radicals in the diet.[4] Protective elements, such as anti-oxidant molecules, are generally lacking from refined foods, And yet among these anti-oxidant compounds, which include some important vitamins, are among the key nutritional elements that plants provide. So one way to mitigate the effects of the modern urban diet in developing countries would be to add diversity, in the form of plants, to the diet.

Xerophthalmia

To take a more specific example, a great deal of attention has been paid to xerophthalmia, blindness caused by a lack of vitamin A in the diet. "Severe Vitamin A deficiency has very high fatality rates (60%) but even sub-clinical deficiency is associated with a 23% increase in preschooler mortality in areas with endemic Vitamin A deficiency."[5] Some 50 million children in sub-Saharan Africa are reckoned to be at risk, as are millions more in south-east Asia.[6] Several treatments have been proposed, among them increasing the amount of fat in the diet, increasing the intake of retinol from animal foods, and increasing the intake of orange coloured fruits and vegetables. (In passing, it might be noted that all of these are fundamentally interventions that increase the diversity of the diet.) Leafy vegetables, especially indigenous leafy vegetables, are not often considered in this context. To some extent this reflects a controversy about the bioavailability of provitamin A in traditional leafy vegetables.[7] Bioavailability is important, and it is often the case that a diversity of items in the same meal can mutually reinforce each other's nutritional benefits by enhancing the body's ability to absorb essential nutrients. The bioavailability of provitamin A in leafy vegetables is, however, in many respects a red herring because as a rich source of [beta] carotene and other carotenoid compounds the enormous diversity of leafy vegetables can contribute not only to the reduction of xerophthalmia but also to other forms of blindness. In Nigeria, for example, studies have shown that people with cataracts eat less leafy vegetables than people without cataracts.[8] This may be related to intake of lutein, a

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[4] L. Packer (2002) The antioxidant response to oxidative stress: from free radicals to genes. In Symposium on Brain Aging and Related Behavioral Changes in Dogs, Advanstar Veterinary Healthcare Communications, KS, USA, pp 27-30. Symposium held in Orlando, Fl., on Jan. 11, 2002

[5] J. McGuire(1993) Addressing micronutrient malnutrition. SCN News No. 9. Administrative Committee on Coordination Sub-Committee on Nutrition (ACC/SCN), Geneva, Switzerland.

[6] J. Low, T. Walker and R. Hijmans (2001) The potential impact of orange-fleshed sweetpotatoes on vitamin A intake in Sub-Saharan Africa Paper presented at a regional workshop on food-based approaches to human nutritional deficiencies. The VITAA Project, vitamin A and orange-fleshed sweetpotatoes in Sub-Saharan Africa 9–11 May 2001, Nairobi, Kenya

[7] S. de Pee, C.E. West, Muhilal, D. Karyadi and J.G.A.G. Hautvast (1995) Lack of improvement in vitamin A status with increased consumption of dark-green leafy vegetables. The Lancet 346:75–81.

[8] E.O. Ojofeitimi, D.A. Adelekan, A. Adeoye, T.G. Ogungbe, A.O. Imoru and E.C. Oduah (1999) Dietary and Lifestyle Patterns in the Aetiology of Cataracts in Nigerian Patients. Nutr. Health; 13:61-68.

xanthophyll in leafy vegetables that apparently protects against the formation of cataracts and other forms of age-related blindness. As a general rule, increasing the amount and diversity of leafy vegetables in the diet will improve nutritional status.

Another response to xerophthalmia has been biofortification, for example increasing the amount of carotenes in staple foods by conventional breeding[9] or genetic engineering [10]. Many objections have been raised to this approach[11] which effectively simplifies the diet even further. In Nepal, for example, xerophthalmia and other nutritionally-based blindnesses are well-documented and severe. In general, they are related to a diet that contains too much rice and not enough fat. More rice is not the answer. More diversity might be.

Benefits of dietary diversity

An irony of the nutrition transition is that it is linked to globalization, through trade and the hegemony of Western cultural ideas, at a time when Western medicine is beginning to question the wisdom of the carbohydrate-rich affluent diet. In the developing world, people cleave to fashionable 'modern' foods and abandon the traditional diet as 'backward' and 'poor'. In the West, however, people are looking to some traditional diets, for example those of East Asia and the Mediterranean, as a source of inspiration about nutrition and health. Indeed, many of the epidemiological connections between diet and health have come from an observation of traditional peoples and the peculiarities of their food intake and health. The importance of plant sterols, omega-3 fatty acids, and other dietary components in reducing diseases has been established largely through the study of traditional diets that are associated with longevity and good health. Maasai people, for example, routinely eat almost double the recommended amount of animal fats, and yet their cholesterol levels are on the low side of normal and they suffer little cardiovascular disease. They also consume more than 25 plant products that contain anti-oxidants more powerful than the well-known antioxidant vitamins C and E.[12]

Measuring dietary diversity

One of the most difficult tasks in promoting the nutritional benefits of a diverse diet is to measure the exact contributions made by individual components of the diet. This is difficult for a variety of reasons. Food Composition Tables, for example, a primary source of information about nutrition, give detailed analytical data about a wide variety of nutrients found in a wide variety of foods. However, they tend to measure a single 'type' of food or else to average across several varieties or cultivars. This average measure can hide large differences. In rice, for example, some varieties contain 2.5 times more iron than others.[13] ,

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[9] Low et al. (2001). See note 6 above.

[10] Ye XS, Al-Babili, Kloti A, Zhang J, Lucca P, Beyer P and Potrykus I. 2000. Engineering the provitamin A (ß-carotene) biosynthetic pathway into (carotenoid-free) rice endosperm. Science 287:303–305.

[11] P. Brown (2001) GM rice promoters 'have gone too far', The Guardian, 10 February 2001. http://www.guardian.co.uk/gmdebate/Story/0,2763,436161,00.html accessed 5 February 2004 See also D. Macintosh (2001) Golden Rice, letter to the editor, Business World, February 26, 2001.

[12] T. Johns, M. Nagarajan, M.L. Parkipuny and P.J.H. Jones (2000) Maasai Gummivory: Implications for Paleolithic Diets and Contemporary Health. Curr. Anthropol. 41:453-459.

[13] G. Kennedy and B. Burlingame (2003) Analysis of food composition data on rice from a plant genetic resources perspective, Food Chemistry 80 (4) : 589-596.

Similar differences exist for other micronutrients, and indeed for some crops and some nutrients there can be hundredfold differences between varieties. 'Scientific' data thus fail to capture important information about foods in the diet. Farmers and others, however, are well aware of these types of differences and often describe certain kinds of food, and indeed certain varieties or landraces, as having particular nutritional or therapeutic value.

Ethiopian farmers, for example, have identified at least three landraces of sorghum that contain about 30% more protein than other varieties. More important, they contained 50 to 60% more lysine (a limiting amino acid in sorghum) than average. These varieties are recognized as having value for sick children and nursing mothers, and the local name for one translates literally as 'milk in my mouth'.[14] Likewise in Nepal, studies of the traditional knowledge associated with traditional varieties of rice indicate that many have very specific health-related uses. A variety called Anadi is used for backache and to treat broken bones while another, Bayarni is considered particularly nutritious for pregnant and nursing women.[15] The Luo people of western Kenya say that the leafy vegetables that form an important part of the traditional diet protect against gastro-intestinal disturbances: at least one of them, *Solanum nigrum*, is powerfully effective against the protozoan gut parasite *Giardia lamblia*.[16]

These are not isolated examples. The challenge is to collect this type of nutritional and health information using sound anthropological methods and then to marry it, if necessary, to other kinds of analyses such as epidemiological and biochemical investigations. Still there will remain problems of interpretation and usefulness. People do not eat foodstuffs in controlled portions. They eat meals. The admixture of different foods in a meal can influence the bioavailability of specific components from the different foods. Food storage, season, growing conditions, food preparation and other factors will all influence to a greater or lesser extent the composition of the meal if one views it in terms of components.

Rather than debate the merits and demerits of different measurement protocols, one can adopt the view that a more diverse diet offers a nutritional buffer, in much the same way that a more diverse ecosystem is buffered against perturbations.

There is certainly some evidence that a varied diet is beneficial.[17] A study of more than 40,000 older women in the US showed that those who consumed a greater number of different foods had a lower risk of mortality.[18] The same researchers had previously shown that a more diverse diet is associated with greater longevity and reduced incidence of cardiovascular disease, diabetes and cancer in men and women.[19] An Italian study demonstrated a link between greater dietary diversity (especially in fruits and vegetables) and reduced incidence of stomach cancer.[20] In developing countries there seems to be less

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[14] National Research Council (1996) Lost Crops of Africa. Volume 1: Grains. National Academy Press, Washington, DC. P 181.

[15] B. Sthapit, pers. comm.

[16] T. Johns, G.M. Faubert, J.O. Kokwaro, R.L.A. Mahunnah and E.K. Kimanani (1995) Anti-giardial Activity of Gastrointestinal Remedies of the Luo of East Africa. J. Ethnopharmacol. 46:17-23.

[17] K. Tucker (2001) Eat a Variety of Healthful Foods: Old Advice with New Support. Nutr. Rev. 59:156-158.

[18] A.K. Kant, A. Schatzkin, B.I. Graubard and C. Schairer. (2000). A prospective study of diet quality and mortality in women. JAMA 283:2109-2115.

[19] A.K. Kant, A. Schatzkin and R.G. Ziegler. (1995). Dietary diversity and subsequent cause-specific mortality in the NHANES I epidemiologic follow-up study. Journal of the American College of Nutrition.14:233-238.

[20] C. La Vecchia, S.E. Munoz, C. Braga, E. Fernandez and A. Decarli. (1997). Diet diversity and gastric cancer. International Journal of Cancer 72:255-257.

published research linking diversity of diet to health. Nevertheless, in Kenya Onyango and colleagues have demonstrated that diversity in the diet has clear beneficial effects on the development of young children up to 3 years old.[21] And in Mali, there is a strong correlation between diversity of fruits and vegetables in the diet and both overall nutritional adequacy and the adequacy of specific nutrients such as vitamins A and C.[22]

All this suggests that one possible strategy for improving the health of poor people in developing countries is to promote dietary diversity in and of itself. This is the approach that IPGRI has taken over the past few years; the impact and benefits suggest that this strategy has much to commend it.

Biodiversity for nutrition

In Tamil Nadu, in the south of India, IPGRI has been working with the M.S. Swaminathan Research Foundation in a project funded by the International Fund for Agricultural Development, to promote the use of biodiversity as a contribution to farmers' livelihoods and improved nutrition. India is just one of six countries involved in this project. In each, the participants have targeted different species and different needs, but in each case the intention is to improve livelihoods and well-being through improved use of biodiversity.

The focus in India is on small-grain cereals, notably millets. These are good for the environment because they can thrive under marginal conditions that would be damaged by an attempt to cultivate more mainstream cereals such as wheat or rice. Millets are also more reliable and produce a harvest even under adverse growing conditions. The project identified two products as worthy of further investigation. One is malt made from finger millet (*Eleusine coracana*), the other a mixed-grain preparation that is particularly useful to diabetics as a result of its low glycemic load. Farmers have worked with food technologists to develop new products, such as biscuits and snacks, that make use of the processed millet grains. And marketers have helped to place these new food products in the shops and supermarkets of nearby towns.

One remaining task is to ensure that urban shoppers are aware that millet-based foods are healthier than more expensive alternatives. Urban dwellers tend to associate traditional foods with peasantry and 'backwardness' and it will take concerted educational efforts to change their minds. With further development of the market, however, this kind of effort can not only improve nutrition but at the same time protect biodiversity directly, as farmers derive income and other benefits from local crops and are thus more willing to protect them. There are also indirect benefits because those crops can be raised in ways that do not threaten the wider environment to the same degree as non-local crops and varieties. These benefits come on top of the better health enjoyed by the farmers, their families, and urban consumers.

IPGRI's African Leafy Vegetables project has been running longer and has had even greater impact. Throughout Africa, hundreds of species of leafy vegetables – some cultivated, some gathered from the wild – find their way into peoples' diets. In very many cases they contain considerably more minerals and vitamins than introduced crops such as cabbage. In Kenya,

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[21] A. Onyango, K. Koski and K. Tucker. (1998). Food diversity versus breastfeeding choice in determining anthropometric status in rural Kenyan toddlers. International Journal of Epidemiology 27:484-489.

[22] A. Hatløy, L.E. Torheim and A. Oshaug. (1998). Food variety – a good indicator of nutritional adequacy of the diet? A case study from an urban area in Mali, West Africa. European Journal of Clinical Nutrition 52:891-898

the total number of species used in this way exceeds 200. For several years now, In Kenya and elsewhere, IPGRI and its partners have worked with farmers to promote the use of this biodiversity. The project has solved a range of problems. For example, seed systems were not adequate for some species. In others, new agronomic techniques ensured a larger or more sustainable yield. Very often women farmers were the focus of attention, because they are responsible both for the home gardens where so many of these crops grow and for feeding their families. Women farmers were receptive to the greater use of biodiversity and noted that their families were healthier. Once they began to market excess production they also enjoyed the benefits of additional income, which gave them a measure of independence and self-determination.

The challenge then is to share the benefits with urban dwellers. Most traditional leafy vegetables are bought by intermediaries and sold from markets and street stalls. Surveys revealed that shoppers were unimpressed by the quality of the produce and disliked the unhygienic sales locations. They also feared contamination from sewerage and some lacked the knowledge and skills to make use of these vegetables. The most recent phase of the project, in Kenya, has been to team the farmers with a non-governmental organization and a supermarket chain. The NGO has now trained about 100 farmers to grow and supply traditional leafy vegetables to higher standards of quality. The NGO also introduced branding and special packaging and collected recipes that have been turned into colourful leaflets that customers can pick up when they buy their vegetables. The supermarket chain helps to coordinate supplies and maintain standards and offers farmers a steadier and higher price for their produce. Sales have improved more than 10-fold, farmers enjoy better livelihoods and health, and consumers get better nutrition at lower prices.

These are just two examples of ways in which biodiversity can serve health and conservation. There are others, for example the contribution to family nutrition of the leafy greens known as quelites in the Milpa systems of Meso-America, or the vital role in health played by medicinal plants (cultivated and gathered) around the world. There is enough evidence to suggest that a deliberate strategy to link nutrition, health and the conservation of biodiversity has much to recommend it. People need a diet that gives them quality as well as quantity, and affordability and availability are often limiting factors. Urban dwellers, who buy their food in a cash economy, may be in an even worse position than those who have access to land in rural areas. If the connections can be made it will benefit everyone.

A strategy for nutrition and biodiversity

IPGRI and its partners are working to implement scale-up efforts in various regions around the world, encouraged by the gains already realized in small-scale and local pilot efforts. Making this approach work will require several different kinds of undertaking. Among these are: an evidence-based approach to nutrition and health and sustainable agriculture by small-scale farmers; the evaluation and use of local foods; food variety and traditional cuisines; culturally sensitive methodologies; dietary education; research into novel and improved methods of food storage and processing; and enhanced attention to marketing. The outcomes, too, are manifold and generally mutually reinforcing (see Figure 1). They include better health, conservation of agricultural and wild biodiversity, reduced poverty and enhanced incomes, public education, and sound public policy.

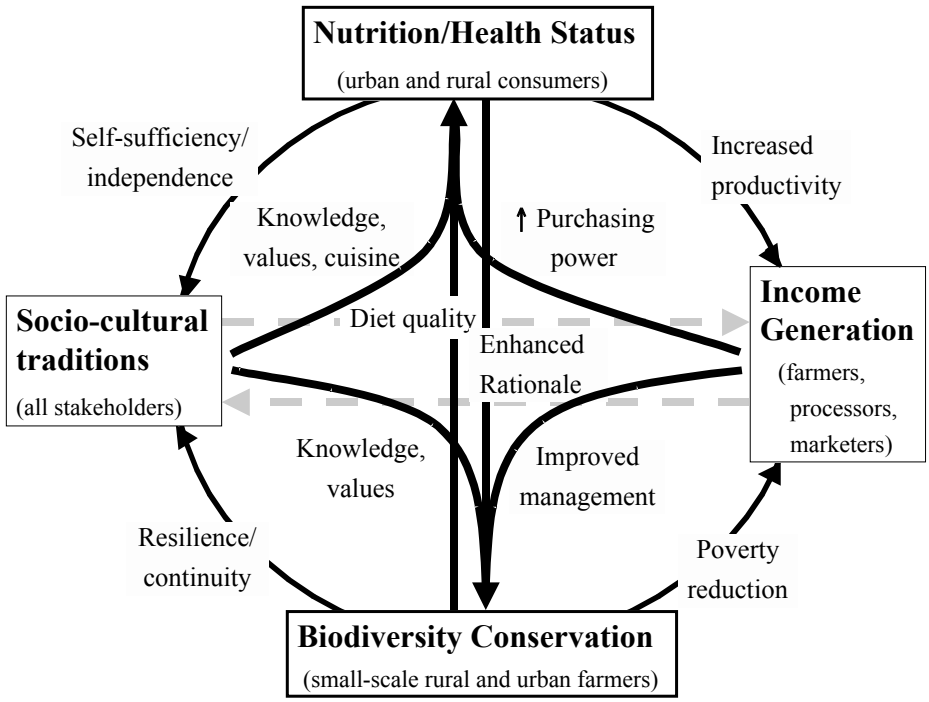

Figure 1: Population–level synergies linking biodiversity conservation and human nutrition in developing countries.

As Johns and Sthapit note: "The model assumes that small-scale farmers can manage and use traditional agro- and wild biodiversity to comparative economic advantage on the premise that the products marketed are desired by, and offer nutritional and sociocultural benefits to (increasingly urban) consumers. Linking biodiversity and health is both a response to the consequences of economic growth but also a way to direct growth in a positive manner."[23]

The fact is that despite the productivity gains of past decades we are still some way from meeting the Millennium Development Goals. This partially reflects the past concentration on reducing hunger by supplying more calories rather than a more balanced diet. This is changing. As M.S. Swaminathan has noted, "the right to food needs to become the right to good food," which in turn is effectively the right to a diverse diet. The problem is that we still have relatively little hard information on the links between diversity, nutrition and health in developing countries, and much of what we do have is anecdotal. Everything we know suggests that there are positive links, and that they beneficially influence conservation too. But we need to do more research and to adapt and scale up the interventions that have proved themselves to date.

The Future Harvest Centres of the Consultative Group on International Agricultural Research are well-placed to contribute to the research that further sustainable development will need. The Group includes centres devoted to specific crops, for example, rice, wheat and potatoes. It includes centres devoted to particular ecosystems, such as arid lands and forestry. It includes centres devoted to more general issues, such as water, food policy and, indeed, diversity. Working together with one another and with partners from national

[23] T. Johns and B.R. Sthapit (2004). Biocultural Diversity in the Sustainability of Developing Country Food Systems. Food and Nutrition Bulletin, in press.

programmes, international organizations and the private sector, the centres can help development to use diversity to supply the good nutrition and good health that everyone deserves.

Conclusion

This approach to nutrition and biodiversity may seem complex, and, in a world increasingly devoted to simple, technological fixes, that could be seen as a drawback. But while diversity is inherently complex, the interventions foreseen are essentially simple, though not simplistic.

Newsweek, a magazine that can be assumed to focus on mainstream concerns of Western consumers, recently offered "eat plants" as the number one priority for a healthful diet.[24] While the article was addressed primarily at weight control, presumably a key concern of the readership, it concluded: "A diet that includes fish, poultry, beans, nuts, fruits and vegetables, whole grains and vegetable oils can work for weight control even as it reduces the risks of disease. In other words, it can bring you greater benefits than any medicine yet invented." Newsweek, in other words, agrees that a diverse diet is a good thing, even for affluent consumers. Furthermore, says the magazine, "It tastes better too."

Affluent consumers are not the only ones who need to combat obesity and other diet-linked diseases. The poor in developing countries increasingly face the same problems, and the solutions are the same for them. That implementing such solutions benefits biodiversity too is an added bonus.

[24] W. Willet and P.J. Skerrett (2004) Going beyond beef, Newsweek 26 January 2004, pp 44-47.