Biodiversity and climate change

Climate change has a major impact on biodiversity, and therefore also on ecosystem services such as food and water provision. At the same time, biodiversity in the shape of forests, functional soils or genetic resources can play an important role in mitigating climate change, buffering the influence of climate change as well as supporting societies in adapting to it.

The term "biodiversity" involves different connotations for different people and is therefore often misunderstood. Using a wide definition, it describes a key feature of all biological resources, ranging from genetic diversity within species and species diversity to the diversity of biotopes and ecosystems. Actually, the Convention on Biological Diversity (CBD) encompasses this wide definition, referring the conservation of biodiversity, its sustainable use as well as access to biodiversity and the fair and equitable sharing of benefits arising from the use of genetic resources as equal goals (see Figure).

How does climate change affect biodiversity?

Climate change has a wide range of effects on biodiversity. As plants and animals rely on specific environmental conditions, changes in temperature and humidity regimes affect the performance and competitiveness and relationships of species. Species adapted to the cold retreat to higher latitudes and altitudes, while species used to living in warm areas may expand their ranges of distribution. This can cause problems if species expand that are regarded as pests or diseases, or if invasive species do harm to locally adapted ecosystems. The desert locust is an example. Just a slight increase in precipitation in susceptible areas in Africa where this insect lives may cause increased population densities (Cheke and Tratalos, 2007).

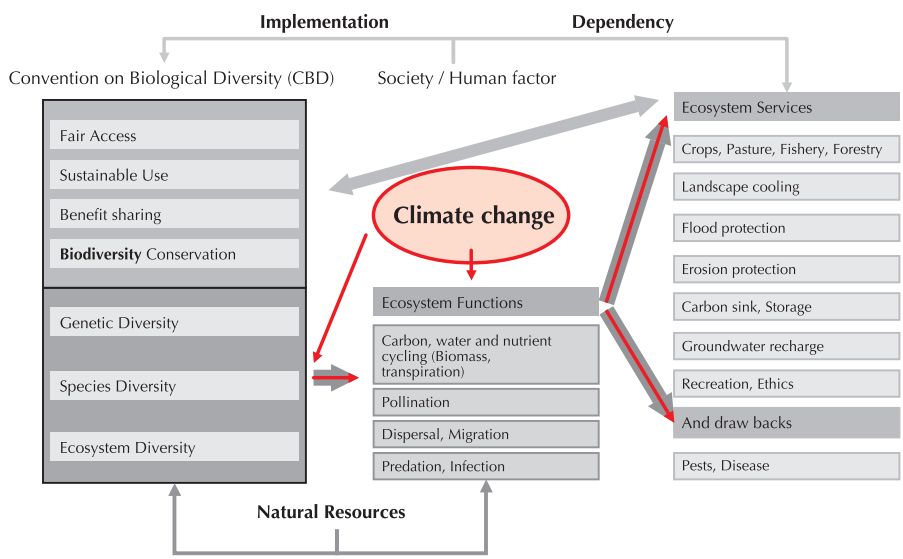
However, shifts in distribution areas are not always possible as species may not be able to migrate through a landscape increasingly fragmented by human activities. Or they may not find a new place to establish as climatic regimes do not fit or land use is inadequate. So generally, climate change must be expected to further increase the global rate of species extinction.

The rapid change of environmental conditions is of particular concern for some hot spots of species diversity, e.g. the Cape region of South Africa or the Amazonian forest. The latter could transform from a tropical rainforest to a savannah-like system. It would then lose a large amount of species, many of which are unknown. These species form part of the living library needed to detect new pharmacological or crop species.

On the single plant level, climate change impacts a plant's phenology, i.e. the time of year when it starts flowering, develops fruits or dies. In temperate regions, plants tend to flower earlier and lose their leaves later, thus prolonging the vegetation period. In tropical regions, the increased variability of precipitation might decrease the number of plant generations per year. In many areas, increasing temperatures are combined with a decreasing or at least more variable supply of water.

Another climate change-related impact is the potential "fertilisation

Pathways between biodiversity, ecosystem function, ecosystem services and societies. Climate change impacts on biodiversity and ecosystem functions, and therefore modifies ecosystem services.



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Amazonia

The Amazon forest is under pressure from land use change as well as climate change, with both of them interacting. Land use change starts with small roads for logging, and attracts small-scale and subsistence farmers and, increasingly, commercial soy bean producers, leading to a fragmented forest with reduced capacity to provide ecosystem services such as climate and water cycle regulation and carbon storage, and increases the risk of disease proliferation (Foley et al., 2007). Climate change as expressed by increasing temperatures and drought frequency could convert the whole tropical rainforest system into a savannah-like system with all the consequences for ecosystem processes and species diversity.

Photo: PIK

It starts with road works for logging and ends up with the destruction of vast areas of tropical rainforests.

effect" of increased atmospheric CO_2. Many plant species are limited in their growth by CO_2, therefore increased supply may lead to increased biomass accumulation or enhanced phenological development – as long as water and other nutrients are not limiting. In principle this is true for crops, too, but recent research results indicate that the dietary value of some crops might be reduced as the supplementary CO_2 leads to more sugar instead of proteins (Stafford, 2007).

Loss of ecosystem services

The Millennium Ecosystem Assessment (http://www.millenniumassessment.org) was the first global assessment of changing "ecosystem services" as a consequence of global environmental degradation. Ecosystem services describe functions of ecosystems that are valuable for humans and human development.

Decreasing biodiversity may be related to reduced food security as varying conditions cannot always be buffered by genetic or species diversity. The risk of famine increases with climate change, particularly when agricultural systems and livelihood options rely on few or only one species and institutions cannot provide support (Fraser, 2007).

Primarily in mountain areas, forest clearing reduces the water storage functionality in catchments. In combination with floods and droughts induced by climate change, people suffer from erosion and water shortage.

Implications for rural development and new alliances

One of the largest challenges for rural development and poverty alleviation is to tackle increasing variability in precipitation (floods & droughts) combined with an overall loss of biodiversity – not only due to climate change, but also due to overexploitation, land use change and chemical pollution.

Rainwater harvesting. One approach to combine the requirements of ecosystems and agro-ecosystems for water is rainwater harvesting (RWH) schemes combined with small-scale irrigation, based on new as well as on traditional methods (Falkenmark and Rockström, 2004). Especially in Africa, a large potential exists to increase and safeguard yields in a sustainable way.

Guidelines for bioenergy production. Rural areas face a new period of agricultural intensification, as they are used not only to feed a growing world population with an increasing demand for better nutrition, but also, increasingly, to produce biomass for energetic purposes. Globally important ecosystems with a high biodiversity such as the Indonesian rain forest are under a massive threat. Whereas bioenergy production might support rural development and maintain biodiversity on a smaller scale, especially on a larger scale, negative impacts will predominate.

Protection of trees and forests. One of the key roles that vegetation plays with respect to climate change is buffering against increasing temperatures. Respiration of vegetation, especially forests, leads to a cooling of the surrounding area, and may even increase the probability of precipitation. Climate regulation by the forests of the Thai National Park in Ivory Coast is increasingly acknowledged by the local population, as cacao plantations

Mangroves

In many coastal regions, rising sea levels negatively affect coastal ecosystems as well as agricultural lands because of salt water intrusion. Mangroves, for example, are highly specialised trees of the coastal regions which are adapted to high levels of brackish water. The plants harbour a variety of species, including commercial ones, and provide local communities with mechanical protection against inundations and tsunamis (Kathiresan and Rajendran, 2005). The Sundarban area in Bangladesh and India belongs to the largest wetlands of the world. Large areas have been cleared to produce rice and shrimps (Gopal and Chauhan, 2006). Now their provision of ecosystem services is further endangered due to rising sea levels.

in central Ivory Coast have become unproductive due to desiccation.

Agroforestry systems. Agroforestry systems are another possibility to combine biodiversity conservation and climate change adaptation. They are more resilient against climate change than tree-less fields, as the trees reduce wind speed and therefore evaporation, and trap water and nutrients. They harbour higher species diversity, including e.g. predators that check insect pests. The increased transpiration by the trees themselves as well as their competition for light and nutrients can be diminished by appropriate tree selection and management methods. Agroforestry systems fulfil a bundle of ecosystem services (Pandey, 2007), and are therefore important in climate change adaptation.

Soil conservation. Another alliance between biodiversity, climate protection and agriculture lies within the area of soils. Both on the surface and underground, vegetation contains large amounts of carbon. In particular, the bogs below the Indonesian rain forest store large quantities of carbon. Soil tillage in combination with high temperatures leads to a rapid oxidation and loss of soil carbon. Organic farming and soil conserving agricultural practices such as mulching or zero tillage enhance both the biological diversity of the soil fauna and reduce carbon losses from the soil (Lal, 2007). Paying attention to maintaining soil services allows a more sustainable agriculture to face climate change.

Forest cleaning results in heavy loss of biodiversity storage, loss of land, and finally in a rise of temperature.

Photo: PIK

Enhancement of genetic crop diversity. High (agro-) biodiversity allows for local adaptation processes. Supporting farmers in maintaining their locally adapted and autochthon varieties is an important insurance against future increase of temperature variation and the occurrence of new pests and diseases. It is an even better safeguard than genetically modified crops, which often have a reduced genetic variability.

Biodiversity governance. For development cooperation to be sustainable under future climate change conditions, biodiversity conservation must be an intrinsic part of international and national legislation as well as government and administration. Protected areas as a means to conserve the library for future crop and pharmacological development as well as retreat areas for plants and animals must be acknowledged more strongly, and these services should be compensated by international funding and trading mechanisms.

Zusammenfassung

Der Klimawandel beeinflusst die Biodiversität in genutzten und naturbelassenen Ökosystemen. Neben einem Anstieg der Temperatur spielen insbesondere Verschiebungen in den Niederschlagsmustern eine Rolle, aber auch die steigende Konzentration von CO_2 verändert Physiologie und Konkurrenzstärke der Pflanzen. Die Abschätzung klimawandelbedingter Veränderungen von Umweltdienstleistungen erfordert, dass auch andere Einflussgrößen erfasst werden, etwa Entwaldung oder Bodendegradation. Der Schutz der Biodiversität erhöht die Möglichkeit, Wirkungen des Klimawandels auf Ökosysteme zu reduzieren und kann in verschiedenen Zusammenhängen als Puffer gegen die Auswirkungen des Klimawandels wie Erosion, Dürren und Überflutungen wirken. Bodenschonende Anbaumethoden erhöhen nicht nur die Funktionalität der Bodenfauna, sondern auch die Speicherkapazität von Böden. Die Förderung lokal angepasster Sorten trägt nicht nur zur ländlichen Entwicklung, sondern auch zur Sicherung der Nahrungsgrundlagen bei.

Resumen

El cambio climático influye de distintas maneras sobre la biodiversidad en los ecosistemas, tanto en los ya explotados como en los de naturaleza virgen. Aparte del incremento de temperatura, juegan un rol importante las variaciones en los patrones de precipitaciones. También las crecientes concentraciones de CO_2 modifican la fisiología y la capacidad competitiva de las plantas.
La evaluación de las transformaciones en los servicios ambientales debidas al cambio climático presupone que también deban registrarse otras variables de influencia, como la deforestación o la degradación de los suelos. La protección de la biodiversidad ofrece mayores oportunidades de reducir los efectos del cambio climático sobre los ecosistemas. La conservación de la biodiversidad puede – dependiendo de las circunstancias – servir de factor de amortiguación contra las consecuencias del cambio climático como la erosión, las sequías y las inundaciones. Los métodos de cultivo que protegen los suelos no sólo aumentan la funcionalidad de la fauna que se halla en ellos, sino también la capacidad de almacenamiento del terreno. El fomento de especies adaptadas a las condiciones locales contribuye, por un lado, al desarrollo rural, y por otro a la seguridad alimentaria básica.