Plants and climate change: which future?

Chapter 7: Linkages between climate change, plants and livelihoods

Chapter summery

Agroecosystems face many of the same threats from climate change as species in natural ecosystems, including the spread of diseases, pests and invasive species and problems adapting to new extremes in temperature and rainfall. Ecosystems managed for agriculture are dependant on the goods and services provided by natural ecosystems. As with natural ecosystems, the key to adaptation is maintaining genetic diversity and it is crucial to conserve crop diversity and crop wild relatives to meet the needs of agricultural breeding programs. Biofuels have been touted as one way to reduce greenhouse gas emissions but they are far from a panacea. Increased biofuel production may drive up food costs for many staple foods, including maize, decreasing food security. Even if non-food crops are used for biofuels, the carbon footprint of fuel production can be significant if intact plant communities are cleared for plant production.

Many of the world's poor depend directly on harvesting non-timber forest products, edible, medicinal and aromatic plants for livelihoods and sustenance. With increasing human pressure and loss of natural vegetation, many of these species are under threat. Climate change will further threaten many of these species and, as a consequence, the people who depend on them.

Key points from this chapter:

- Plants are the basis of global food production. While a mere 30 crops are often stated to 'feed the world', in fact over 7,000 plant species are actually utilised in food and agriculture. Plants also underpin the world's grazing systems and support all livestock production.

- The negative impacts of climate change on agriculture (reductions in yield, shifting crop growing zones, increased pests and diseases) are likely to be most severe in tropical Africa and South Asia, where an additional 75 million people or more could become at risk of hunger. The most food-insecure people will be those most affected by climate change.

- Loss of plant diversity in farming systems means loss of capacity for adaptive responses, making farmers more vulnerable to change, including climate irregularity and extreme events.

- Crop Wild Relatives (CWR) hold the key for developing new varieties with enhanced climate tolerance. However, models have shown that many crop CWR are in danger of extinction due to climate change.

- 80% of the world's population rely on traditional medicine – largely based on plants – for their primary healthcare. The international trade in medicinal plants is estimated to be worth US$60 billion per year. Understanding the impacts of climate change on medicinal plants is therefore clearly necessary in the context of sustainable development and health planning, as well as biodiversity conservation.

- A destructive cycle already exists between poverty and environmental degradation in many developing countries. Plant species losses due to climate change will exacerbate this, depriving millions of people of important livelihood resources.

- Well-managed carbon forestry projects provide opportunities for local communities to benefit, while at the same time restoring degraded land and storing carbon.

Case studies from this chapter:

Case study 7.1 - Deforestation and mudslides

Hurricane Mitch, one of the most powerful hurricanes on record in the Atlantic basin, stalled off the coast of Honduras in October 1998, in some places dropping up to 60 cm of rain in one six-hour period. The resulting flooding and mudslides killed over 10,000 people. Many of the deadly mudslides occurred in areas where forests had been cleared for agriculture (Chivian, 2002).

Case study 7.2 - Mangroves and tsunamis

On 26 December 2004 a devastating tsunami hit the coasts of south and southeast Asia, causing the deaths of over 200,000 people and enormous environmental damage. Damage assessments later indicated that areas with a relatively intact, natural shoreline were in some cases less affected by the tsunami. Reefs and mangroves can absorb at least 70-90% of the energy of wind generated waves. The tsunami devastation emphasized the strong link between natural coastal ecosystems and human livelihoods (UNEP-WCMC, 2006).

Case study 7.3 - Rice yields decline with higher night time temperatures

Looking at weather data from 1979 to 2003 at the International Rice Research Institute in the Philippines, the annual mean maximum and minimum temperatures have increased by 0.35°C and 1.13°C respectively. There is a close link between rice grain yield and mean minimum (i.e. night) temperature during the dry cropping season, so much so that grain yield declined by 10% for each 1°C increase in growing season minimum temperature (Peng *et al*., 2004).

Rice is one of the world’s most important food crops. It provides 27% of the energy intake and 20% of dietary protein for people in the developing world. Three of the world's four most populous nations use rice as their staple food - China, India and Indonesia. Together, these countries have 2.5 billion people.

Case study 7.4 – Impact of climate change on coffee production

Coffee is the first, second or third largest export crop for 26 mostly poor countries in Africa and Central America. Yet coffee is sensitive to changes in average temperatures. In Uganda, the total area suitable for growing Robusta coffee would be dramatically reduced with a temperature increase of 2°C. Only higher areas would remain, the rest would become too hot to grow coffee.

Over 500,000 farm households in Uganda depend on coffee for their livelihoods and in 2006/7 Uganda earned US$170 million through sales of coffee (UNEP, 2007c).

Case study 7.5– Agriculture and climate change in India

The agriculture sector represents 35% of India's Gross National Product (GNP) and as such plays a crucial role in the country's economy. Negative impacts on agriculture could result in problems with food security and threaten the livelihood activities upon which much of the population depends. The Indian Agricultural Research Institute examined the vulnerability of agricultural production to climate change using a variety of crop growth models. The predicted changes vary greatly by region and crop. Findings for wheat and rice were:

Wheat:

- Increases in temperature (by around 2ºC) would reduce potential grain yields in most places. The reduction in yield is likely to be less in northern areas.
- There will be boundary changes in areas suitable for the crop.
- Reductions in yield are likely to be more pronounced for rain-fed crops and under limited water supply situations because there are no coping mechanisms for rainfall variability.
- The difference in yield is influenced by baseline climate. In sub-tropical environments, the decrease in potential wheat yields ranged from 1.5 to 5.8%, while in tropical areas the decrease was relatively higher, suggesting that warmer regions can expect greater crop losses.

Rice:

- Overall, temperature increases are predicted to reduce rice yields. An increase of 2 to 4ºC is predicted to result in a reduction in yields.
- Eastern regions are predicted to be most impacted by increased temperatures resulting in relatively fewer grains and shorter grain filling durations.

In northern India, potential reductions in yield are predicted to be offset by higher radiation, lessening the impact of climate change (Defra, 2005).

Case study 7.6 – Invasive species' impacts on agriculture

Some invasive species transform grasslands that support grazing. For example, *Lantana camara* poisons cattle and destroys understorey species. The tree, which is seedy and thornless, can form dense thickets. It is difficult to eradicate once established, making extensive areas unusable and inaccessible, and threatening native plants.

A detailed modeling study of climate change impacts on Namibian biodiversity and ecosystems was conducted by the South African National Botanical Institute (SANBI) for Namibia in 2003. The SANBI study projected significant additional bush encroachment of the savannah under climate change, and an expansion of Nama Karoo-type (dwarf shrubland) habitat. This would severely compromise livestock production, one of Namibia's main livelihood sectors, and put pressure on the ecology of marginal farming areas.

Similiarly, the Triffid weed (*Chromolaena odorata*), a plant native to the Americas has severely impacted natural areas in Africa and reduces crop productivity in agriculture and grazing. In Ghana the weed occupies 59% of all arable lands, and in Ubombo, South Africa it reduces the grazing capacity of animals by 150% (UNEP, 200b7).

Case study 7.7 – Seed production in India

Such effects have already been felt in the seed industry of India. Since seed production requires a certain degree of chilling to induce seed formation in temperate crops, many vegetable seed farms are located in mountainous regions, such as the Hindu-Kush Himalayas. While mountainous regions can provide such a climate, they also make farmers increasingly vulnerable to the effects of climate change. Farmers in the Kullu valley of Himachal Pradesh are finding that overall temperature rise combined with increasingly unpredictable rains have led to several crop failures. Whilst vegetable seed yields decrease, the challenge of ensuring sufficient natural pollination under changing climatic conditions has not yet been adequately addressed by researchers, much less farming communities (Sharma, 2006).

Case study 7.8 - Impact of climate change on pests on agriculture

In Scotland, the mild winter of 2006/2007 led to very early flights of peach-potato aphid (*Myzus persicae*) and potato aphid (*Macrosiphum euphorbiae*), with many crops of potatoes infested with aphids as soon as they emerged. This increased the threat of virus transmission by aphids into seed potato crops and consequently required aphicide treatments from crop emergence onwards.

The threat from pests not yet in the UK is increased as the Scottish climate becomes more suitable for these pests to survive and breed. For example, the climate in some areas of Scotland could be suitable for survival of Colorado potato beetles as early as 2020, should it be introduced into Scotland. New pest problems already arising in Scottish crops are cabbage stem flea beetle and rape winter stem weevil in winter oilseed rape, and orange wheat blossom midge in cereals.

Other pests have already been introduced into the UK and have established themselves. Turnip sawfly for example was eradicated from the UK but has re-established and caused serious damage to winter oilseed rape in the autumn of 2006. By 2050 it is likely to have spread from central, southern and eastern counties of England to the eastern and central areas of Scotland.

Some pests such as wheat bulb fly will decrease in severity, as the wetter winters will lead to a higher level of winter kill, making areas where the pest is currently endemic unsuitable for its survival. This increase in winter rainfall will make the north and west of Scotland the most favourable for the survival of grey field slugs, as summer rainfall will not change much. However, the reduction in summer rainfall in the east of Scotland will not favour slugs (Scottish Agricutural College, 2008).

Case study 7.9 – Crop Wild Relative breeding for climatic tolerances

Use of CWR for breeding for tolerance to abiotic stresses is less common than for biotic stresses (Hajaar and Hodgkin, 2007) but some notable examples include wild tomatoes (*Lycopersicon chilense* and *L. pennellii*), which have been used to increase drought and salinity tolerance (Rick & Chetelat, 1995). *Oryza rufipogon* genes have been exploited for tolerance to soils with high acidic-sulfate content in Vietnam (Nguyen *et al*., 2003), and *O. longistaminata* genes for drought tolerance (Brar, 2005).

Case study 7.10 - Palm oil

High in vitamin A and magnesium, palm oil from the species *Elaeis guineensis* has recently replaced soy as the world's leading edible oil. 90% of the world's palm oil exports are produced in Malaysia and Indonesia. The development of the oil palm industry has brought economic benefits to both of these countries. However, palm oil is now starting to be used as an ingredient in biodiesel and as a fuel to be burnt in power stations to produce electricity. This is a new market for palm oil and is a trend that has the potential to dramatically increase global demand for this commodity.

Image courtesy of Marco Schmidt

In Indonesia over 100 million people depend upon access to rainforest resources for their survival, but the development of oil palm plantations is causing massive rainforest clearance. A recent report suggests that palm oil plantations are responsible for 87% of deforestation in Malaysia, and forest fires - the quickest and cheapest method of clearing trees - are often started by palm growers. Moreover, forest land that is allocated for clearing, in order to make way for oil palm plantations, is frequently left abandoned and undeveloped once the valuable trees have been removed (New Agriculturalist, 2006).

Case Study 7.11 - Biodiesel and the Amazon

The Brazilian Amazon has been decimated by a combination of loggers, farmers and ranchers over the last 40 years. Environmentalists say as much as 20% of the rainforest has already been destroyed, mostly since the 70s. After three years of reduced deforestation, levels have recently risen sharply again. Subsidies for biofuel crops in the USA have encouraged farmers to switch from soya to maize to produce ethanol. This has increased the world soya price and encouraged Brazilian farmers to clear forests for soya farms and buy up large expanses of cattle pasture. This has pushed ranchers further into the Amazon and made cattle food more costly, creating another incentive for forest conversion to pasture. Scientists have warned that 40% of the Amazon could be lost by 2050 if these trends continue (Soares-Filho *et al.,* 2006).

Case Study 7.12 - Bioenergy and floodplain restoration in Hungary

Contrary to the negative press about the potential environmental and social impacts of bionergy, this new sector can provide surprising solutions for nature conservation, as illustrated by a pilot restoration project in Hungary's Tisa floodplain.

Invasive species are a particular problem for these restoration efforts – the most aggressive one being false indigo (*Amorpha fructicosa*), a fast-growing shrub from North America. Removal of this invasive has been quite costly as it requires the use of heavy machinery to harvest the false indigo several times a year for more than a year. However, its suitability for bioenergy production (once dried, it burns well) has meant that the local power plant is willing to buy the biomass as fuel and the funds generated have been used to help finance the eradication work. Ideally, once the land is cleared of the invasive, the traditional extensive land-uses, including floodplain forests with native species, can be reintroduced as sustainable, diverse sources of local livelihoods (Vaszkó, 2007).

Case study 7.13 - Medicinal plants and species extinction

The story of the potential anti-HIV drug Calanolide provides a tragic reminder of what we risk losing with species loss. Chemists from the U.S. National Cancer Institute identified a novel agent (named Calanolide A) from the leaves and twigs of a tree *Calophyllum langierum* found in Sarawak. It was discovered on a return visit to Sarawak that the original tree was gone and that other *C. langierum* trees could not be found. It was not clear whether the species was extinct. A close relative *C. teymannii* was identified and was found to contain a weaker drug, named Calanolide B, which, while having anti-HIV activity and the same mechanism of action (it is a non-nucleoside reverse transcriptase inhibitor), nevertheless was not as potent as Calanolide A. Calanolide B is currently in clinical trials, the result of a successful venture between MediChem Research and the government of Sarawak (UNDP no date).

Case study 7.14 - Saving the snow lotus

The snow lotus (*Saussurea laniceps)* is popularly used in Tibetan medicine. However, increased world demand for the blossom is pushing the species towards extinction. Medicinal uses for the flower range from rheumatism to 'women's diseases'. It is also highly sought after by tourists as a symbol of the region. The plant favours steep, unstable scree slopes well above 12,000 feet. In heavily harvested areas, the plant is all but gone.

Botanists have been comparing the size of specimens preserved in herbariums to plants found in the wild, and they believe that humans have played a role in actually shrinking the species by as much as four inches in the past century. In an accelerated version of natural selection, harvesters take the biggest blossoms they can find and leave only the smaller ones to sow their seeds.

For the snow lotus, the underpinnings of conservation already exist in Tibetan culture and holy sites, such as the eight sacred mountains of Tibetan Buddhism, have become pockets of biodiversity in a rapidly changing landscape (Arnold, 2006).

Case Study 7.15- Conservation of medicinal plants in the Himalaya

The situation in the Himalayas is particularly critical. Medicinal plants collected from these peaks play a significant role in the region's culture and economy. They are a major source of income for communities in the region and provide basic healthcare for millions of people. This resource base, in terms of both the plants themselves and the knowledge of their use, is being eroded at an alarming rate. In some areas plants are becoming increasingly scarce, while others have disappeared completely from their traditional harvesting areas.

Ensuring a sustainable future for medicinal plants in the Himalayan region is therefore of great importance. A collaborative project between Plantlife International and national partners in five Himalayan countries – Bhutan, China, India, Nepal and Pakistan – is focussing on the identification and conservation of IPAs for medicinal plants in the Himalaya.

53 IPAs of medicinal plants have been provisionally recognised in the Himalaya, with a significant number of smaller sites at a more local level. The identification of these sites will be useful for landscape-level planning, including the siting of protected areas. Based on the gross geography of the IPAs (as currently recognised) protected area networks in the Himalaya should be reviewed. A good distribution of protected areas will help ensure survival of species in the face of climate change. It will also help to ensure that the genetic diversity of medicinal species is conserved
(Hamilton & Radford, 2007).