Briefing

Food and agriculture

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Policy pointers

Innovations based on traditional knowledge provide climate smart alternatives that can significantly increase productivity and incomes, while ensuring sustainability and maintaining genetic diversity, as required by SDG2.

Indigenous knowledge and practices play a crucial role in maintaining and enhancing genetic diversity, which reduces agricultural risk and increases resilience to climate change.

Urgent investment is needed in *in-situ* conservation measures to prevent genetic diversity and indigenous knowledge from disappearing, including support for community seed banks, community-led landscape management and participatory plant breeding.

Agricultural policies and research should recognise the value of resilient local landraces and indigenous knowledge and ensure their conservation, particularly in centres of crop diversity, including by removing harmful subsidies and requiring benefit-sharing.

SDG2: achieving food security, sustainability and resilience using genetic diversity and indigenous knowledge

The genetic diversity preserved by indigenous knowledge and practices provides a valuable resource for improving food security and adapting to climate change. Evidence from the SIFOR project (Smallholder Innovation for Resilience) in Kenya, India, China and Peru shows how these practices can significantly enhance productivity, incomes and resilience in harsh environments, contributing to the targets set out in Sustainable Development Goal 2. We argue that greater support is needed for indigenous peoples' innovations and practices to ensure that we do not lose the genetic diversity and knowledge they hold. Priority should be given to conserving and improving resilient landraces *in-situ*, through community seed banks, community-managed landscapes, participatory plant breeding and market linkages for traditional products.

SDG2: integrating food security, environment and resilience

The Sustainable Development Goals (SDGs) set out a new agenda for food security, integrating environmental sustainability and resilience to climate change in SDG2, which includes the following key objectives:

- By 2030, end hunger and ensure access to food by all people, particularly poor and vulnerable people (target 2.1); and end all forms of malnutrition (2.2)
- By 2030, double agricultural productivity and incomes of small-scale producers "particularly women, indigenous peoples, family farmers, pastoralists and fishers including through secure and equal access to land" (2.3)
- By 2030, ensure sustainable production and implement resilient agricultural practices, that increase productivity, help maintain ecosystems and strengthen capacity for adaptation to climate change and extreme events, and improve land and soil quality (2.4)
- By 2020, maintain genetic diversity of seeds, cultivated plants, farmed and domesticated animals, and their related wild species, including through seed banks and equitable benefit-sharing from the use of genetic resources and associated traditional knowledge (2.5).

Of the 795 million undernourished people globally, around half are smallholder farmers surviving off marginal lands, 20 per cent are landless farmers, 10 per cent depend on herding, fishing or forest resources, and about 20 per cent are urban slum dwellers.[1]

Increasing productivity is particularly important in marginal lands that are already impacted by climate change. But ending hunger also requires improved access to food, incomes and land tenure for vulnerable groups.

Using local seeds, knowledge and innovations, communities have strengthened productivity and resilience

Previous increases in food production, spurred by the 'green revolution', have depended on high yielding crop varieties supported by costly inputs such as seed, fertiliser and irrigation. But over time yields have stagnated or declined,[2] while the focus on mono-cropping and often excessive use of pesticides and fertilisers has resulted in poor soil quality, groundwater pollution and loss of genetic diversity. Reliance on fossil fuel-based inputs also contributes to climate change — agriculture accounts for about a quarter of greenhouse gas emissions.

How to significantly enhance productivity, while ensuring sustainability and resilience, and maintaining genetic diversity? Lessons can be learnt from communities living in marginal areas who over the centuries have developed resilient local varieties and production strategies, sustaining rich genetic diversity.

Using local seeds, knowledge and innovations (all free and easily accessible), they have strengthened productivity and resilience. However, much of this potential remains under-utilised.

The Smallholder Innovation for Resilience (SIFOR) project is a five-year participatory action research project working with 64 indigenous and traditional communities to explore this potential. Based on evidence from this research, this briefing assesses the role of such technologies and practices for achieving SDG2.

Box 1. The Potato Park and SDG2

The Potato Park near Cusco was established by six Quechua communities, supported by ANDES (Peru), to collectively manage an indigenous territory of over 9,000 hectares, based on customary laws and traditional knowledge. By pooling their lands, the communities were able to test potatoes in different areas and increase yields despite severe soil pests due to rising temperature. Food security has been further boosted by a near doubling of incomes from landscape-based products and services, notably eco-tourism and women's micro-enterprises (for traditional foods, crafts and herbal products). Agroecological farming practices and conservation of genetic diversity, wildlife and ecosystem services ensure sustainability, while crop diversification reduces risk and strengthens resilience. Potato diversity has nearly doubled since 2004, following an agreement with the International Potato Centre, which returned 410 native potato varieties.[12]

The importance of genetic diversity and traditional knowledge

Genetic diversity reduces risk in agricultural systems and allows farmers to adapt to a changing environment, yet an estimated 75 per cent of crop diversity was lost between 1900 and 2000 with local varieties replaced by modern ones.[3] A key challenge for 'climate smart' technologies is to enhance productivity without causing the loss of genetic diversity for future adaptation by farmers.

Local landraces are often more resilient to drought and pests than their modern equivalents, and more nutritious. In Guangxi, southwest China, maize landraces survived the severe spring drought of 2010, but maize hybrids did not.[4] DNA analysis of 191 maize landraces shows that they are more genetically diverse than the same lines held in gene banks for 20–30 years.[5]

Indigenous people and smallholders have domesticated and improved most of the crops we use today using traditional knowledge, and continue to innovate for climate adaptation. The evolving gene banks they sustain provide a vital source of resilient germplasm for national agricultural systems. Traditional knowledge is also the source of most agroecological farming practices. Indigenous, local and traditional knowledge "are a major resource for adapting to climate change."[6]

Yet traditional knowledge is disappearing fast. Decades of top-down agricultural research and extension has contributed to the loss of traditional knowledge and innovations.

"If we lose indigenous knowledge, we will have to invest millions of dollars to re-invent solutions of adaptation." Carlos Loret de Mola, Ministry of Environment, Peru.[7]

How can genetic diversity be effectively maintained?

While progress has been made in securing genetic diversity in national gene banks, they are not a perfect solution. Not all genetic resources can be stored in gene banks, and those that can are no longer evolving or co-evolving through selection and breeding by farmers. Local genetic diversity found in and around farmers' fields is still largely inadequately documented and managed.[3]

In-situ conservation, including community seed banks, needs investment to help vulnerable communities access diverse resilient seeds and aid recovery after extreme events. Conservation at landscape level is also important to maintain wild crop relatives, domesticated varieties and the continuum of semi-domesticated varieties in between.

Community leadership and cultural values are essential to motivate indigenous farmers to conserve traditional varieties.[8,9] Where community leadership has not been prioritised, agrobiodiversity has not been effectively maintained.[7] The indigenous-led Potato Park provides a proven model for maintaining and enhancing genetic diversity (Box 1).

Participatory Plant Breeding (PPB) using local varieties is a key tool for increasing productivity and resilience, while conserving genetic diversity. PPB in China produced drought tolerant maize with 15–30 per cent higher yields (see Box 2). The International Centre for Agricultural Research in Dry Areas (ICARDA) in North Africa and the Middle East has documented PPB yield increases of 30–50 per cent.

PPB allows farmers to participate equally in the development of new varieties, and so empowers women and builds social capital. It also helps 'mainstream' genetic diversity in public agricultural research and extension systems, and is quicker and cheaper than conventional breeding.[10]

Box 2. Participatory Plant Breeding in China

In Guangxi province, Participatory Plant Breeding, facilitated by the Centre for Chinese Agricultural Policy (CCAP), has strengthened food and seed security in harsh mountain areas by tailoring crops to local conditions. Using resilient landraces and traditional knowledge, eight drought-tolerant maize varieties have been developed with 15–30 per cent higher yield than local landraces. They have spread rapidly and spontaneously to neighbouring villages. Some 1,000 local landraces have also been conserved *in-situ*, providing options for adaptation.

A linked community-supported agriculture programme, supplying ecological restaurants in urban areas, has tripled farm incomes and spurred the revitalisation of traditional agroecological practices (such as duck-in-rice) and locally threatened heritage varieties of crops and livestock. New farmers' organisations and women's seed fairs have strengthened social capital and empowered women. The programme also facilitated a change in China's Seed Law, allowing farmers to benefit from selling conventional seeds locally.

Can genetic diversity, traditional knowledge and agroecology achieve SDG2?

The SIFOR project identified over 500 innovations or 'new ways of doing things' drawing on indigenous knowledge and genetic diversity, sometimes combined with modern science. Some of these have been very effective in enhancing productivity, incomes and resilience, while benefiting nutrition, climate change mitigation and environmental health.

The research explored trends in climate, livelihoods, food security and crop diversity in the Peruvian Andes, Indian Himalayas, southwest China and coastal Kenya, largely between 2002 and 2012,[11] and looked at biocultural innovations in 64 communities (over 900 households), in mountain, semi-arid and dryland areas.

The findings show that these communities are already experiencing significant adverse changes in climate. These include decreased and more erratic rainfall, increased drought, increased temperatures, and more intense pests and diseases (Table 1).

Biocultural innovations

Improving resilience and yield. Farmers in all 64 communities select and save seeds from plants with desirable characteristics for adapting to changing conditions. Women play a major role in seed sourcing, saving, selection and conservation, particularly for landraces, to improve seed quality for household food security. Some farmers (eg elders and women) are also plant breeders.

In the Potato Park, Peru, potato yields slightly increased between 2002 and 2012, despite severe climate change impacts, thanks to an ancestral strategy of varietal diversification. Farmers select varieties that are resistant to higher temperatures, pests and unexpected frosts, from the park's gene pool of about 650 native potato varieties (or 1,350 according to local classification). A community gene reserve including wild relatives of different crops aids the evolution of resilient characteristics.

In the Eastern Himalayas, India, Lepcha and Limbu, farmers have adapted a variety of cardamom from close to Bhutan to local conditions through gradual selection, creating a higher yielding variety that requires much less

Table 1. Climatic changes observed by households since 2002 (1982 in Kenya)

Households	Decreased and more erratic rainfall (%)	Increased drought (%)	Increased temperature (%)	Increased pests and diseases (%)
SW China Guangxi and Yunnan (344 households)	92	63	70	67
India — C & E Himalayas (160 households)	85	95	88	87
Peru — Potato Park, Pisaq (61 households)	92	56	50	50
Kenya coast — Kilifi and Kwale (375 households)	78	90	91	82

water and shade. They also developed a new higher yielding cultivar — black rice bean, the most important local food crop. In the Central Himalayas, a farmer has bred a new variety of radish, improving yields by almost 25 per cent and enhancing resilience.

In Guangxi and Yunnan, southwest China, communities have conserved and improved drought-tolerant landraces of maize, rice and wheat, and developed drought-tolerant maize through PPB (Box 2). Five wheat landraces survived the spring droughts of 2010–2014 in the Stone Village, northern Yunnan. This ancient Naxi capital is a centre of diversity for maize, soya, buckwheat and Tibetan barley. Soya landraces and wild relatives provide an important safeguard for China's soya industry.

Farmers in coastal Kenya have discovered that planting pruned cassava tops increases yields four–fivefold and reduces maturation periods by six months. Farmers are increasingly planting cassava rather than maize to withstand drought.

Diversification and risk management. Many farmers have started to grow different varieties of the same crop together, including hardy local varieties, to reduce the risk of crop failure.

In coastal Kenya, 43 per cent of farmers in five Mijikenda communities have started planting hybrid, improved and traditional varieties of maize and cassava together, reducing the incidence of crop failure by nearly 20 per cent. Farmers have successfully domesticated wild fruit and medicinal trees to increase their incomes by 11–48 per cent, and have planted trees on farms, contributing to climate change mitigation.

In the Central Himalayas, more intensive mixed cropping close to the house (eg buckwheat, pumpkin, radish, French beans, lentils and gaderi) has increased productivity, making food available throughout the year. Intensifying finger millet production, and reintroducing flax seed and proso millet, has improved nutrition and income. Women have started cultivating fodder trees on farms, reducing forest degradation.

In the Eastern Himalayas, farmers are switching from potatoes to traditional mustard cultivation following dew damage and reviving dryland paddy, thanks to seed saving by older farmers. In the Potato Park, several biocultural innovations were identified that spread risk across space and time.

Soil and water conservation. In the Potato Park, family and community micro-reservoirs, which combine traditional water harvesting technology (aruna) and modern materials and techniques, ensure water availability for irrigation and consumption.

In the Central Himalayas, new composting techniques have improved soil fertility and moisture, resulting in higher yields and efficient water use.

In southwest China, villages are reintroducing traditional farming techniques and crops to reduce soil erosion, exacerbated by erratic weather. In Guangxi, villages are bringing back traditional intercropping using maize, soybean, pumpkin and sweet potato to improve soil fertility and composition. They have also reintroduced the use of fish waste as fertiliser on fields.

Communities in coastal Kenya are combining modern and traditional tilling practices to enhance productivity, using bigger hoes to dig deeper. Aerating the soil by ploughing and adding manure increases its capacity to hold water. Planting nitrogen fixing trees with food crops (agroforestry) is improving soil fertility and increasing grain production by 15 per cent.

Natural pest control. In Guangxi, traditional techniques combining organic rice farming with duck and fish production provides natural pest control. Villages are also reintroducing traditional biopesticides using wild herbs and chilli pepper. Growing the new cash crop *Pelargonium citrosa* next to rice and wheat fields deters pests due to its citronella-like smell.

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Knowledge Products

The International Institute for Environment and Development (IIED) promotes sustainable development, linking local priorities to global challenges.

The Association for Nature and Sustainable Development (ANDES), is an international NGO involved in poverty alleviation, biodiversity management and strengthening traditional resource rights.

The Center for Chinese Agricultural Policy (CCAP), Chinese Academy of Science, aims to analyse and help formulate policies related to agricultural R&D, natural resources and sustainable development.

The vision of LCM has been to work relentlessly for improving and transforming the concept, condition, behaviour and opportunities in the hill region.

KEFRI is a centre of excellence in forestry whose mission is to conduct research and provide information and technologies for sustainable development.

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Notes

[1] FAO, IFAD and WFP (2015) The State of Food Insecurity in the World. FAO, Rome. / [2] IPES-Food (2016) From university to diversity. A paradigm shift from industrialised agriculture to diversified agro-ecological systems. International Panel of Experts on Sustainable Food Systems. / [3] FAO (2010) The State of the World's Plant Genetic Resources for Food and Agriculture. FAO, Rome. / [4] Song, Y *et al.* (2016) Smallholder farming systems in southwest China. Exploring key trends and innovations for resilience. IIED, London. / [5] Zhang, S and Song, Y (forthcoming) Genetic diversity of 191 farmer maintained maize landraces from Southwest China based on fluorescence-labelled SSR markers. CCAP, China. / [6] IPCC (2014) Fifth Assessment Report. Working Group II. Part A. Summary for Policy Makers. / [7] Zongwen, Z 'GIAHS policies and implementation in China: Opportunities and Challenges'. Presentation at 'Landscape approaches for mountain community sustainable development in a time of climate change', Lijiang, May 2016. / [8] Swiderska, K *et al.* (2009) Protecting community rights over traditional knowledge. Implications of customary laws and practices. Key findings and recommendations. 2005–2009. IIED, London. / [9] FAO (2010) The State of the World's Plant Genetic Resources for Food and Agriculture. FAO, Rome. / [10] Ceccarelli, S *et al.* (2009) Plant Breeding and Farmer Participation. FAO, Rome. / [11] Data for Kenya is since 1982. Data on changes in climate is based on farmers' perceptions; data for years prior to 2012 relied on farmers' recall. / [12] Asociacion ANDES (2016) Resilient Farming systems in times of uncertainty. Biocultural innovations in the Potato Park, Peru. IIED, London.