

The Role of Traditional Knowledge and Crop Varieties in Adaptation to Climate Change and Food Security in SW China, Bolivian Andes and coastal Kenya

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1. Introduction

Indigenous peoples and local communities often live in harsh natural environments, and have had to cope with extreme weather and adapt to environmental change for centuries in order to survive. They have done this using long standing traditions and practices – or traditional knowledge (TK) – relating to adaptive ecosystem management and sustainable use of natural resources.

There is growing evidence of the role of traditional knowledge in responding to climate change. The IPCC's 4th Assessment highlighted the role of indigenous knowledge and crop varieties in adaptation (Working Group II, Cross-chapter case studies p.864-867). The UNU-IAS recently identified over 400 cases of indigenous peoples' role in climate change monitoring, adaptation and mitigation, including a variety of successful strategies (Galloway McLean, 2010). The 15th Conference of Parties (COP15) to the United Nations Framework Convention on Climate Change (UNFCCC) in 2010 adopted a Decision on "Enhanced action on adaptation" which identified the need to draw on 'traditional and indigenous knowledge' as well as the best available science. However, because negotiating parties at the UNFCCC COPs are countries rather than communities, TK largely gets marginalized and has struggled to get the acknowledgement it deserves.

This paper provides evidence of the role of traditional knowledge and traditional crop varieties - which are the product of TK - in adaptation to climate change. It draws on recent case studies with indigenous farmers in the Karst mountains SW China, coastal Kenya and the Bolivian Andes. These studies documented farmer perceptions of climate change impacts and local TK-based responses. The China case also examines the use of TK in Participatory Plant Breeding, and the threats to traditional varieties from modern agriculture and intellectual property rights (IPRs). The role of TK in weather forecasting is also considered in the Kenya and Bolivia cases. The studies took a holistic perspective on TK, as part of wider 'biocultural systems', building on previous research on TK protection by IIED and partners (IIED *et al.*, 2009). The paper also draws on this research to explore the role of biocultural systems in adaptation to climate change, and the drivers of change causing the loss of traditional knowledge and varieties.

The role of TK and ecosystems has tended to be under-represented in adaptation responses and economic evaluation of adaptation (see World Bank, 2010). The main emphasis has been on structural approaches and agricultural intensification, although ecosystems or ecosystem services now feature in about 56% of National Adaptation Programmes of Action projects (Reid *et al.*, 2009). In addition, the linkages between TK and genetic resources or ecosystems are not always adequately recognised - eg. there has been limited attention to TK in work on Ecosystem Based Adaptation (see Campbell *et al.*, 2009).

This paper highlights the close inter-linkages and inter-dependence between TK and genetic resources, and their role in adaptation to climate variability and change. It also shows the need for those making and implementing climate change policies at national and international levels to address the multiple drivers of loss of TK and genetic resources, including modern agriculture and IPRs.

2. The role of traditional knowledge and crop varieties in adaptation to climate change

Traditional farmers have domesticated, improved and conserved thousands of crop species and varieties, using their traditional knowledge. The diversity of traditional varieties sustained by farmers around the world is increasingly valuable for adaptation as climate changes, particularly as modern agriculture relies on a very limited number of crops and varieties. The communities of the Potato Park, Cusco Peru, for example, hold about 1500 varieties of the 4000 or so potato varieties found in the world (ANDES (Peru) *et al.*, Forthcoming). This diversity has value in itself in the face of uncertainty.

In addition, traditional varieties or landraces are more genetically diverse than modern varieties and so are better able to withstand environmental stress such as lack of water or nutrients (CBD Secretariat, 2010). In SW China, laboratory analysis has shown that *in situ* varieties have much higher genetic diversity than those held *ex situ* for 30 years, which shows the positive influence of environmental factors and farmers (Sihuang Zhang and Yiching Song, forthcoming). In coastal Kenya, Mijikenda sacred forests (or 'kaya') conserve plant and animal biodiversity which will provide a valuable source of germplasm for species that can tolerate the current extreme weather and soil conditions including drought, salt, pest and disease tolerance (Mutta *et al.*, 2011).

There are at least five types of TK useful for adaptation in agriculture:

i) Knowledge about resilient properties, such as drought and pest resistance.

Traditional farmers often live on marginal land where climate change impacts and selection pressures are greatest. Thus, they are well placed to identify resilient crop species and varieties for adaptation.

ii) Knowledge about plant breeding: Traditional farmers are also plant breeders actively experimenting on farm. In SW China, local women's maize breeding experience and expertise has been developed over many years. For generations,

farmers have done seed selection for preferred and adaptive characteristics and innovative farmers even try to cross some lines for crop improvement. Today, given the trend of male out-migration, local landraces are largely saved by women and the old, most of whom are experienced in seed selection (Song and Li, 2011).

iii) Knowledge about wild crop relatives: Wild areas around farms provide wider gene pools for crop improvement and domestication (Jarvis *et al.*, 2008), and communities use wild foods to supplement their diet. For the Mijikenda in Kenya, for example, some wild food plants are popular amongst farmers when crops fail (Mutta *et al.*, 2011).

iv) Knowledge about resilient farming and resource management practices: Traditional agriculture practices conserve key resources for resilience and adaptation - such as biodiversity, water, soil and nutrients. The 4th IPCC assessment highlighted the potential of traditional water engineering, soil management, pest management, nutrient fixing, erosion control and land restoration. (Working Group II, Cross-chapter case studies p.864-867).

v) Knowledge about climate forecasting: TK can help to forecast local weather, predict extreme events, and provide accessible information to farmers, at a scale which can be more useful at local level than sophisticated models. Climate models often provide information at a scale too large to be of use when planning what to plant and when at the farm scale. With the onset of climate change, the Mijikenda's traditional knowledge system has become a source of crucial information on weather forecasting for farmers in coastal Kenya (Mutta *et al.*, 2011). TK can also monitor climate change in specific locations, and fill the resolution gap of scientific models.

Farmers are already using traditional varieties and knowledge to adapt to climate change, particularly where traditional farming systems have been maintained. For example, farmers in the Eastern Himalayas have adopted varieties grown at lower altitudes in response to rising temperatures (Ruchi Pant, in Reid & Swiderska 2008).¹

3. Case Studies

3.1. The role of Biodiversity, Traditional Knowledge and Participatory Plant Breeding in climate change adaptation in Karst Mountain Areas, SW China (Yiching Song and Jingsong Li, June 2011)²

Participatory Plant Breeding has been carried out for the past 10 years in 3 provinces in SW China, facilitated by the Centre for Chinese Agricultural Policy (CCAP). A systematic study on climate change impacts and adaptation was conducted in Guangxi, Guizhou and Yunnan provinces in the Karst mountains, SW China, a region inhabited by 33 ethnic groups and rich in Plant Genetic Resources (a centre of maize diversity). The study involved a survey carried out in 2009 and 2010 in 54 villages and 162 households in the 3 provinces; semi- structured interviews in 6 PPB villages

¹ For further examples, see reports of the Up in Smoke Coalition: <http://www.upinsmokecoalition.org>

² The full case study report can be found at: <http://pubs.iied.org/pdfs/G03146.pdf>

and 6 non-PPB villages in Guangxi in 2010; and use of qualitative findings from PPB action research.

The main study contents are: 1) climatic changes and impacts in 10 years (1998 to 2008), 2) local adaptation tools and practices (TK, biodiversity, Participatory Plant Breeding, community group's collective actions etc), 3) results of adaptation, by comparing PPB project villages and non-ones, i.e. TK and local varieties with modern technologies and varieties, 4) taking gender as a cross cutting aspect integrated in the above 3 items given the popular phenomena of feminization of agriculture and aging agriculture in China.

The study looked at changes in climate and in the socio-economic situation of poor farmers, including male outmigration and increased rural poverty. It found that climatic and socio-economic changes are interlinked and mutually affected complex processes. Farmers' perspectives of climate change revealed that they have been severely affected and most farmers felt the effect of increasing temperature and drought and lower rainfall (see Table 1). It is noticeable that: 70% of the respondent villagers face the drought problem; 77% feel lack of rainfall; 87% realize that the temperature has increased; 62% feels stronger wind force; 56% of the villages feels stronger sunshine; 72% have more runoff, and in 64% of the villages, new pests and diseases have emerged³.

Table 1: Farmers' perspectives on the effects of climatic change

attitude indicators	-2 (much less /lower)	-1 (less/lower)	0 (normal)	+1 (more/higher)	+2 (much more /higher)
Drought		2%	28%	70%	
Rainfall	4%	77%	17%	2%	
Temperature			13%	87%	
Wind force		4%	34%	62%	
Sunshine		8%	37%	56%	
Runoff	13%	8%	8%	72%	
New pests/disease			27%	64%	9%

Farmers (mainly women and old people) are relying on their TK and genetic resources and on collaboration with public institutions and scientists for adaptation, using the following practices and tools:

i) **Landrace conservation:** 53% of respondent households still use landraces (especially of maize and rice) because they taste good, are better adapted to mountainous and barren land, are easy and cheap to obtain, and have drought and dislodging resistance (to protect from wind force). Most landraces come from farmers' own saved seeds, whereas hybrids have to be bought and the old and poor cannot afford them. Farmers also noted that cultivating diverse varieties can help reduce risks. Evidence from the field in Guangxi has shown that most farmer improved landraces and Open Pollen Varieties (OPVs) survived the big spring drought in SW China in 2010, while most of the hybrids were lost. The villages

³ Scientists have paid great attention to those new diseases such as BLSB, grey spot, rust, ear rot and MRDV, reported by scientists from the Chinese Academy of Agricultural Sciences.

involved in Participatory Plant Breeding (PPB) which have more landraces and OPVs survived and adapted to the drought. Yet other villages, which had grown only hybrids, lost all their production due to a shortage of hybrid seed in the market. This event has shown the importance of farmers' seed systems for adaptation and resilience.

ii) Participatory Plant Breeding: Faced with climate change, farmers require well adapted characteristics of crops and varieties, such as drought resistance, anti-dislodging, resistance to new pests and diseases etc. PPB is based on farmers' ancestral selection and breeding knowledge and genetic resources to better achieve locally adapted and preferred characteristics. At the same time, the team seeks knowledge and expertise from formally trained plant breeders. The PPB initiative started in early 2000 in SW provinces, focusing on maize initially and then also on rice. Its main aim is to establish cooperative and complementary relations between the previously separate formal seed system and farmers' seed system. Cooperation is necessary to provide opportunities for empowerment of farmers, mainly women farmers, as most men have migrated to the cities. The farmers become active partners in plant breeding, on-farm biodiversity management and seed marketing (Ashby 2009, Song and Vernooy 2010).

Field experiments have targeted four types of maize OPVs and landraces: 'exotic' populations (from abroad), farmers' 'creolized' varieties (developed by breeders but further adapted by farmers, sometimes by crossing them with landraces), farmer-maintained landraces and formally conserved landraces. So far, more than 200 varieties have been used in trials at the Guangxi Maize Research Institute station and in the villages. Based on 10 years of experimentation, 6 farmer-preferred PPB varieties have been selected and released in the research villages. They have also spread beyond these villages. In addition, 5 varieties from the International Maize and Wheat Improvement Center that were showing increasingly poor results have been adapted locally; and 5 landraces from the trial villages have been improved. Agronomic traits, yields and palatability of all these varieties are satisfactory and they are better adapted to the local environment than modern hybrids (CCAP 2004; Song, *et al.*, 2006).

PPB and related activities have also led to enhanced crop and animal diversity, forest resources and herbal medicines, and related TK and culture system. PPB villages have higher rice and maize diversity and more cultural and collective activities. In addition, farmer incomes have increased by about 30% in PPB project villages, as compared to non-project villages, as a result of project supported activities like productivity increase, value addition to local speciality foods and women's seed production. PPB has also attracted some young people to work in their villages. Farmers are more confident and organised with better links to external markets, eg. a women's group has gained contracts for organic vegetable production. Women are also participating more in decision making including as local leaders.

iii) Farmers' Seed Fairs: As one of the PPB activities, the first Farmer Seed Fair was organized at the beginning of 2003 in Guangxi, to encourage and enable women farmers and further strengthen, formalize and legalize the existing local process of farmers' seed exchange for adaptation. The farmers, especially women, like such seed fairs very much and are very proud to share their seed and knowledge with each other

to meet their newly emerged needs due to economic and climatic changes. They organize, with assistance from the project, farmer seed fairs every year and gradually integrated more local culture and knowledge into it for local seed exchange and adaptation. Such farmer seed fairs have spread to more mountainous villages in neighboring provinces in every post-harvest season in SW China.

iv) Community based seed production by women's group: Small scale and community based seed production has been conducted by a group of women farmers in Shanggula village since 2006. Normally the women's groups select quality local varieties and PPB varieties for local needs in adaptation to climatic and market changes. Seed production training for the group was carried out in the field by experienced women farmer breeders, local extensionists and formal breeders. The farmer produced seeds have been shared and exchanged among farmers within and between villages through farmers' seed exchange system. So far, a few farmer improved open pollen varieties (OPVs) and a waxy PPB hybrid variety have been produced and shared within and between PPB villages. The OPV are selected and preferred by farmers because of their specific traits like drought resistance, anti-dislodging etc. and more importantly, farmers can save seed themselves. The hybrid, Gunou 2006, has very good market value, in both its seed and fresh cob, and became an important income generating item for the women's groups.

Evidence from field studies in SW China shows that traditional varieties face significant threats. The biggest reason for the loss of landraces and agricultural genetic resources is the extension of "modern" varieties, mainly hybrids. For the three main traditional crops – maize, rice and soybean, we find that, between 1998 and 2008: 1) varieties of both maize and rice, as staple food crops, have been highly commercialized with a large area of hybrids; 2) the cultivating areas of landraces of maize and rice have rapidly decreased, the reduction in maize is even more serious than rice; 3) soybean landraces, as traditional intercropping and supplementary crops, have been well conserved and adopted, staying dominant and stable in SW region. This is also because soybean is not a staple food crop (like rice, maize and wheat) and is not the target of hybrid breeding and extension by both public and private sectors. Yet, in the last few years soybean hybrid breeding has drawn increasing efforts from government and companies.

As a common good, agricultural germplasm resources should be enhanced by government, public research institute and farmers. However, there is a lack of incentives and responsibilities amongst all these key stakeholders. There is an urgent need for policies and regulations to create incentives and encourage responsibility for PGR management. This includes changes in breeding, testing & release systems for 'modern' agriculture (such as DUS – Distinctness, Uniformity and Stability criteria), because these standards lead to an increasingly narrow genetic base, less biodiversity and limited options for both breeders and farmers.

As the seed market has not yet been well-regulated in China, it is necessary for public agricultural service systems to provide seed access facilitation and regulation for farmers. However, the agricultural service system (previously called extension system) in SW China has proved dysfunctional in public service provision (Song and Vernooy, 2010). It needs to be strengthened, especially on (severe) weather broadcasting and pre-caution, varietal information provision, market monitoring, etc.

The transformation of public breeding institutes from current mixed commercial and public roles to pure public functions, would not only enhance support for PGRs and TK, but would also allow fairer market competition and bring more opportunities and resources (both technical and human resources) for seed enterprises. Having a clearly defined public role will also benefit fundamental research on issues such as meeting diversified varietal needs of farmers and others, conserving agro-biodiversity and broadening genetic base in breeding. Currently, the public role played by these institutes is vague and weak (Song and Vernooy, 2010)

Another challenge is the negative impact of the big international seed companies, like DuPont, Pionire, Monsanto etc, and related IPRs. Their strategies are joint ventures with domestic companies, passing the national DUS and applying for IPRs. One hybrid maize, Zhenda 619, has wiped out half of the remaining maize landraces in Guangxi province since 2002 (CCAP report to IDRC, 2008). Another hybrid, Xianyu 335, by a joint venture company (Pionire and Denhai) has become the second biggest maize seed, in terms of growing area covered in China, in 2010. Risks in terms of seed safety, genetic narrowing, resilience and adaptation to change have caused increasing concerns. The challenges of breeding in a climate change impacted world may require the widest possible circulation and sharing of germplasm to ensure effective, timely and adaptive breeding with farmers as a key partner.

3.2. The role of traditional knowledge and bio-cultural systems in adaptation to climate change: The case of Kenya's coastal communities (Doris Mutta, Paul Ongugu and Mohammed Pakia, 2011)

A preliminary study with the Mijikenda was conducted by the Kenya Forestry Research Institute (KEFRI) in June 2011. The study entailed interviews and focused group discussions around two kaya sacred forests (Kaya Fungo and Kaya Kinondo), coastal agroecosystems (crop and livestock) and fisheries in Kilifi and Kwale counties.

The findings show that changes in climate are impacting on the Mijikenda's socio-cultural, economic, environmental and food security situation. The communities are experiencing shifts in seasons including extreme temperatures, floods, prolonged drought, tidal changes and ocean storms. They have observed notably new and worrying unpredictability of the weather conditions including timing of onset of rains. The rains are either too low and unreliable or too much. Previously, droughts would occur once every ten years. Currently droughts are more frequent and prolonged. The communities are responding using both traditional biocultural management approaches and contemporary government approaches.

Recurrent crop failures in monoculture systems have been experienced since crops don't receive adequate moisture to grow to maturity; leading to poor yields and food insecurity. Traditional cropping calendars have also been severely disrupted by the changing weather patterns. Previously specific crop plants were cultivated in defined times of rain guided by traditional practices and rules of the elders. Following the Green Revolution and adoption of modern agriculture in an effort to improve food production and food security, a high proportion of farmers grow improved monoculture crop varieties and less traditional variants. However, most of the

indigenous community members still maintain strong trust in indigenous varieties especially for maize, millet, simsim and cassava, and allocate a land parcel that carries these traditional variants.

In response to changes in climate, there has been a fall back to some of the traditional crop varieties that had been systematically overtaken by improved modern crop varieties. These include traditional maize varieties namely *mingawa* (white seeded, matures with extended rains), *Mzihana* (black and white seeded, matures with medium rains), *kastoo/njerenjere* (small yellow seeded, matures faster and is used when rains are not enough), and *bomba* (big seeded). There is an understanding that fast and slow maturing variants can be grown together to reduce risk of crop loss. The indigenous communities believe that the traditional variants are: hardy and can cope better with the unpredictable weather conditions and local pests; easy to obtain from the last harvest or from friends and relatives; and known to establish without the need for inputs (fertilizer and pesticides) required by modern crop varieties.

The farmers share seeds of various varieties and hence enhance crop diversity on most farms (i.e. avoid concentrating specific varieties in certain areas only) in order to spread the risk and ensure the survival of the varieties even when there is total crop failure in some parts of the community area.

Farmers admit that old methods may not exclusively lead them to sustainable food security. But they insist that certain traditional crop varieties, practices and concepts must be maintained and synchronized with the modern knowledge system and practices. Owing to the high cost of modern farming practices, maintaining traditional crop varieties and farming practices forms an important survival strategy for the rural poor.

Some of the contemporary agricultural strategies work against the traditional systems e.g. efforts to introduce improved seeds undermine traditional seeds. This may be very risky given that the latter are a possible life line for survival in the unpredictable future of changed climate. Government efforts should be directed towards strengthening of traditional community seed banks for traditional crop varieties to complement its focus on modern crop varieties.

Changes in climate have also impacted on kaya forests, with significant consequences for food security (see Box 1). The current governance structures that reduce the role of traditional elders have not been effective in protecting the kaya forests. It is important that the traditional governance structures are strengthened to ensure that biocultural resources that could help in adaptation to climate change are more effectively protected and conserved.

Box 1 – Impacts of climatic changes and TK based responses in Mijikenda forestry, livestock and fisheries

Forestry

a) Prolonged drought has led to a significant decrease in survival of vegetation leading to scarcity and local extinction of certain species, especially preferred animal and plant species including: small mammals and birds such as gazelles, rodents, doves, guinea fowls etc, that formed common bush meat; plant species such as *Combretum schumannii* –an important

house building plant; *Zanthoxylum chalybeum* – an important medicinal plant; and *Pepeta* – a plant that produces wild edible berries; thus diminishing supply of forestry resources for subsistence. Coupled with increasing population, this has brought increasing pressure on the traditional *kaya* forests leading to a state where the *kayas* form islands of forest patches in a wholly cleared bare farm or grazing land.

b) Long droughts result in shrinking swamps, drying rivers, diminished water supply and in the formation of hard pan of the clay soils that lead to low survival of plant species and declining biodiversity. These events provide an opportunity to identify drought tolerant plant species.

Response

i) These trends point to the need to strengthen traditional governance structures that would help ensure the protection of the sacred forests. The *kaya* elders feel that they should be enabled to control plant and animal resource harvesting using their customary laws and informal courts.

ii) Other measures proposed by the Government include the creation of buffer zones around the *kaya* forests traditionally used as communal grazing grounds.

Livestock Farming

Unpredictable rains have led to rivers and water sources remaining dry most of the year and affecting grazing lands and availability of pasture for livestock. Owing to the extended drought certain preferred grass species disappear causing livestock farmers to move to greener areas and causing soil erosion.

Response

i. Livestock farmers relocate to greener pastures and permanent rivers as a survival strategy. They follow the traditional practice of sharing their animals with friends and relatives with different sources of water and pasture until favorable conditions resume. This helps to minimize chances of losing the whole stock if placed in one place where conditions may get worse leading to loss of livestock.

ii. Traditional approaches included setting aside a land parcel for communal grazing but these are difficult to maintain owing to privatized farms and increasing population pressure for agriculture expansion.

Fisheries

Marine biodiversity was once very rich but changes in climate have led to a declining population of some fish species namely *paramanita* and *mkizi* (King fish) as confirmed by substantially reduced landing statistics (except in marine protected areas). Fishing conditions have worsened due to rougher waters and erosion of beach lines. The destruction of coral reefs through bleaching has damaged breeding grounds and habitats for species such as *mkizi*, octopus and squid.

Response:

i. The government has established Beach Management Units as a governance structure to manage fisheries activities. However, the leadership of the BMUs comprise of youth and have left out traditional elders, which means that useful TK and customary practices that can contribute to conservation may not be considered.

ii. Emphasis is being placed on environmental conservation including rehabilitation of mangroves to protect shorelines and breeding grounds for fish, placing control measures on endangered fish species, reintroducing the traditional practice of zoning off areas from foreign fishermen, and documenting traditional knowledge on fisheries.

3.3 Mountain agricultural systems, Andean people and decision-making processes under climate change realities (Rolando Oros and Sandra Barriga,

April 2011)

A study by PROINPA with Quechua farmers in the highlands and valleys of the Cuchumuela community, Cochabamba, Bolivia, found that farmers are already experiencing changes in climate, in terms of unpredictable rainfall, more extreme weather events and higher temperatures. The farmers perception is that climate has strongly changed in recent years. This has had negative impacts especially on food security crops such as potatoes, due to new pests causing crop losses. Farmers report reduced crop yields for all crops, water shortage, increased drought, increased pests (potato moth, Andean weevil) and diseases (chocolate spot), and emergence of new pests (black corn weevil). Due to increased moth attack, potatoes can only be stored for 1-3 months rather than 7 months as previously, and farmers have to buy potatoes for the rest of the year.

The Andean potato weevil is a major potato pest in Bolivia, and the rise in temperature has led to a dramatic increase in the population of the more damaging gender (from 9% to 69%) which had previously been kept in check by low temperatures. Rising temperatures have also enabled the potato moth to spread from the south of the country to the north and highlands. Changes in climate have led to changes in the planting season of many crops – and this has also favoured the potato moth. The moth causes about 30% crop damage in the field and 50% in stores when not controlled. Farmers in the highlands are not prepared to deal with this new pest and commonly use highly toxic chemicals to control tuber moths. As a result, production costs increase, farmer health is compromised and moths develop resistance to most treatments. However, to protect potatoes in storage, farmers also use native plants that have repellent properties (muña and eucalipto leaves), and biological control - they bring ants that eat potato moth and andean weevil larvae.

In response to new pests and low harvests of certain varieties, farmers are also specializing in more resistant and flexible varieties. The diversity of local varieties has enabled them to select those which are best adapted to the new conditions. For example, “Doble H” was not planted before in the community, but is now the most common variety in the region because it will always produce, even with little rainfall. The species grown have not changed, but the varieties have changed. Less varieties are now grown due to changes in climate and in the market.

The study also compared the predictions of a PRECIS (Providing Regional Climates for Impact Studies) model with actual meteorological observations and found approximate correlation in some areas which suggests that the changes observed are due to human induced climate change. However there are also significant differences in temperature and precipitation estimates in some areas, which suggests that climate change models may not be very precise in the Andean region, and should be complemented with assessments by local communities.

The research suggests that productive agro-ecosystems and related TK and practices are in danger being severely impacted by climate change, and that the changes are happening too fast for local people to adapt their practices. Many natural indicators used by their ancestors to predict the weather have been lost with the loss of TK and some signs are no longer useful due to recent changes in climate.

The study identified the following priorities for reducing vulnerability of poor Andean farmers, which stress the need to use both science and traditional knowledge:

- Developing crop varieties that are resistant to pests and diseases, and tolerant to abiotic impacts, through participatory plant breeding.
- Local seed production and dissemination for timely response to natural disasters
- Promoting mass organic production because farmers prefer it and have limited or no access to chemical inputs.
- Zoning microcentres of genetic diversity of cultivated species, semi-cultivated and wild relatives in Bolivia; and strengthening existing local conservation strategies in these microcentres.
- Reevaluation of local knowledge and linking it with scientific knowledge.

4. The role of bio-cultural systems in adaptation to climate change

Research by IIED and partners with several indigenous communities in Peru, Panama, China, India and Kenya (IIED *et al.*, 2009) found that traditional knowledge and traditional crop varieties are very closely linked and highly inter-dependent. The maintenance and transmission of TK depends on the use of diverse biological resources (wild and domesticated), and the re-introduction of traditional varieties can revive related traditional knowledge and practices. It also found that TK and traditional varieties are themselves dependent on other factors: traditional landscapes, cultural and spiritual values and customary laws. These elements of biocultural systems are all inter-connected.

Landscapes sustain genetic diversity and TK and contribute to adaptive capacity by:

- sustaining wild gene pools, diverse ecosystems, and ecosystem services;
- sustaining sacred sites (eg. forests, mountains, rivers) which promote TK transmission, cultural values and beliefs; and
- providing the physical space for sharing and exchange of landraces and TK across wide distances based on customary laws.

Cultural values and preferences are a key reason why communities sustain traditional varieties despite the pressure to adopt modern hybrids. In SW China for example, landraces are sustained because their taste is preferred and for use in ceremonies (eg. maize wine for weddings). For many communities, certain traditional varieties are sacred and used in rituals and ceremonies.

Customary laws promote TK use and transmission, conservation of natural resources and social equity. Our research identified three customary law principles that guide all aspects of life: Reciprocity (equal exchange), Duality (complementarity) and Equilibrium (balance in nature and society). We found that wide sharing exchange of seeds and knowledge (eg. between villages) based on reciprocity enhances biodiversity, since receiving triggers the obligation to reciprocate in equal measure. Indigenous communities also have specific customary rules for conservation (eg. taboos on harvesting at certain times). Much research has shown that recognising

existing customary laws is more effective than imposing external conservation rules (MA, 2005; Laird *et al.*, 2009).

Climate change is likely to require exchanges over large distances for communities to access the range of crop varieties they need for adaptation, given the speed and scale of the changes predicted. The biggest constraint to such exchange may not be differences in culture or language, but in farming and value systems – eg. subsistence versus commercial. Strong sharing and reciprocity values are common to traditional farmers of different cultures, and exchanges can occur over large distances. In SW China, results of research on maize by CCAP (both in the field and in the lab) showed that variety exchange and gene flow occurs over large distances across the region (3 provinces) and that women play a crucial role.

5. Drivers of change affecting traditional knowledge and varieties for adaptation

Traditional knowledge, crops, practices and forms of organisation offer huge potential for resilience and adaptation to climate change. However, it is estimated that 50-90% of all languages – an indicator of TK- will be extinct or threatened by 2100 (UNESCO, 2003). Despite being based on hundreds of years of accumulated practical experience, TK has been sidelined and undervalued centuries, being considered unscientific, ungodly or anti-development. And climate change could accelerate the loss of TK.

Research by IIED and partners (2009) identified multiple drivers of loss of traditional knowledge and genetic diversity, which are often inter-linked and mutually reinforcing:

- Agricultural policies, subsidies and research/extension which promote modern varieties and technologies, at the expense of local knowledge and biodiversity.
- The existence of plant breeders' rights and patents to protect new varieties without commensurate protection of farmers' rights over traditional varieties, which means that farmers often have no incentive to sustain them.
- Promotion of modern varieties/foods in the media, which influences consumer demand and reduces markets for traditional varieties.
- Limited arable land and reduction in size of landholdings, which can force communities to adopt higher yielding modern varieties.
- Erosion of cultural values and customary rules, due to modernisation, weakening of traditional authorities, out-migration and changes in occupation.

The findings of the China case study suggest that IPRs are facilitating the spread of commercial hybrids. The expansion of IPR regimes in agriculture tends to create a market for seeds that is dominated by a few large companies (Dhar, 2002). IPRs in agriculture also raise the price of seeds and have led to concerns over limiting access to seed by farmers and scientists (Tansey and Rajotte, 2008).

6. Conclusions and recommendations

The three case studies presented above provide evidence of the crucial role of traditional crop varieties, knowledge and practices in enabling adaption to changes in

climate. The question is whether the climatic changes observed in these cases are human induced climate change or just natural changes. The findings show that indigenous farmers in SW China, coastal Kenya and the Bolivian Andes are already severely impacted by changes in climate, including drought, with serious consequences for crop production and food security. The scale of the changes, and the fact that they have occurred quite recently (in the last 10 or 20 years), suggests that they may be the result of human induced climate change. In the Bolivian case, a number of observed changes in climate are backed up by scientific models, and hence likely to be human induced. Even if the changes are not human induced, the studies show that TK has clear potential to contribute to climate change adaptation, alongside modern science. This implies a revaluation of traditional knowledge, and a rethinking of mainstream agricultural policies that erode traditional varieties and knowledge.

In each case, the maintenance of diverse traditional crop varieties and access to seeds has been essential for adaptation and survival by poor farmers. Traditional varieties used include drought and wind resistant maize in SW China; maize resistant to unpredictable weather and new pests in coastal Kenya; and potato varieties in Bolivia that are more resistant to new pests and lack of rainfall. All 3 cases also found that traditional varieties have the advantage of being cheap and easily accessible as they come from farmers own saved seeds, whereas modern varieties have to be bought, depend on market availability, and require costly inputs. In SW China the old and poor cannot afford hybrids and hybrid farmers lost all their production to drought in 2010 due to shortage of hybrid seed in the market. While modern agriculture and modern varieties may increase productivity, the findings show that under conditions of environmental stress and climatic variability, survival depends on more resilient and readily available traditional varieties.

In the China and Kenya cases, farmers also identified planting diverse traditional varieties as a means to reduce risk, and the importance of sharing and exchange of seeds to gain access to diverse varieties. In Bolivia, native plants and biological control is providing a less costly alternative to toxic chemical control which affects farmer health and leads to resistance in pests. In coastal Kenya, adaptation requires the strengthening of customary governance to restore kaya sacred forests since current governance structures have not been effective.

This study also underlines the need to look at climate change impacts alongside other socio-economic issues and trends facing poor farmers, which are often compounding the effects of climate change – eg. out- migration and growing poverty in SW China; and population pressure in coastal Kenya.

Interestingly, the three different case studies identified the need for very similar adaptation responses - conservation of traditional varieties/seed banks, community seed production and PPB. In the China case, these tools have been tested in practice and shown to be effective. The conservation of landraces and development of improved varieties through PPB is not only enabling adaptation, but has enhanced biodiversity conservation and related TK, increased incomes of poor farmers by about 30% (over 10 years), empowered poor farmers and women, and started to improve public sector support for farmer seed systems.

This suggests the need to support initiatives such as local landrace conservation, local seed production, seed fairs, community seed banks, and community based conservation and adaptation. Adaptive capacity of the world's poorest and most affected communities depends not only on TK or on ecosystems (ecosystem based adaptation), but on both – on the interlinked biocultural systems from which new innovations can develop and spread; and on the landscapes, cultural and spiritual values and customary laws that sustain them.

Amongst the drivers of loss of indigenous knowledge and varieties perhaps the most significant are agricultural policies, laws and institutions that promote commercial varieties and seed privatisation at the expense of local varieties and seed systems. The challenge of climate change cannot be confronted by modern agriculture and intensification alone – indeed the spread of intensive agriculture to centres of genetic diversity could seriously undermine human adaptive capacity.

Yet, the current dominance of private sector objectives in government agriculture policies and institutions poses a serious threat to remaining centres of diversity as can be seen from the China case. IPR standards (plant breeders' rights and patents) can facilitate the rapid spread of hybrids as seen in the China case, restrict access to genetic resources for adaptation by both farmers and scientists, and do not provide any incentives for *in situ* conservation by farmers. Reform of IPRs, protection of farmers' rights to traditional varieties (as required by the FAO Treaty on Plant Genetic Resources for Food and Agriculture), and improved market access for farmer varieties are urgently needed to create incentives for in situ conservation of thousands of traditional varieties that are in danger of being lost. These measures should be addressed as a priority in national adaptation actions and international climate change negotiations.

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