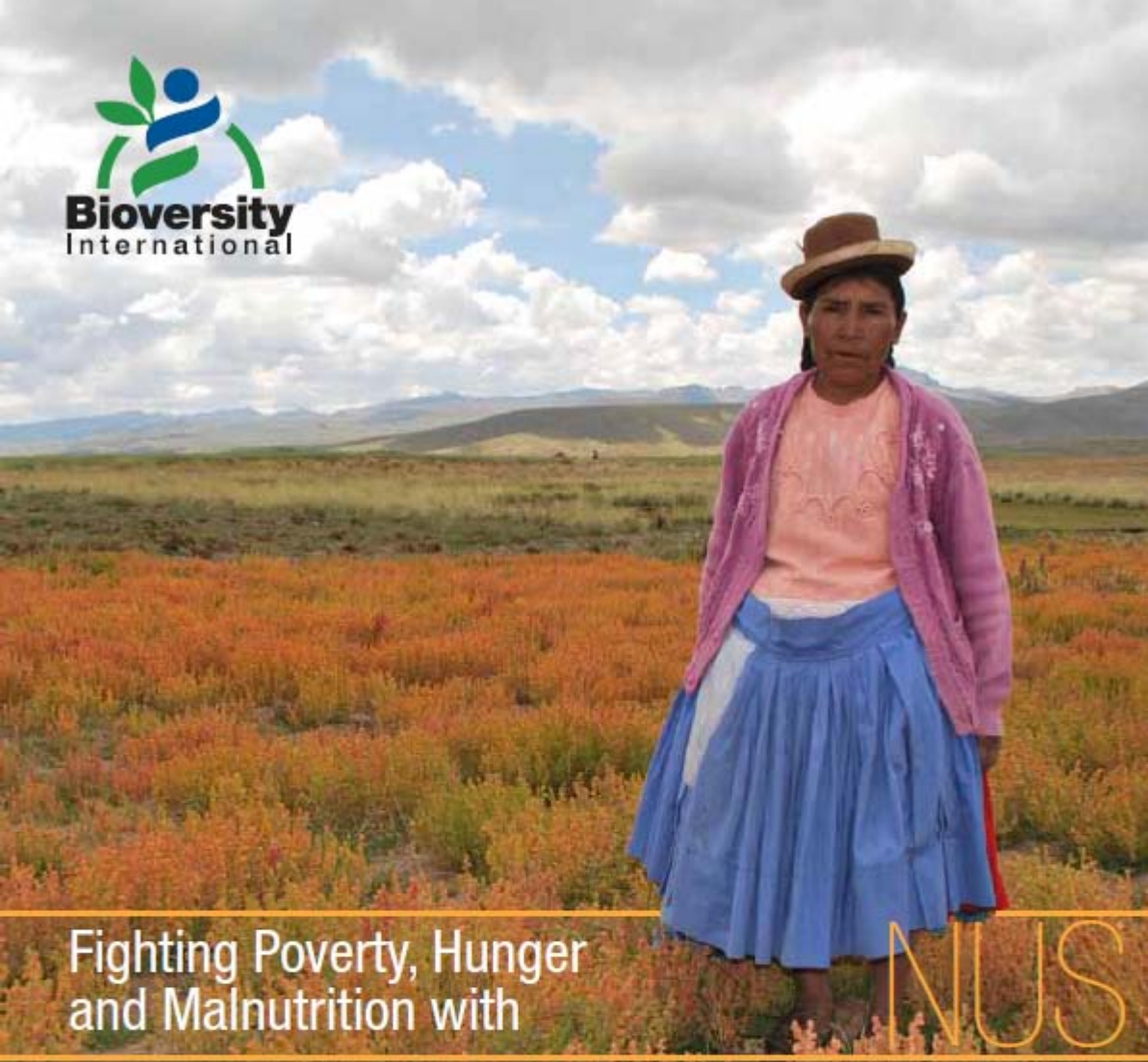

Bioversity International

Fighting Poverty, Hunger and Malnutrition with NUS

Neglected AND Underutilized Species

NEEDS, CHALLENGES AND THE WAY FORWARD

Stefano Padulosi, Judith Thompson and Per Rudebjer

NUS

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Bioversity International is a research-for-development organization working with partners worldwide to use and conserve agricultural and forest biodiversity for improved livelihoods, nutrition, sustainability and productive and resilient ecosystems. Bioversity International is working towards a world in which smallholder farming communities in developing countries of Africa, Asia and the Americas are thriving and sustainable. Bioversity International focuses on rain-fed farming systems, primarily managed by smallholder farmers, in areas where large-scale agriculture is not a viable option. Its research influences policy decisions and investment in agricultural research, from the local level to the global level.

Bioversity International is a member of the CGIAR Consortium, a global partnership that unites organizations engaged in research for a food secure future. CGIAR research is dedicated to reducing rural poverty, increasing food security, improving human health and nutrition and ensuring more sustainable management of natural resources. It is carried out by the 15 centres which are members of the CGIAR Consortium in close collaboration with hundreds of partner organizations, including national and regional research institutes, civil society organizations, academia and the private sector. www.cgiar.org

Bioversity International's headquarters are near Rome, Italy, along with the Rome-based UN food agencies FAO, IFAD and WFP. Bioversity International has regional offices in Colombia, Kenya and Malaysia. The organization, founded in 1974, has more than 300 staff and scientists worldwide working with around 700 partners.

www.bioversityinternational.org

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Cover
Bolivian farmer in her field of cañihua, an underutilized Andean crop that farmers value for its cold tolerance, a trait increasingly appreciated for adaptation to climate change. Photo: S.Padulosi/Bioversity.

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Bioversity International
Via dei Tre Denari 472/a
00057 Maccarese, Rome, Italy
Tel. (39-06) 61181
Fax. (39-06) 61979661
bioversity@cgiar.org

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Summary

Neglected and underutilized species (NUS) are those to which little attention is paid or which are entirely ignored by agricultural researchers, plant breeders and policymakers[1]. Typically, NUS are not traded as commodities. They are wild or semi-domesticated varieties and non-timber forest species adapted to particular, often quite local, environments. Many of these varieties and species, along with a wealth of traditional knowledge about their cultivation and use, are being lost at an alarming rate.

Yet NUS present tremendous opportunities for fighting poverty, hunger and malnutrition. And they can help make agricultural production systems more resilient to climate change. Not least, acknowledgment of the value of NUS in traditional foods and cultures can empower indigenous communities (women in particular) and reaffirm their identity.

The time for action on NUS is now. There is a growing realization that agriculture must diversify. NUS have an important role to play in advancing agricultural development beyond the Green Revolution model of improving and raising the yields of staple crops.

[1] In this document we shall focus only on plant genetic resources.

Mangosteen (*Garcinia mangostana*) on sale at an Indian market.

H.Lamers/Bioversity

Neglect by agronomic researchers and policy makers, genetic erosion, loss of local knowledge, marketing and climate change are major challenges to the sustainable use of NUS. Reversing the neglect, tackling these challenges, and ensuring that NUS are conserved and used sustainably, means taking urgent action in eight areas:

1 Change the perceptions of NUS as unimportant 'poor man's food'.

The neglect of NUS and failure to use them fully stems from a lack of awareness of their economic and nutritional value. Researchers, farmers, consumers and policymakers focus on the major commodity crops. Public awareness campaigns, better information and training can help farmers and consumers realize the benefits NUS can bring and can encourage scientists and policymakers to optimize and promote these benefits.

2 Develop capacity in researching, teaching, policymaking, trading and farming NUS.

The entire agricultural sector needs to recognize the importance of NUS and to protect and conserve traditional knowledge about NUS for future generations. This means training farmers and other groups along value chains in, for example, crop management, producing good quality seed, selecting varieties, intercropping systems, managing soil health, adding value and developing products, packaging, bookkeeping and marketing. Training is particularly important for women as it empowers them to play an important role in taking NUS to markets. Broadening agricultural curricula to include the conservation and use of NUS along with the staple crops will encourage young scientists to take food and nutritional approaches to agricultural development. Information campaigns can help convince policymakers of the need for incentives and support for programmes promoting the use of NUS. Supporting the development of infrastructure and institutions, such as providing better cultivation tools, processing machinery and storage facilities, will also be important.

3 Undertake more research on NUS, particularly with regard to their adaptive qualities and the links between NUS and nutrition and livelihoods.

Investing in research on NUS will help realize the full potential of these crops. Properly documenting, characterizing and collecting and sharing

data on NUS are essential. In particular, research on the nutritional aspects of NUS, and their adaptive traits are important. Research will need to include molecular work to identify NUS material suitable for breeding. Links between scientific and traditional knowledge systems will need to be created and inter-disciplinary research networks established.

4 Set up global on-farm NUS conservation programmes.

Setting up global NUS conservation programmes will strengthen *in situ* conservation of wild species and *ex situ* conservation in genebanks. A combination of *in situ* and *ex situ* approaches will empower local farmers, particularly women. To do this, local, national, regional and international agencies can finance programmes to conserve and use NUS, and leverage existing mechanisms and programmes that focus on major staples and commodity crops.

5 Involve the full range of stakeholders in participatory partnerships to promote and conserve NUS, particularly farmer and women's organizations.

Addressing challenges, needs and opportunities related to promoting NUS calls for active collaboration with local communities and mainstreaming gender-sensitive approaches. Through each step of the research and development processes, stakeholders – from smallholder farmers to policymakers – must be consulted and involved through open participatory processes. Farmer organizations and traditional seed systems can help make programmes to promote the relevance and effectiveness of NUS more effective.

6 Find innovative ways to upgrade NUS market chains and to develop and market value-added products.

Key priorities in marketing NUS are improving access to markets, adding value and stimulating demand. Because new technologies developed for commercial crops are not always suited to traditional NUS, this means finding innovative solutions to simplify processing, create new products and establish multi-stakeholder platforms for NUS value chains. Top chefs, restaurants and food retailers can play a leading role in promoting the use of NUS in gastronomy and food systems.

7 Put in place legal frameworks, policies and financial incentives to promote NUS and encourage agricultural diversification.

Policies, such as including NUS in school feeding programmes and promoting them as components in sustainable diets, enriching food aid with nutritious NUS and subsidising cultivation and marketing of NUS, can encourage their use. Incentives can support farmers to grow and conserve NUS on-farm, and can be complemented by incentives to conserve NUS *ex situ*. Governments can mainstream NUS best practices, methods and tools into routine operations. Financial support can take the form of schemes such as payment for conserving agrobiodiversity. At the international level, including NUS in the Annex 8 International Treaty on Plant Genetic Resources for Food and Agriculture will be important.

8 Encourage collaboration in researching, promoting, conserving and sustainably using NUS, and coordinate activities and multi-stakeholder platforms across sectors.

More needs to be done to ensure that NUS are no longer ignored and neglected by researchers and markets. This means strengthening cooperation among stakeholders and creating synergies at national, regional and international levels. Coordination to promote NUS at different levels and in different areas will help establish common approaches, such as standard methods for documenting and monitoring on-farm conservation and international policies for trading NUS. The current lack of interaction across sectors (agriculture, nutrition, health, education) and stakeholder groups (farmers, researchers, value chain actors, decision makers) limits the potential of NUS. Mechanisms and processes that facilitate strategic synergies among national, regional and international networks, and collaborative platforms, need to be encouraged and supported.

Buckwheat (*Fagopyrum esculentum*) at flowering stage in a Chinese field.

Bioversity/Beijing Office

Introduction

‘Nature’s bounty’ is a term that needs no definition. It is what feeds us, clothes us, warms us, shelters us, defines our livelihoods and underlies the myriad cultures of human populations. All of this bounty rests on plant life, upon which all animal life, including that of humans, ultimately depends. Approximately 30,000 edible plant species have been identified, of which more than 7,000 plant species have been used in the history of humanity to meet food needs (FAO 1998). At present, however, no more than 150 species are commercially cultivated and, of these, just 103 crops provide up to 90% of the calories in the human diet.[2] Just four of these (rice, wheat, maize and potato) account for fully 60% of the human energy supply.[3]

[2] Prescott-Allen and Prescott-Allen 1990

[3] http://www.fao.org/biodiversity/components/plants/it/

Amaranth (*Amaranthus caudatus*) at the INIA Research Station in Cuzco, Peru.

S.Padulosi/Bioversity

Almost all the efforts of the Green Revolution from the 1960s through the 1980s focused on improving these major staple crops. However, from the perspective of *sustainable food security*, relying on such a narrow food base makes our food supply extremely vulnerable. Basing our diet on a very small number of major crops has dire implications for both food security and nutrition. The lack of genetic diversity within the genepools of these few crops leaves our agricultural systems vulnerable to pests and diseases, and to abiotic stress. In this inter-connected world, a variation on the devastating Irish potato famine of the nineteenth century could have far-reaching and disastrous consequences. Foretastes of what could happen were experienced in the 1970s, when hybrid varieties of maize were shown to be sensitive to leaf blight, in 1930 when a fungus damaged all taro cultivation in Samoa, and in 1875 when a rust fungus devastated the coffee crop in Sri Lanka. A current global threat to wheat production is stem rust. This aggressive and very destructive disease first appeared in Uganda, but has spread through the Middle East, destroying wheat crops. It is threatening wheat-producing countries worldwide where resistant varieties are lacking. To prevent this and other food crop calamities, there is clearly a need to maintain diversity both within and between crops in our production systems.

As a consequence of the commercial advantages of mono cropping and the high yield of many improved hybrid crops, crop diversity – typified by local, traditional crop varieties and minor crops – is being neglected by agronomists as well as extension services. In many areas these crops are being lost altogether, along with a wealth of traditional knowledge about their cultivation and uses.

At the same time, pervasive malnutrition, widespread poverty, degradation of agroecosystems and the impacts of climate change on agricultural production call urgently for new efforts on neglected and minor crops, similar to those already being made in support of the primary food crops. It is becoming increasingly clear that bolder and more consistent action is needed to broaden the food basket of the world by supporting the development of traditional crops marginalized by current research and agricultural policies.

Internationally, there is rising interest in new foods and other products that can contribute in novel ways to human health and nutrition. This interest can be exploited to develop markets for non-staple crops from which poor communities can benefit, providing incentives for farmers to plant these crops. Agriculture must go beyond the Green Revolution technologies of the last half century, which were based on genetic improvement and increased yields of the staple crops, but at high external cost. While these increases did allow countries to reduce hunger, they also resulted in inappropriate and excessive use of agrochemicals, wasteful use of water in inappropriate irrigation schemes, loss of beneficial biodiversity (pollinators, soil fauna, etc.), water and soil pollution, and significantly reduced crop and varietal diversity.

Black cumin (*Nigella sativa*) at the AREA Research Station in Dhamar, Yemen.

S.Padulosi/Bioversity

What are NUS? Why are they important?

Agricultural species that are not among the major staple crops often come under the heading of 'neglected and underutilized species' (NUS) and are sometimes called 'orphan' crops.

The NUS concept applies to useul plant species which are marginalized, if not entirely ignored, by researchers, breeders and policy makers. They are non-commodity crops and belong to a large, biodiverse group of thousands of domesticated, semi-domesticated or wild species. They may be locally adapted minor crops as well as non-timber forest species. The designation 'NUS' is also fluid, as when a crop is simultaneously a well-established major crop in one country and a neglected minor crop in another. In some countries, moreover, agricultural statistics and research do not distinguish between NUS and other crops.

NUS differ from staple crops in fundamental ways. They tend to be managed with traditional systems, use informal seed sources and involve a strong gender element. Their processing can be laborious, grading and packaging primitive and the products marketed locally with limited involvement of large enterprises. Having long been neglected by mainstream agriculture for a variety of agronomic, genetic, economic, social and cultural reasons, today these crops are receiving increasing recognition because of their potential role in mitigating risk in agricultural production systems. Over the last ten years or so, an increasing number of projects have directed their attention to the significance of NUS in improving nutrition, generating income, maintaining ecosystem health and empowering the poor and marginalized, as well as in promoting cultural diversity.

Examples of NUS used for food from around the world[4]

Roots and tubers

Yams (*Dioscorea spp.*), yacon (*Smallanthus sonchifolius*), ulluco (*Ullucus tuberosus*), taro (*Colocasia esculenta*), arracacha (*Arracacia xanthorriza*), American yam bean (*Pachyrhizus spp.*), maca (*Lepidium meyenii*), oca (*Oxalis tuberosa*), parsnip (*Pastinaca sativa*), cocoyam (*Xanthosoma sagittifolium*)

Cereals and pseudo-cereals

Einkorn (*Triticum monococcum*), emmer (*T. dicoccon*), spelt (*T. spelta*), tef (*Eragrostis tef*), fonio (*Digitaria exilis*), cañihua (*Chenopodium pallidicaule*), finger millet (*Eleusine coracana*), kodo millet (*Paspalum scrobiculatum*), foxtail millet (*Setaria italic*), little millet (*Panicum sumatrense*), proso millet (*Panicum miliaceum*), amaranth (*Amaranthus caudatus*), buckwheat (*Fagopyrum spp.*), Job's tears (*Coix lacryma-jobi*)

Fruits and nuts

Maya nut (*Brosimum alicastrum*), breadfruit (*Artocarpus altilis*), jackfruit (*Artocarpus heterophyllus*), baobab (*Adansonia digitata*), jujube (*Ziziphus mauritiana*), cherimoya (*Annona cherimola*), cape gooseberry (*Pysalis peruviana*), naranjilla (*Solanum quitoense*), pomegranate (*Punica granatum*), noni (*Morinda citrifolia*), marula (*Sclerocarya birrea*), tamarind (*Tamarindus indica*), Annona (*Annona spp.*), safou (*Dacryodes edulis*), mangosteen (*Garcinia mangostana*), monkey orange (*Strychnos cocculoides*), salak (*Salacca spp.*), nipa palm (*Nypa fruticans*), duku (*Lansium domesticum*), boscia (*Boscia spp.*), carissa (*Carissa edulis*), coccinia (*Coccinia trilobata*), acacia (*Acacia toritilis*), kei apple (D*ovyalis caffra*), tree grapes (*Lamnea spp.*), medlars (*Vanguera spp.*), pitanga (*Eugenia uniflora*), Malabar chestnut (*Pachira aquatica*), camu camu (*Myrciaria dubia*), dragon fruit (*Hylocereus spp.*), Brazil nut (*Bertholletia excels*), egg nut (*Couepia longipendula*), quince (*Cydonia oblonga*), Yara Yara (*Duguetia lepidota*), Araza (*Eugenia stipitata*), lúcuma (*Lucuma obovata*), miracle fruit (*Synsepalum dulcificum*)

[4] More can be found at http://bit.ly/14RDz0V

Vegetables

Moringa (*Moringa oleifera*), African eggplant (*Solanum aethiopicum*), leaf amaranth (*Amaranthus spp.*), brassica (*Brassica rapa varieties*), locust bean (*Parkia biglobosa*), winged bean (*Psophocarpus tetragonolobus*), chayote (*Sechium edule*), chrysanthemum (*Chrysanthemum coronarium*), bitter gourd (*Momordica charantia*), angle gourd (*Luffa acutangula*), snake gourd (*Thrichosantes cucumerina var. anguina*), Ceylon spinach (*Basella rubra*), spider plant (*Cleome gynandra*), jute (*Corchorus olitorius*), black nightshade (*Solanum nigrum*), ivy gourd (*Coccinia grandis*), gourd (*Lagenaria siceraria*), celosia (*Celosia argentea*), dika (*Irvingia spp.*), egusi (*Citrullus lanatus*), marama (*Tylosema esculentum*), shea butter (*Vitellaria paradoxa*), giant swamp taro (*Cyrtosperma merkusii*), akoub (*Gundelia tournefortii*), crambe (*Crambe spp.*), cardoon (*Cynara cardunculus*), eru (*Gnetum africanum*), purslane (*Portulaca oleracea*), golden thistle (*Scolymus hispanicus*), bitter leaf (*Vernonia amygdalina*)

Legumes

Mungbean (*Vigna radiata*), adzuki bean *(V. angularis*), ricebean (*V. umbellata*), lupin (*Lupinus mutabilis*), Bambara groundnut (*Vigna subterranea*), jack bean (*Canavalia ensiformis*), grasspea (*Lathyrus sativus*), lablab (*Lablab purpureus*), pigeon pea (*Cajanus cajan*), African yam bean (*Sphenostylis stenocarpa*), Kersting's groundnut (*Macrotyloma geocarpum*)

Spice, condiment, food dye agent

Makoni (*Fadogia ancylantha*), annatto (*Bixa orellana*), mustard seed (*Brassica juncea*), fenugreek (*Trigonella foenum-graecum*), pandan (*Pandanus amaryllifolius*), polygonum (*Poligonum odoratum*), antidesma (*Antidesma venosum*), uer (*Lippia carviodora*), rocket (*Diplotaxis spp.*), caper (*Capparis spinosa*), monkey cola (*Cola lateritia*), sea buckthorn (*Hippophae rhamnoides*), nigella (*Nigella sativa*)

Farming families in poor rural areas consume NUS, use them for medicine and to generate income. In many areas women are the main custodians of these crops and the associated traditional knowledge; men in many cultures concentrate on producing staple and commercial crops, meaning NUS can be particularly important for empowering women.

NUS offer tremendous opportunities to all countries – regardless of their development status – to: improve people's diets and to strengthen the potential for income generation not only for farmers, but also for all the other actors engaged in the associated value chains. Their use also empowers indigenous communities (women in particular), reaffirms people's identity by placing a value on traditional food and the associated culture, and makes agricultural production systems more resilient in the face of climate change.

Neglected and marginalized

NUS often suffer from a negative image. Traditional crops or landraces, local varieties and wild relatives of crops may be deemed old-fashioned and associated with the rural poor, particularly in the eyes of newly urbanized populations in developing countries, who may prefer modern, exportable or imported food stuffs. And rural people themselves often scorn the crops of their ancestors in favour of a few commercially dominant crops and, in the process, forget the accumulated knowledge of the properties and uses of these traditional crops. Crucially, major crops dominate national and international markets and government policies, to the detriment of hundreds of other minor and local crops that together have huge significance. The underlying reasons for this may be as much political as economic. The frequent result is that NUS are being lost at an alarming rate before they can be fully characterized, researched and promoted.

Scientific efforts since the Green Revolution have focused primarily on major crops and staples, to the neglect of local crop diversity and related knowledge, culture and traditions. Decades of policies biased towards supporting major crops have contributed to the marginalization of NUS, despite their inherent important adaptive and pro-livelihood features. For these reasons, countries' capacity for research on NUS is generally weak (Rudebjer et al. 2013). The fact that governments provide subsidies only for major crops is an illustration of the political and economic neglect that has plagued the development of NUS.

One consequence of the very limited research support for NUS has been a lack of crop improvement. Very few NUS are improved but are traditional varieties, landraces or ecotypes, or are undomesticated, as in the case of NUS harvested directly from the wild.

These local crops are, therefore, largely conserved not in genebanks, but *in situ* or on-farm, thanks to the work of millions of farmers who maintain crop genetic diversity along with traditional knowledge, often on small patches of land and in home gardens. It is on these small farms that work to conserve this valuable genetic heritage must concentrate.

Food security and resilience of food systems

Many NUS have the potential to contribute to food security at local and regional levels. In an increasingly globalized and interdependent world, eradicating hunger is a prerequisite for peace and world security. If we are to feed 9,000 million people in 2050 in a sustainable way, while at the same time protecting the environment, providing healthy and nutritious food for all, and enhancing the livelihoods of farmers, we need more diverse agricultural and food systems.

At the national level, NUS can strengthen a country's food and buffer economic and social shocks that might hit the population as a result of concentrating on fewer and fewer crops. Often known as 'famine food', farmers have returned to and relied on NUS throughout history whenever major staple crops have failed. NUS can also provide a safety net during periods of stress and following disasters

Kyanika Women's Group in Kitui, eastern Kenya, conserves local landraces of beans and other crops.

Yusuf Wachira/Bioversity

Scientific efforts since the Green Revolution have focused primarily on major crops and staples, to the neglect of local crop diversity and associated knowledge, culture and traditions.

Student practicing their interviewing skills: nutrition survey in Benin.

The relationship between crop diversity, dietary diversity, nutrition and health remains complex and the subject of many, often conflicting studies.

and other emergencies. This was demonstrated in several Asian countries following the 2004 tsunami and in West Africa and other regions following war and civil strife.

Although NUS characteristically have lower yields than the main staple crops, they often compensate for this by being more resistant to biotic challenges and providing dependable harvests in unfavourable climatic conditions or on difficult soils. This adaptive capacity is one of the key traits of many NUS. They are often grown in poor areas where difficult agroecological conditions predominate, and where smallholder farmers do not have the means to adopt the high-input agricultural practices geared to major staple crops. Farmers maintain high levels of traditional varietal diversity. This provides insurance since traditional varieties are often best adapted to marginal ecosystems and heterogeneous environments, and the most resistant to local pests and diseases.

The erosion of agricultural diversity, especially of NUS, thus has serious implications for agriculture – the loss of resilience in the face of climate change, social and economic shocks and less ecosystem functionality. Enhancing diversity by growing alternative food and forage crops will not only diversify agroecosystems, but will also improve their adaptability to extreme climatic conditions and provide resilience to biotic

and abiotic stresses (Padulosi et al. 2002). In addition, forests and forest biodiversity provide environmental services, such as clean water and carbon sequestration.

Examples of these functions have been recorded in all regions of the world. Padulosi et al. (2009) reported that minor millets in India, because they have a short biological cycle and an efficient root system, have a comparative advantage where water is scarce and rainfall is low. This, plus the fact that they offer modest yields from marginal/poor soils with low inputs, has made them important in mountain, tribal and hill agriculture. In Sahelian Africa, diversity in traditional varieties of sorghum and pearl millet appear to have been an important component of the survival strategies of poor farmers over the 20-year period of drought in Niger and Mali (from the mid 1980s). Diversity was maintained, traditional varieties adapted to changing environmental conditions and there was an increase in early maturing types. (Kahane et al. 2012). In many areas, NUS play an important role in resistance to pests and diseases. They are likely to be increasingly important in strategies to limit damage by pests and diseases, as farmers recognize that crop diversification can reduce the frequency and severity of epidemics.

Examples such as these, combined with growing concerns over climate change and its impact on agriculture, contribute to a better appreciation of the role of NUS in food security and resilient food systems, since crop diversification is one of the best ways to ensure sustainable agricultural production systems. This, in turn, calls for more reliable seed systems that allow farmers to exploit the abiotic resistance traits to be found in many NUS.

NUS and nutrition

In the Green Revolution and the decades that followed, the focus of agricultural research was on increasing crop yields to ensure adequate calories for people who would otherwise have gone hungry. However, less attention was given to nutritional quality – providing a sufficient quantity of food trumped providing nutritious food. As a result, diets deficient in essential vitamins and micro-nutrients still persist in many parts of the world. Of the world's estimated 7,000 million people, 500 million still suffer from protein-energy malnutrition, but over 1,600 million suffer from iron deficiency, over 200 million from vitamin A insufficiency (WHO 2008, 2009) and it has been estimated that over 400,000 children die each year from effects directly related to zinc deficiency (HarvestPlus 2011). Underutilized crops provide essential micro-nutrients and thus complement staple foods. Additionally, NUS provide flavouring in local cuisine, strengthen local gastronomic traditions and provide income opportunities for both the rural and urban poor. Many NUS are high in carotenoids and minerals and

therefore could play a role in helping to improve the micro-nutrient content in the diets of millions of people around the world.

Strategies based on diverse local food crops can provide a valuable and sustainable complement to other means of tackling malnutrition. It is widely accepted that increased consumption of locally available indigenous or traditional fruits, vegetables, grains, roots and tubers can improve nutrition and increase human productivity (Bala Ravi et al. 2006; Smith and Longvah 2009; Frison et al. 2011; Mayes et al. 2011; Kahane et al 2012). However, for many people in developing countries fruit and vegetables are difficult to find and afford (Ruel et al. 2005), and while fortified food products and increased consumption of fish and animal products are effective means of addressing some nutrient deficiencies, these products are often out of reach for the poorest in society. In addition, many locally available fruit and vegetable species have not yet been adequately researched, marketed or improved by plant breeding.

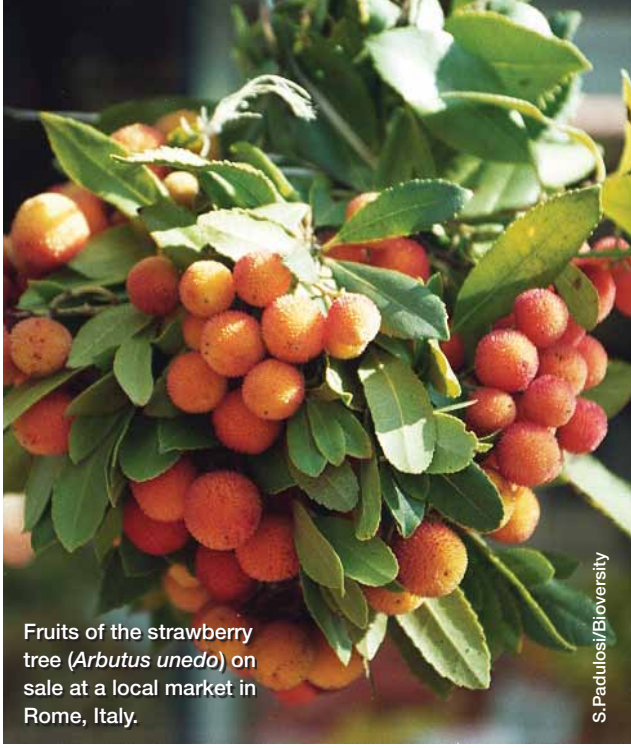
The transition from traditional diets based on local foods to a 'Western-style' diet, high in fats, salt, sugar and processed foods, increases the incidence of non-communicable diseases, such as diabetes, obesity, heart disease and certain types of cancer.

In countries where urbanization is changing the ways of life, green vegetables and fresh fruits are often given pejorative labels, and are considered to be the food of the poor or suitable only for women and children. In many of these countries, researchers find micro-nutrient deficiencies in populations that have achieved sufficient caloric levels to remove them from the ranks of the hungry. Increased consumption of NUS of fruit and vegetables could help address such deficiencies.

The transition from traditional diets based on local foods to a 'Western-style' diet, high in fats, salt, sugar and processed foods, increases the incidence of non-communicable diseases, such as diabetes, obesity, heart disease and certain types of cancer. This trend is global, but is particularly worrying when combined with poor micro-nutrition. This 'hidden hunger' – enough calories, but insufficient vitamins and minerals – affects both developed and developing countries, but is increasingly evident in sub-Saharan Africa and South Asia. NUS can be effective in curbing both food insecurity and hidden hunger, and are particularly useful in improving diets which are too rich in refined carbohydrates and fats. NUS offer opportunities to enrich diets with healthier food (particularly legumes, fruits

and vegetables) in ways that reflect food culture, besides contributing to making meals more interesting.

The relationship between crop diversity, dietary diversity, nutrition and health is complex and is the subject of many, often conflicting, studies. One study, carried out in Kenya by Bioversity International, Save the Children UK and the National Museums of Kenya, examined the role of wild NUS in reducing the cost of a nutritionally adequate diet. The study found that adding wild foods to the diet not only lowered the cost, but also helped meet micro-nutrient requirements, especially for iron, in women and in children between one and two years of age. It is unlikely that poor households would be able to afford a nutritionally balanced diet without wild foods. Wild foods and other NUS, especially those which are locally available and culturally acceptable, would thus seem to be ideally placed to play a much greater role in improving nutrition and health (Kahane et al. 2012).



Fruits of the strawberry tree (*Arbutus unedo*) on sale at a local market in Rome, Italy.

S.Padulosi/Bioversity

NUS, income and livelihoods

Higher incomes for small-scale farmers and entrepreneurs are often quoted as one of the benefits of improving the production and quality of NUS, especially high-value crops, such as local fruits and vegetables. Strategic interventions to that end will involve making NUS more commercially competitive by developing improved 'modern' varieties. Poor competitiveness also stems from lack of capacity in poor rural areas to negotiate with the private sector to access the new technologies and markets which would increase the potential demand for these local crops.

Several studies and projects have highlighted the consistent contribution of NUS to generating income in both domestic and international markets (Asaha et al. 2000; Mwangi and Kimathi 2006; Chadha and Oluoch 2007; Joordan et al. 2007; Rojas et al. 2009). In India, for example, adding value to little millet enhanced farmers' incomes three-fold and generated employment in villages – particularly for women. This also enhanced women's social status and self-esteem (Vijayalakshmi et al. 2010). Internationally, there is a rising interest in new foods and other products

which can contribute in novel ways to human health and nutrition. This interest can be exploited to develop markets for non-staple crops from which poor communities can benefit, if promotion takes the right approaches. Promoting niche markets through denomination of origin (DO), eco-labelling, fair trade, organic, and Slow Food initiatives (Kahane et al. 2012) may be particularly useful.

Marketing another category of NUS, non-timber forest products (NTFP), received considerable attention as a strategy to alleviate poverty in forest margin or forest dwelling communities, particularly during the 1990s. Because most NTFP have low cash values and are consumed within communities rather than offered for sale, they provide food, dietary supplements or income in times of shortage and are an important safety net. A few NTFP already have a commercial value, contribute significantly to rural cash incomes and are entry points for rural development strategies (Wollenberg and Belcher 2001). These include rattan and bamboo, resins, various fruits and nuts, and medicinal plants. The FAO, a global leader in promoting the sustainable use of NTFP, estimated that 80% of the populations of developing countries use NTFP to meet their needs in health and nutrition (FAO 1998).

Local, national and global markets will be effective in supporting diversity only if consumers are educated about diversity and are willing to pay for products that support diversity. Higher-value niche markets can be developed through strategic placements of NUS in large commercial outlets, such as supermarkets catering to urban populations and the developing middle-classes. Training stakeholders in value chain development is important, as is increasing the availability of credit to small producers and micro-processors. Training will need to be broad and cover areas such as processing, packaging, bookkeeping, economies of scale, accessing market information (e.g. through channels such as text messaging on mobile phones), negotiating with different actors and learning how to respond to market changes (Kahane et al. 2012).

Cultural identity

Increasingly it is being recognized that traditional food systems are intertwined with the cultural identity of indigenous peoples. Their knowledge of local ecosystems and food sources has evolved over generations. It is becoming clear that conserving traditional food systems is a powerful way to contribute toward saving local ecosystems and food sources as well. While modern agriculture has succeeded in increasing the yields of staple crops to feed a burgeoning world population, at the same time there have been some unintended consequences with regard to the food systems of traditional, indigenous

farming systems in many regions of the world. Indigenous populations, those who "… retain knowledge of the land and food resources rooted in historical continuity …" (Kuhnlein 2009) have often faced problems of extreme poverty, discrimination and marginalization. These problems are accompanied by the loss of the cultural and traditional knowledge associated with their foods and lifestyles and in many cases by the disappearance of the crops themselves. As Kuhnlein (2009) has noted, "… traditional food systems … touch the full spectrum of life in ways that modern food systems do not." Increasingly sophisticated agricultural technologies have "… led to great disconnections between people and their food."

Because of the benefits traditional food systems offer in terms of physical health and the continuity of cultures, many indigenous groups are actively finding ways to combat the loss of their food heritage and their sense of 'connection to the land'. These efforts include stemming the loss of the agricultural biodiversity on which food systems are based and conserving the local ecosystems on which generations of people have based their patterns of living and their traditional cultures. Also of critical importance are the many ongoing attempts to document, before it is lost, the indigenous knowledge of local plant foods, including their growth requirements, storage and other post-harvest needs and methods of food preparation.

Support to seed systems for traditional crops is also a priority for many programmes initiated by international aid and scientific organizations. Many activities focus on the women in the communities, as women often play key roles in cultivating, gathering, preparing and storing foods as well as in managing the family diet. Often the objective of these activities is to increase the self-esteem of women and to introduce ways of "… lightening the burden of food preparation methods by including food scientists and engineers in project intervention plans." (Kuhnhein 2009).

The conservation of traditional food systems is important among the migrant groups that characterize modern societies. Many migrants are from traditional rural communities where off-farm labour is an important component of livelihoods and causes individuals to leave their home villages and regions in search of work. When transferred to urban areas, having access to traditional foods and methods of preparation is important in maintaining a connection with the migrants' cultural roots and in fostering cohesion among fellow migrants.

The Museve women's group: a partner in Bioversity's African Leafy Vegetable Project, Kenya.

P.Maundu/Bioversity

Status of NUS around the world

Bioversity International recently examined the status of NUS around the world and the trends in use and conservation based on the *Second Report on the State of the World's Plant Genetic Resources for Food and Agriculture* (FAO 2010) and official country reports.

While the importance of NUS is not clear in some countries, including many European ones, the analysis concluded that they are increasingly considered of high to medium importance in most countries in sub-Saharan Africa, Latin America and South and East Asia. Less than 15% of all countries surveyed accorded them low importance. The status of the conservation of these species is unclear or poor in many countries. Only a quarter of the countries surveyed worldwide reported a good conservation status of NUS.

The use of NUS as sources of food, medicine, construction materials and export income is well developed in many countries worldwide. In Asia and the Pacific, for example, 10 countries out of 19 report intensive use of NUS, although use appears to be decreasing in both Bangladesh and China. Countries that report good use of NUS include India, Malaysia, Nepal and the Philippines. NUS are moderately used in Indonesia, Papua New Guinea and Sri Lanka. To illustrate the wide range of NUS uses around the world, several boxes in this section (Boxes 1-5) summarize their economic, nutritional and social uses in sub-Saharan Africa, Latin America, Europe and western Asia.

Sub-Saharan Africa

In the Côte d'Ivoire a considerable variety of minor leafy vegetables, legumes and vegetable crops are used for their appreciated rich nutritional content. In Ghana several minor forest and timber species are gathered from the wild for economic development programmes focusing on housing construction,

Box 1:
Status of NUS in the Philippines

In the Philippines, important policies and projects relating to NUS have been implemented over the last ten years. Agricultural statistics released by the Philippine Bureau of Agricultural Statistics have listed and classified the following vegetables and legumes as minor: asparagus, broccoli, carrots, cauliflower, ginger, gourd, common (field) bean, lettuce, okra, Chinese cabbage and pak choi. In 2004, 36,354 ha were devoted to these crops and production was 351,304 tonne. A base collection was established for seed crops. The base collection for coconut species, including minor ones, is maintained by the Philippine Coconut Authority, sweet potato by the Philippine Root Crop Research and Training Center and Manila hemp by the National Abaca Research Center.

furniture and export. NUS also provide food and are exploited for ornamental and medicinal use, generating significant income for some populations in West Africa. The use of some NUS is also significant in Malawi, particularly with regard to Bambara groundnut (*Vigna subterranea*), sorghum, finger millets and pearl millets. In Nigeria, NUS such as fonio (*Digitaria exilis, D. iburua*), Ethiopian tef (*Eragrotis tef*), lima beans (*Phaseolus lunatus*), pigeon peas (*Cajanus cajan*) and sword beans (*Canavalia ensiformis*) are common food crops. In East Africa, the value of nutritious leafy green vegetables is increasingly recognized. In Uganda, despite neglect by agricultural research and development programmes, poor communities continue to grow and market minor species such as

Box 2:
Status of NUS in Uganda

Most NUS used at the local level in Uganda lack documentation that identifies varieties, but the process of retrieving this information from farmers and recording it is now underway. The ethno-botanic surveys so far undertaken show that NUS plant diversity, both wild and cultivated, has contributed different nutritional components to people's diets at low cost. Many local groups have prepared public awareness materials which have been extremely well-received, especially at annual agricultural shows. Television viewers have been exposed to the issues that underline the value of NUS and how these relate to the management of natural vegetation and environmental degradation. CONVOL, an American NGO, has promoted the commercialization of Shea butter (*Vitellaria paradoxa* subsp. *nilotica*) in the northern, northeast and northwest districts (Lira, Gulu, Katakwi, Arua, etc.), in particular by empowering women processors and fruit gatherers.

Vigna subterranea, Crotalaria spp. and *Solanum nigrum*. Zimbabwe reports significant use of NUS, especially finger and pearl millets.

Latin America

The uses of NUS in Bolivia are diverse and rely on indigenous knowledge. They are used for food, drinks, spices and condiments, stimulants (*Erythroxylum coca*), textiles, construction and medicines. NUS are also heavily used in Brazil as food and spices, as forage and timber, as well as for medicines. NUS generate income for Brazilian communities through the sale of products from palm trees. In Chile, NUS are important sources of food and medicines, and are also used for industrial purposes. In Cuba they are essential for animal forage, human food, drinks, condiments, medicinal and ornamental purposes, timber, insecticides and in religious and cultural ceremonies as 'magic' plants. In Guatemala, NUS are valued in human nutrition and for their medicinal properties. They also provide timber that generates income from international trade. Jamaica NUS supply the domestic market with food, timber and aromatic, medicinal and ornamental plants. Jamaica also has established international markets for aromatic plants, root tonics and cosmetic products based on NUS. Over the last ten years, Peru has placed great emphasis on using the significant diversity and variability of NUS, particularly of the many *Solanum*

Farmer Enoc Inocente introduces food entrepreneur Fernando Dávila, of the "Pepperes" company, to chilli varieties on his farm in Peru.

M.V.Zonneveld/Bioversity

While NUS are increasingly recognized as an important component of diets and livelihoods in many countries in every region of the world, they continue to languish as untapped resources in many countries most in need of their benefits.

Box 3:

Status of NUS in Brazil

Thanks, in large part, to the introduction of irrigation for NUS and major crops, Brazil is currently undergoing strong economic growth. Brazil has also been taking important measures to expand knowledge of its genetic resources, including NUS. Local communities have taken some steps in on-farm management of genetic resources through joint initiatives with the Ministry of Agricultural Development. Innovative work has been carried out by the Brazilian agricultural research organization (EMBRAPA – Empresa Brasileira de Pesquisa Agropecuária) and the Ministry of the Environment in mapping NUS for food, agriculture and biomedicine. Mapping the occurrence of native species and wild relatives is also planned. Significant progress has been made in the molecular characterization of NUS. The country has made great efforts to implement the Convention on Biological Diversity. Recent decisive actions include expanding legal protection for biodiversity conservation areas, fostering the sustainable use of genetic resources, which include NUS resources, and advances in the adoption of policies giving access to and sharing benefits derived from the use of these resources.

varieties. St. Vincent and the Grenadines use NUS as food and medicinal plants, and export herbal remedies derived from NUS. In Trinidad and Tobago, NUS are used mainly for nutritional purposes and, therefore, contribute to food security. In Venezuela only a few NUS species, such as celery, yam and Chinese taro, are widely used.

Europe

In Georgia, there is significant (although decreasing) use of NUS for domestic consumption and also for sale (income generation). While NUS are used primarily for food in Germany, in Poland they are mainly used for medicinal and aromatic products. NUS have multiple uses in Romania, and in the Ukraine they are used for domestic consumption, commercial purposes and breeding programmes.

Western Asia

Good use is made of NUS in Pakistan, as food or for generating income, and in Turkey, for food security, healthy nutrition, generating income and, therefore, reducing poverty. Moderate and decreasing use is made of NUS in Yemen but little use is reported in Uzbekistan. The use of NUS is not clear in the other countries in the region. In the face of challenges to the conservation and use of NUS, research institutions

and governments are beginning to recognize opportunities for change, and to implement activities and policies to protect and promote NUS. In countries as varied as Kenya, Bolivia, Jamaica, Laos and Poland attention is being given to the opportunities offered by minor medicinal plants for generating income, alternative healthcare and combating environmental degradation.

Box 4: Status of NUS in Azerbaijan

In Azerbaijan, economic policy in the agrarian sector is reflected in a number of laws, including on the Food Security Programme, the State Programme on Poverty Reduction and Economic Development, and the State Programme for Development of Small and Medium Entrepreneurship. More than 100 laws, decrees, orders, decisions and other legal documents were adopted 1995-2006, although none specifically addressed NUS. Plans are in place to explore the current state of wild plant diversity and the distribution of rare, endemic plants threatened with extinction nationwide using geographic information systems (GIS). The results will contribute to models and systems for the evaluation of the status of wild crop ancestors and relatives, and the status of other wild plants used for food, as well as to make recommendations for the elimination of threats to biodiversity.

Box 5: Status of NUS in Pakistan

In Pakistan, significant progress has been made in collecting and conserving germplasm. Since 1996 this has included mapping, collecting and conserving NUS. An important step in the ex situ conservation of plant genetic resources was the establishment of the National Programme on the Conservation of Plant Genetic Resources at the National Agricultural Research Centre in Islamabad. This institution has been able to conserve more than 23,000 accessions of various crops, including minor and medicinal plants. The programme is presently executing two projects funded by Southampton University and the Agriculture Linkage Programme of the Pakistan Agricultural Research Council. These projects are concerned mainly with the collection and characterization of NUS germplasm.

While NUS are increasingly recognized as an important component of diets and livelihoods in many countries in every region of the world, they continue to languish as untapped resources in many countries most in need of their benefits. This means that governments, scientists and farmers all have roles to play in conserving and developing these crops which are so valuable for the future of humankind.

Seller of leafy vegetables in a market in Cairo, Egypt.


R.Khalil

Stories of impact

Investing in NUS pays off. The number of programmes to upgrade value chains and conserve NUS, disseminate information about NUS, provide financial and political support for NUS research, and use diverse media to publicize the benefits of NUS is growing.

This demonstrates a mounting conviction on the part of donor agencies, governments, scientists and farmers that promoting and conserving NUS can make a significant difference to people's livelihoods, and help fight poverty, hunger and malnutrition.

Improving food and nutrition security: NUS are proven to be strategic allies in fighting food and nutrition insecurity, including hidden hunger in Burkina Faso[5], highly nutritious fruits, such as *Diospyros mespiliformis* (jackalberry), *Balanites aegyptica* (desert date or soap berry tree) and *Ziziphus mauritania* (jujube), are eaten regularly. The fruits play an important part in local diets, providing minerals, vitamins, sugar, and minor proteins and lipids. Leafy vegetables such as amaranth, pumpkin leaves and African nightshade contain valuable minerals and vitamins[6]. Vegetables eaten in rural Africa which are collected rather than grown, such as *Cleome gynandra*, the African spider flower plant, are even richer in iron, zinc and β–carotene[7]. Considering the hundreds of wild and cultivated species of leafy vegetables in Africa, the scope for improving nutritional security by making more use of these species is huge.

Building resilience: Furthermore, NUS play an important part in building resilient production systems. For example, the Bambara groundnut (*Vigna subterranea*), a highly nutritious legume originating from West Africa and grown throughout sub-Saharan Africa, is also drought tolerant. Other drought-tolerant NUS

[5] Lamien et al. 2009

[6] Ogle and Grivetti 1995; Lyimo et al. 2003

[7] Msuya et al. 2009

Box 6:

The IFAD NUS Project

A 10-year project funded by IFAD and coordinated by Bioversity International provides examples of how NUS have become important in generating income for the poor. In India, local entrepreneurs who added value to minor millets by producing quick-moving, nutritious millet products derived net incomes ranging from Indian Rupees 15,000 to 45,250 (about USD 300 to 950) per tonne. Apart from enhancing entrepreneurs' incomes, this also created work, particularly for women, at the rate of 140 to 300 person-days per tonne of grain.

In India and Nepal, NUS have played a prominent role in empowering women, and boosting their self-esteem and self-confidence. Other countries involved in the project – Yemen and Latin American countries – have seen similar results.

In Bolivia, technology introduced through the project contributed to raising incomes among Andean grain processors by around Bolivia Bolivano 8,700/per tonne (about USD 1,259/ per tonne) for cañahua and Bolivia Bolivano 4,500/per tonne (approximately USD 650/ per tonne) for amaranth. The higher returns make these crops more attractive to everyone along the value chain, including small-scale farmers.

Partnering with the private sector also pays off. A joint venture, between the project in Bolivia and the coffee-shop chain Alexander Coffee, helped popularize new snacks and recipes made from cañahua and amaranth flour among urban dwellers. The popularity of the new products established sustainable, long-term horizontal and vertical links along the value chain and had positive impacts on the poor rural farming communities around Lake Titicaca which grow these NUS.

(Padulosi et al. 2013). See also the IFAD video http://bit.ly/10z2giW

are the minor millets, a group of coarse cereals used particularly in South Asia that are also nutritionally important. Cañahua *(Chenopodium pallidicaule)*, an underutilized Andean grain, is remarkably frost tolerant compared with quinoa *(Chenopodium quinoa)*, a widely grown Andean grain.

Generating income: NUS show potential in both domestic and international markets. Several studies and projects, including the IFAD NUS Project (Box 6), have demonstrated this. Another project supported by IFAD, the Oxfam-Italia Project, promoted and commercialized NUS. The project had positive effects

on incomes, and boosted local cultural identities and self-esteem, especially among women. In Ecuador, for example, production of amaranth increased by 180% and sales by 115%. This raised the annual income of producers involved in the pilot projects by 20%. In Morocco's Errachidea Province, wild fennel was domesticated for the first time, a major innovation. Farmers growing fennel raised average household income by 75% in just one year.

Improving human wellbeing: NUS can significantly improve human wellbeing. The Slow Food Project *1000 Gardens in Africa*, for example, has shown very clearly that NUS can improve people's lives in many ways – by providing food, preserving knowledge, protecting the environment and conserving biodiversity. The Slow Food Project is setting up food gardens in every Terra Madre community across Africa. The food garden idea is not new, but is gaining momentum in many agricultural and educational projects underway around the world. Vegetable plots for growing local plant varieties and intercropping fruit trees, vegetables and medicinal herbs are farmed sustainably, using composting techniques, natural treatments for pests, and rational use of water. The project educates farmers and young people, encourages awareness of local plants and biodiversity, teaches respect for the environment, and introduces the sustainable use of soil and water. The old people pass on knowledge to the young, and the gardens reinforce a spirit of collaboration. Moreover, the plots provide a regular supply of fresh and healthy food for communities, improving the quality of life and helping develop local economies.

Sustaining impact: Malnutrition and hunger in Africa stem, among other things, from the transition from traditional agriculture – based on diversity, local varieties and the exchange of seeds between communities – to agribusiness – mono cropping for example cotton or biofuel feedstock for export. The use of artificial fertilizers and pesticides on a large scale is not only expensive, but can impoverish the land. Small local initiatives, such as community gardens, can help change direction, preserve biodiversity and give communities the freedom and responsibility to decide what to grow, eat and sell. Community gardens show that NUS have a crucial role making this change happen.

Woman from Puno region, Peru, with a quinoa variety she helped develop through participatory plant breeding.


S. Padulosi/Bioversity

Key challenges facing NUS today

Neglected and underutilized crops have great untapped potential to support smallholder farmers and rural communities by improving their incomes and food and nutritional security while also sustaining the genetic resources needed to address present and future environmental challenges.

The Second Report on the *State of the World's Plant Genetic Resources for Food and Agriculture* (FAO 2010) found ample evidence of the main challenges facing those who maintain and manage NUS. These challenges cross a spectrum of areas, from social to economic and environmental, and are summarized in Table 2.

For the complete report, including the individual country reports, see http://bit.ly/12pYIx2

Some of the challenges listed in Table 2 merit further reflection:

Effects of climate change: The rapid advance of climate change that will alter agroecologies in many areas of the world will have an impact on agrobiodiversity, including NUS. However, given their greater resilience as compared with major crops, NUS are expected to offer opportunities to farmers to better cope with abiotic stresses (Padulosi et al. 2011). More research is needed to validate the claims made by local farmers and other users on the resilience and adaptation features of NUS.

Loss of genetic diversity and knowledge: Increased mechanization and the demands and expectations of modern supply chains lead farmers to concentrate on fewer and fewer crops. The result is a steady loss of biodiversity. Complacency and inaction to counter

TABLE 1: Challenges to NUS by category[8]	
Social	• Decisions of farmers to replace traditional, local crops with new varieties and improved crops • Changes in diet that accompany urbanization • Loss of the indigenous knowledge of traditional and local crops • Inadequate awareness of the nutritional value of local varieties • Perceived low status of some local and traditional foods • Migration of farm labour to urban areas • Overexploitation of wild resources
Economic	• Changes in land use • Low commercial value of NUS • Lack of competitiveness of NUS with other crops • Lack of market infrastructure • Lack of market niches for NUS • Lack of incentives for farmers to continue to maintain NUS in their fields and gardens
Environmental	• Genetic erosion of NUS genepools through the effects of droughts, fires, pests, diseases, overexploitation, overgrazing, land clearing and deforestation • Effects of climate change • Environmental pollution • Ecosystem degradation
Agronomic	• Insufficient propagation materials and seeds • Lack of seed supply systems • Insufficiently trained human resources • Overuse of pesticides, fertilizers and other agrochemicals
Political	• Failure of national and local governments to make conservation and use of NUS a priority • Lack of funds for *ex situ* conservation • Lack of adequate facilities and electricity supplies to maintain *ex situ* collections • Failure of governments to support scientific research on NUS • Lack of characterization, breeding and evaluation information • Absence of legal frameworks, policies, projects, national programmes and strategies • Lack of integration between conservation and use programmes

[8] Source: Country reports for the Second Report on the State of the World's Plant Genetic Resources for Food and Agriculture (FAO 2010).

this erosion will lead to irretrievable loss of the strategic resources necessary for the wellbeing of millions of people, and arguably of humanity at large. The rate of loss of NUS through extinction and genetic erosion is accelerating in many areas of the world as a result of droughts, bushfires, pests and diseases, overexploitation, overgrazing, land clearing, deforestation, mining, overuse of pesticides, fertilizers and other agrochemicals, increasing urbanization, and lack of incentives for farmers to maintain this diversity. Together with the loss of the species themselves, there is an accompanying, and equally alarming, widespread erosion of local traditions and knowledge. In an unrestrained feedback loop, the loss of this knowledge contributes in turn to the loss of hundreds of species worldwide.

Undervaluation through lack of knowledge and research: When, through lack of knowledge or research, the nutritional or economic values of local varieties are not recognized, farm households and agricultural programmes tend to pay them little attention. Many of the agronomic practices that have been adopted for these crops have not been documented or even considered by researchers and, therefore, their potential contribution is lost. In addition, the lack of common approaches and protocols has also made it difficult to compare species and agricultural methods and thereby develop lessons which could

Seeds of minor millets grown at Kolli Hills, Tamil Nadu, India.

S.Padulosi/Bioversity

The rapid advance of climate change that will alter agroecologies in many areas of the world will have an impact on agrobiodiversity, including NUS.


S.Padulosi/Bioversity

A custodian farmer showing her saved seeds of minor millets at a Seed Fair in Madhya Pradesh, India.

be more widely applied. Fragmentation of approaches, disciplines and funding systems have also made funding for an integrated approach difficult to obtain. Traditional plants, crops and crop varieties, and their uses have often been the victims of progress. They are deemed to be old-fashioned and unattractive in comparison to modern, exportable crops produced in much simpler (and potentially more vulnerable) production systems. All too often, such valuable genetic resources can be lost before they can be fully characterized and effectively used.

Poor competitiveness and lack of infrastructure: Today many NUS have been neglected because of poor economic competitiveness. Major crops have benefitted from consistent investments in research and development or from direct support for their production and markets (e.g. subsidies and other incentives). Major crops dominate national and international markets and government policies to the detriment of hundreds of other important life-saving crops which together have huge significance. Poor or episodic market-oriented-research, and the consequent lack of attention by governments and policy makers, has deprived underutilized crops of improved varieties, enhanced cultivation practices, technologies to address drudgery in adding value, and organized and efficient market chains. To compound matters, their marginalization is aggravated by the mistaken perception

that these traditional crops are the 'food of the poor'. An important constraint is the lack of stable sources of quality seed for many NUS crops, although with sufficient training, particularly in marketing and managerial skills as well as in the technology of seed production, farmers' groups can successfully provide sustainable supplies of quality seed (Witcombe et al. 2010).

Policies and investment: The conservation and wise, sustainable use of NUS are hampered by inappropriate rural development policies and programmes that focus on a limited number of commodities. The major challenges in these areas include:

- Absence of legal frameworks, policies, projects, national programmes and strategies
- Poor investment in research, projects and programmes on NUS
- Lack of characterization, breeding and evaluation of NUS
- Lack of integration between conservation and use programmes
- Absence of seed distribution schemes.

In terms of *in situ* conservation, the challenges include: insufficient propagation material and seeds, insufficient human resources, lack of training and financial resources, and the failure of governments to make NUS a national priority. In the area of *ex situ* conservation, genebanks are faced with a lack of funds, personnel and training, insufficient equipment, lack of adequate infrastructure and regular electricity supplies. To correct all of these deficiencies and tap the development potential of NUS, these species require supportive policy and legal environments. Without increased research and investment, the objective of supplying the world with a nutritious and dependable food supply based on agricultural diversity will be out of reach.

The conservation and wise, sustainable use of NUS are hampered by inappropriate rural development policies and programmes that focus on a limited number of commodities.

Green powder from the leaves of the Baobab tree (*Adansonia digitata*) for sale in a market in Benin. The powder, used to make sauces, is more vitamin-rich than the baobab fruit.

B.Vinceti/Bioversity

What needs to be done?[9]

Raising the profile of NUS means:

- Developing better varieties
- Improving cultivation practices
- Enhancing value adding technologies
- Helping producers get better access to markets
- Providing evidence and promoting the nutritional benefits of NUS
- More effectively maintaining on-farm genetic diversity
- Building the capacity of stakeholders
- Developing national and international policies to support sustainable conservation and use.

Addressing these issues means taking the following action.

[9] Several agencies and papers have proposed strategic frameworks for developing NUS (see Thies 2000; Williams and Haq 2000; IPGRI 2002; Padulosi et al. 2002; Gundel et al 2003; IPGRI et al. 2005; Jaenicke and Höschle-Zeledon 2006; Dawson et al. 2007; Chishakwe 2008 a, b; Will 2008; Hermann 2009; Jaenicke et al. 2009; FAO 2010, 2012; Padulosi et al 2012, Anonymous 2012, 2013; Massawe et al. 2013, Rudebjer et al 2013). This section builds on their previous analyses and recommendations and suggests a global action plan for NUS based on current challenges, trends and opportunities.

1 Change perceptions

What needs to be done:

The imbalance in agricultural policies and practices, currently skewed towards the major commodity crops, needs to change. It is important to make smallholder farmers and consumers in both urban and rural areas of poor countries aware of the benefits of conserving and using NUS and to make scientists and policymakers aware of the need to both protect and promote NUS.

Why:

Researchers, farmers, consumers and policymakers neglect and underutilize NUS because they are unaware of their economic and nutritional value.

How:

Raise awareness. Changing perceptions will mean raising public awareness of the value of NUS and providing training on NUS.

Disseminate information. Disseminating information on NUS through local agencies, in fact sheets, newsletters and other media can promote household consumption of NUS, particularly of local fruits and vegetables. In the Philippines, for example, advertising campaigns featuring local actors successfully promoted NUS. Information campaigns to promote greater use of NUS and boost demand can target the general public with messages about the nutritional value of traditional and local foods, and the role a varied diet plays in maintaining human health. National publicity campaigns promoting the benefits of consuming NUS can highlight products made with NUS ingredients. In countries such as Kenya, urban supermarkets have been successfully encouraged to stock traditional NUS foods, such as African leafy greens, that were previously shunned as 'food of the poor'.

Provide policymakers with evidence. Getting the message across to policy makers means providing evidence that conserving and using NUS can benefit communities, contribute to human nutrition and health, and bring benefits both nationally and internationally. Scientists can generate, collect and disseminate information on the food and nutritional value, and consumption of NUS, and establish formal databases and repositories of information on the economic and social aspects to provide evidence of the economic and social contributions of NUS.

2 Develop capacity

What needs to be done:

Organizations involved in research, education, development, policy departments, the private sector and farming communities need to develop skills and capacity in conserving and using NUS. Young scientists need to acquire the skills to holistically address the inter-disciplinary research challenges related to NUS and integrate nutrition into agricultural development. Policymakers and institutional leaders need to understand the role and benefits of NUS so as to integrate NUS in research and development (R&D) strategies and programmes, including adaptation to climate change.

Why:

The major staple crops and commodities dominate agricultural education and are the mainstay of national agricultural R&D, and agribusiness. Neglect of 'minor' crops and trees is widespread, and skills appropriate for staple crops are not always applicable to minor crops. A wheat breeder, for example, might not necessarily have a command of research methods and procedures appropriate to the participatory breeding of an underutilized cereal such as fonio (*Digitaria exilis*). Developing and marketing NUS requires multi-disciplinary, multi-stakeholder approaches that consider the entire value chain from seed to consumers.

How:

Upgrade capacity in value chains.

Building capacity in value chains means strengthening abilities to facilitate multi-disciplinary, multi-stakeholder approaches and bring together teams spanning agronomy and socioeconomics. Training needs for farmers and other stakeholder groups range from crop management, producing quality seed, selecting varieties, intercropping systems, managing soil health, adding value, developing new products and packaging to bookkeeping and marketing. Supporting farmer associations and cooperatives, and establishing self-help groups, such as those in India for growing, processing and marketing minor millets, can build hands-on capacity. Training facilitators to bring participants together and give them the tools they need to create effective cooperative endeavours is also important. This is particularly relevant for empowering women.

Foster capacity across sectors.

Integrating nutrition into agricultural development means helping policy

makers and institutional leaders understand the role and benefits of NUS and facilitating collaboration across sectors, such as health, nutrition and agriculture. Better understanding and collaboration will encourage the deployment of NUS in R&D strategies and programmes, including those to combat climate change.

Boost infrastructure and institutions. Building the capacity of human resources needs to go hand-in-hand with boosting infrastructure such as better tools for cultivation, machinery for processing grain and bins to safely store seed. Strengthening institutional capacity, by establishing micro-credit facilities to enable people in poor communities to start small enterprises or multi-stakeholder platforms, can build capacity beyond pilot project sites.

3 Enhance research

What needs to be done:

It is extremely important to invest in research on NUS and on improving them. Data on NUS use, propagation and growth characteristics, resistance traits and intra-specific variation must be systematically collected in databases and disseminated and shared, and methodology strengthened. Scientific knowledge and indigenous knowledge need to be integrated. Instruments and processes for sharing lessons learned at the national and international levels need to be strengthened. Conservation must be linked to use.

Why:

The lack of research on NUS, particularly on their nutritional aspects, prevents them from realizing their full potential. There are huge gaps in knowledge, such as the importance of NUS in the diets of the poor[8], the bioavailability of nutrients, the impact of NUS on vitamin A deficiencies and the role of NUS carotenoids and minerals in healthy diets. Lack of research data constrains the marketing of NUS. Information on the geographic or ethnic distribution and use of species will be a valuable guide to enhancing practical use of NUS and reducing drudgery.

The lack of standard methodology in NUS research means it is still difficult to link germplasm resources and select material for breeding because different molecular markers give different genetic

[8] Garnett et al. 2013

distances and seldom correlate well with morphological analysis. Combining scientific with indigenous knowledge of NUS will be useful in identifying specific traits to focus on when selecting germplasm and assessing the productivity, and susceptibility of NUS to pests and diseases.

How:

Document and characterize NUS. This is critical for further research on the genetic and economic aspects of NUS as well as for breeding. Holistic approaches that link conservation to use via value or market chain approaches will help identify priority species and add value to address limited competiveness.

Study adaptation in NUS. Scientists also need to study adaptive traits in NUS landraces that could be important for breeding varieties resilient to climate change; for example, studies of the sensitivity to photo periods for broadening the range of cultivation. Research on microbiology, soil and the assimilation of nitrogen by NUS is important to assess productivity. The susceptibility of NUS to pests and diseases will determine the role NUS can play in developing agricultural systems resistant to both abiotic and biotic stresses.

Strengthen methodology in NUS research. Scientists can use tools and knowledge already developed for other crops and adapt these to strengthen research on NUS. Sequence-based approaches, for example, allow comparisons of related species and genes. Molecular data can be used to identify suitable material for breeding.

Link scientific and indigenous knowledge. Participatory research methods, which include farmers, value chain actors and consumers and give them a voice, can link scientific and indigenous knowledge. In view of the sheer number of NUS species, strategic research in the form of case studies of representative species will make best use of limited resources and facilitate the scaling up and mainstreaming of results.

Share knowledge and lessons learned. Research networks help generate and share knowledge and lessons learned on NUS – from conservation, genetics and agronomy to value chains, nutrition and policies – at the national and international levels.

4 Improve conservation

What needs to be done:

Species that are not suited to conservation in genebanks need to be conserved on-farm. In parallel, greater *ex situ* conservation of NUS in genebanks, when practical, is needed. Enhancing use of NUS needs to be in harmony with traditional rights, cultural identities, ecosystem integrity and the principles of gender equity and benefit both the rural poor and urban consumers. A global on-farm conservation programme for NUS needs to be established.

Why:

On-farm conservation allows species to evolve in response to environmental changes and facilitates their use by farmers and researchers. Dynamic evolution and adaptation supports the economic development of marginalized agricultural areas and communities. On-farm management of NUS and *in situ* conservation of wild species and forest crops empowers local farmers, particularly women, and strengthens the cultural identity of local communities. Establishing a global on-farm conservation programme for NUS will acknowledge their value and enhance their use.

How:

Protect NUS biodiversity. Biodiversity in NUS can be protected by both *ex situ* and *in situ* conservation. To establish a global on-farm conservation programme for NUS, local, national, regional and international agencies need to raise funds from donor organizations to finance conservation and use, and to leverage existing mechanisms and programmes.

5 Involve stakeholders

What needs to be done:

International and national research systems and genebanks need to recognize and support small-scale farmers (both women and men), communities and organizations in maintaining diversified and resilient agricultural systems. Communities and farmer organizations need to be consulted to ensure that research programmes are relevant and appropriate. Frameworks for involving communities in addressing challenges, needs and opportunities need to be set up. Farmers need access to seed, as well as training in maintaining and exchanging quality seed and planting material according to phytosanitary regulations.

Why:

Unlike globally important crops, NUS mainly benefit local communities. Poor and marginalized groups in particular have used and safeguarded NUS over generations. Mainstreaming gender-sensitive approaches allows vulnerable groups like women – who are too often marginalized – to enhance their capacity to sustainably manage, conserve and use NUS in new ways, and in so doing to strengthen their economic status. Farmers themselves practice plant breeding and select planting material according to changes in local environments. Farmer organizations make advances available to other farmer groups in similar circumstances and exchange varieties not only within countries, but also among countries. They play a pivotal role in promoting the use of NUS, and disseminating knowledge and materials. Involving stakeholders will make certain research programmes are relevant and appropriate, that limited resources are channelled to species with the greatest potential for improving people's livelihoods[9]. Encouraging farmers to produce and disseminate seed will sustain reliable quality supplies.

How:

Collaborate with local communities.
To address challenges, needs and opportunities related to NUS scientists can use participatory approaches to consult local communities on proposed research or development. Participatory approaches should be truly open so that all stakeholder groups – farmers, processors, women's groups and traders, among others – can share their opinions. Developing frameworks for community collaboration can help effectively engage stakeholders and harmonize views, objectives and agendas.

[9] Padulosi et al. 2008

Engage farmer organizations. Researchers should consult farmer organizations during project planning. Scientists should acknowledge that farmers are practical plant breeders and that selecting planting material in response to changes in local environments happens at the farm level. Farmer organizations can make advances available to others in similar circumstances and exchange varieties, not only among farmer organizations within a country, but also with organizations in other countries. These exchanges will be important in responding to climate change.

Encourage local production and dissemination of seed. Policymakers, government agents and agronomists can promote informal seed exchange – including of genebank materials – among farmers, in particular between those in similar agroecological zones. Studies of informal seed systems will improve understanding and point to ways to support them. Support could include developing knowledge systems, training, encouraging farmer seed enterprises and linking regional genebanks. Organizing seed and biodiversity fairs will increase exposure and raise public awareness.

Kenyan farmers in their field of traditional leafy vegetables.

S. Mann/Bioversity

6 Add value and upgrade market chains

What needs to be done:

Sustainable markets for NUS need to be developed and strengthened at the local, national and international levels while ensuring that benefits are shared fairly. Research to find innovative solutions to mitigate harvest and post-harvest limitations, and to develop profitable local NUS enterprises, is a priority. Technological improvements along value chains need to be accessible to farmers and other groups, particularly the poor. Time and money needs to be invested in NUS food crops. Support to develop effective value chains for NUS (through enhanced vertical and horizontal integration) is also needed. Domestic demand for NUS and value-added NUS products needs to be expanded and trade barriers for NUS products in developed countries need to be removed. The links between farmers, researchers and consumers need to be strengthened, and programmes need to highlight the growing importance of NUS in gastronomy.

Why:

The transition from small-scale agriculture to industrial and intensive production systems has often involved mechanization. The technologies developed for commercial crops are not always suited to traditional NUS, which are generally grown in marginal areas where mechanical technologies are either not suitable or are economically out of reach. As a result, only a handful of companies with technical expertise and major investment in research take an interest in growing and adding value to local agricultural produce. Marketing local species that have to be eaten fresh may be difficult because post-harvest conservation technologies are not available. Producers who do not have access to appropriate technologies avoid growing produce that needs to be consumed quickly after harvesting. Cocona fruits (*Solanum sessiliflorum*), for example, wilt quickly and have a short shelf life.

Developing and strengthening markets for NUS at the local, national and international levels will improve farmers' access to markets, encourage value adding and stimulate demand for a wider range of crops. Diversifying the ways in which NUS are used will ensure sustained production, regardless of changes in agricultural policies, lifestyles or dietary trends. Diversity in uses, just like genetic diversity, is crucial to the survival of crops, including NUS.

How:

Develop market-oriented strategies. National governments should develop market-oriented strategies for sustainable

development of NUS. Policy makers and other stakeholders can take advantage of rising interest in nutrition to develop markets for NUS, such as through protected denomination of origin (DO), eco-labelling, fair trade, organic and Slow Food initiatives. Chefs, restaurants and food retailers can play an important role in promoting the use of NUS and adding value. They can encourage the development of local markets, provide better access to international markets and ensure equity among all participants.

Improve value chains. Governments can also support the development and/or improvement of value chains. They can provide incentives for cultivation, processing and marketing of NUS products and promote collaborative platforms among value chain actors.

7 Create a supportive policy environment

What is needed:

Legal frameworks are needed to protect NUS (wild or cultivated). National governments also need to put in place policies to effectively conserve and use NUS. There need to be incentives for managing NUS on-farm. Policies, guided by principles of equity and fairness, need to safeguard germplasm for crop improvement and sharing, and provide better access to international markets.

Why:

Legal protection of NUS (wild or cultivated) is currently limited. National and international policies – to meet legal requirements concerning plant breeders' rights – mainly protect crops which are uniform, distinct and stable. Private sector interest in NUS is mainly on species with either an economic or a health value. In most cases, local communities have been growing and caring for these species for generations. In some cases companies are trying to patent these species. In India, for example, around 50 companies tried to patent neem products (70% of the patent requests were rejected).

Policies conducive to conserving NUS on-farm encourage the improvement and sharing of germplasm. Appropriate policies can also encourage the development of local markets and provide better access to international markets. Including NUS in rural development policies can enhance adaptation to climate change and buffer agricultural production systems against climate shocks. Wider adoption and sustainable use of NUS can multiply the many

livelihood benefits they confer. Research policies to address bottlenecks can support full utilization of NUS.

How:

Create a supportive policy environment at national level. National governments can create a supportive environment by developing policies that promote:

- Including NUS as part of, for example, school feeding programmes and sustainable diets
- Enriching food aid with nutritious NUS
- Providing subsidies for growing and marketing NUS
- Providing official support for education campaigns to promote use of NUS among young people
- Running communication campaigns to change the all-too-common perception of NUS as the 'food of the poor'.

Create a supportive policy environment at the international level. International agencies can advance the NUS agenda by advocating for the inclusion of NUS in national nutritional policies and crop diversification programmes.

Mainstream best practices. Governments can mainstream best practices for NUS by integrating the methods and tools for NUS into government programmes.

Provide incentives. Governments can provide incentives for growing and conserving NUS *ex situ* and on-farm. These could include payment schemes for environmental services, such as payments for agrobiodiversity conservation services (PACS), a new concept now being tested in many areas worldwide.[10]

Establish legal frameworks. To promote the use of a wider range of crops, particularly NUS, policymakers at the international level should explore expanding the list of crops in *Annex I of the International Treaty on Plant Genetic Resources for Food and Agriculture.* The Treaty considers not only global food security, but also the increasing importance of nutrition and the role of genetic resources in countering climate change. Expanding the Treaty to include NUS would promote the sharing of germplasm material and hence support research. Also on the international level, legal frameworks, such as the European Union Novel Food Regulation, which provide certification and protection, result in high prices for niche products.

Establish an ombudsman. In addition to strengthening national and international legal instruments and frameworks, appointing an ombudsman would ensure that national and international decision-making bodies consider the rights of future generations[11]. The ombudsman could work with national parliaments and the UN system.

[10] A PACS for farmers of minor millet landraces in India (Krishna et al. 2013), for example, showed that such schemes can focus farmer experimentation and market development on threatened crops. However, the study concluded that additional issues would have to be addressed, such as defining scientifically-informed conservation goals, safe minimum standards and the potential impact of incentive mechanisms on other threatened species not covered by PACS schemes.

[11] Anonymous 2013

8 Increase cooperation

What is needed:

NUS are local and traditional, but are globally significant and thus require scientific and political attention beyond the local and national levels. More needs to be done to strengthen cooperation among stakeholder groups and create national, regional and international synergies. Success stories need to be better shared and more widely disseminated. Coordination to promote NUS at different levels and in different geographical areas is needed. At the international level cooperation to lobby for global recognition of NUS, sustainable conservation *ex situ* and *in situ,* standardized methods for documentation and monitoring on-farm and supportive international policies for their export are needed.

There is a need for mechanisms and processes to facilitate strategic synergies among existing national, regional and international networks and collaborative platforms. Concomitantly, there is a need to link priorities and programmes across the conservation spectrum. Genetic resources experts (from the *ex situ* sector), including geneticists, plant collectors and breeders, need to work more closely with the experts of the *in situ* sector, and to involve experts from other relevant disciplines, such as economics, nutrition, business, anthropology, sociology, ecology and development, in planning discussions.

In addition, cooperation among different stakeholders needs to be promoted along the whole value chain from farm to fork.

Why:

Cooperation among stakeholder groups and synergies among national, regional and international synergies is weak, with the result that researchers and markets ignore and neglect NUS. Lack of coordination between levels, sectors and geographical areas means lessons are not shared and work is duplicated. NUS value chains are often poorly organized or non-existent. The future of many promising NUS depends on close interaction across sectors, such as agriculture, nutrition, health, education, the public and private sectors, and among stakeholders such as farmers, researchers, value chain actors and decision makers.

How:

Cooperate across levels. Some local and international agencies, both public and private, have already forged links to promote the marketing and use of NUS. Launching a new international dialogue on plant genetic resources for food and agriculture would help enhance policies and set priorities to promote the use of a wider range of crops. This dialogue should champion investment in NUS research, the exchange of information and the transfer of technology related to agricultural biodiversity. It should also explore the possible expansion of the list of crops covered by the multilateral system of the International Treaty on Plant Genetic Resources for Food and Agriculture.

Create multi-stakeholder platforms. In the last couple of decades multi-stakeholder platforms have played a strategic role in promoting several NUS. Creating these platforms and ensuring that farmers, civil society organizations (CSOs), non-governmental organizations (NGOs), research agencies, the private and public sectors, and policy makers, are represented could promote the participation of stakeholders along the whole value chain from farm to fork. Diversity of representation is fundamental.

Carambola, also known as starfruit, for sale at the market in Sarawak, Malaysia.

P.Bordoni/Bioversity

NUS are local and traditional, but are globally significant and thus require scientific and political attention beyond the local and national levels.

A woman shows a NUS plant collected from the wild in the forest reserve of Oueme-Boukou, Benin.


B.Vinceti/Bioversity

Conclusions

There is an urgent need to broaden the food basket of the world by supporting the development of traditional crops neglected and marginalized by current research and agricultural policies

NUS, with their greater adaptability to extreme climatic conditions and their resilience to biotic and abiotic stresses, can be effective instruments for curbing food insecurity. Although they are characterized by lower yields, NUS will also produce harvestable yields where major crops may fail. They are also valuable in fighting hidden hunger and are particularly useful in improving diets that are too rich in refined carbohydrates and fats. In addition, agricultural production focused on agrobiodiversity can contribute to harnessing and safeguarding centuries-old traditions and is a powerful instrument for keeping alive the cultural identity of farmers and indigenous communities.

Neglected and underutilized crops have great untapped potential to support smallholder farmers and rural communities by improving their incomes and food and nutritional security while also sustaining the genetic resources needed to address present and future environmental challenges. Making full use of these crops, however, will involve making them more commercially competitive with improved 'modern' varieties. Part of this poor competitive value is because poor rural areas often have little capacity to negotiate with the private sector, thus excluding the possibility of access to new technologies and markets that could increase the potential of these locally used crops.

Interventions in support of NUS are many and include:

- The development of better varieties
- Improved cultivation practices
- Enhanced value addition technologies
- Better access of producers to markets
- Validation and promotion of nutritional benefits
- More effective maintenance of genetic and cultural diversity on-farm

- Sustained capacity building of stakeholders groups
- Policies at the national and international levels for supporting the sustainable conservation and use of these crops.

NUS crops, part of humanity's food basket honed through millennia of agricultural experimentation and cultural transmission of knowledge across generations, is wealth that merits careful conservation because of the many benefits it brings to populations worldwide. Through concerted action at international as well as at local and national levels, this resource can be transmitted on to future generations and used to improve humankind's wellbeing.

Indian women transplanting plantlets of minor millets at the research field station of the University of Bangalore, India.

S. Padulosi/Bioversity

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