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Part 1: Basic elements for avoiding greenhouse gases and generating climate-neutral energy (technical toolbox)

Chapter 2-10

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2.10 Nature-based solutions

At first glance, it may seem surprising that a chapter on "technical building blocks" contains a sub-chapter on so-called nature-based solutions. However, a holistic view of the climate situation reveals that these must be an absolutely necessary component of any solution that succeeds in limiting climate change to a manageable and tolerable level. A 100% emission-free energy system that also meets global prosperity ambitions is not achievable using the technologies we know today.

The need for nature-based solutions is therefore based, among other things, on nature's ability to extract CO_2 from the atmosphere and store it over long periods of time or permanently. In this context, we speak of the natural CO_2 cycle. It is an important supplement to the technical CO_2 cycles described in the previous chapters.

In addition, there are other weighty arguments that underpin the importance of nature-based solutions beyond their climate protection dimension: it contributes to the creation and preservation of value added and is thus a crucial element of the implementation of the 2030 Agenda and thus to the simultaneous realisation of development AND environmental and climate protection.

The following four building blocks of the GES reference solution belong to the field of nature-based solutions:

- Programme to preserve the remaining rainforests to maintain its CO_2 buffer function
- Reforestation on 1 billion hectares of degraded soils to bind (as permanently as possible) 5 billion tonnes of CO_2
- Restoration of 1 billion hectares of degraded soils using biochar to bind (as permanently as possible) a further 5 billion tonnes of CO_2
- Establishment of short-rotation plantations on 150 million hectares to produce biomass for the production of climate-neutral fuels (cf. also Chapter 2.7.).

They are described in more detail later in the chapter. Beforehand, it is justified that they make sense and can be implemented.

2.10.1 Nature-based solutions - definition and different categories

The term nature-based solutions (NbS) is used in the context of climate protection. It covers all climate protection measures that make use of nature's ability to store CO_2. At the core of these measures are natural processes such as photosynthesis and various forms of

sustainable land use. At the core of these measures are natural processes such as photosynthesis and various forms of sustainable land use.[541]

A variety of nature-based solutions can be distinguished in the categories forests, agriculture/grassland and wetlands/marshes.[542] In the following, the most important categories of nature-based solutions in terms of their impact are briefly described, which are of particular importance for the GES solution model:

Conservation. This is about the preservation of existing ecosystems. Conservation is of particular importance, especially for the remaining rainforests. Saving them must be an absolute priority because intact rainforest stores up to 500 tonnes of CO_2 per hectare above and below ground.[543] In addition, there is a special problem: even years after deforestation, CO_2 still escapes from the soils and corresponding areas can remain CO_2 sources in total despite possible reforestation measures.[544]

Reforestation. This refers to the reforestation of deforested or degraded areas. Here, the phenomenon described above must be taken into account that deforested areas remain CO_2 sources for years, even if they are reforested. Against this background, priority should be given to the reforestation of degraded areas in order to actually achieve a positive climate impact.

Afforestation. It refers to the targeted planting of trees in areas where there are no or few trees.

Agroforestry. It is a land use practice that combines agricultural and forestry elements. Trees and plants are integrated into an agricultural system. In addition to climate impacts, considerable other positive effects can be achieved, from improving soil fertility with resulting increases in yields, to biodiversity and the promotion of local communities. Another element is improved water and soil management.

Soil Improvement. Soil improvement refers to targeted measures to improve soil quality, which at the same time increase the carbon content in the soil. So-called biochar plays an important role in this. It is produced by pyrolysis from plant waste, is introduced into the soil and contributes to improving the productivity of the soil.[545]

[541] Cf. Alliance for Development and Climate (2021).
[542] Cf. Griscom et al. (2017).
[543] Cf. FAO (2022)...
[544] Cf. Mills et al. (2023).
[545] There are also processes in which biochar is not introduced into soils, but is used in technical processes, for example as a substitute for coke, see Küffner (2022). Such examples make it clear that there can be major competing uses for biomass.

2.10.2 Nature as a CO_2 sink

Chapter 2.8 described a number of technical CO_2 removal approaches or Negative Emission Technologies (NET) that make it possible to contribute to reducing the CO_2 content of the atmosphere. In order to achieve an overall climate-neutral system, the CO_2 storage capacity of nature also plays a decisive role. A global climate-neutral energy system cannot be achieved without nature-based solutions, as there will also be unavoidable CO_2 emissions in the energy system in the long term, for example at steel and cement plants, but also from volatile CO_2 sources such as cars and trucks. The CO_2 storage capacity of ecological systems, first and foremost the rainforests, but also the oceans, is considerable. In total, we are talking about about 20 billion tonnes of CO_2.[546] The status quo should be maintained or even expanded at all costs.

The fact that the preservation and restoration of nature and ecosystems has become a central task of our time is underpinned by the Vision 2050 of the World Business Council for Sustainable Development. The vision, which calls for 10 billion people to be able to live well and within the limits of the planet by 2050, identifies three "urgencies" where there is great pressure for action. Among them are two where nature is of central importance: "*Nature in Crisis*" and "*Climate Emergency*".[547] The annual Global Risks Reports of the World Economic Forum also clearly show that risks resulting from the destruction of nature and climate change pose the greatest threat to humanity as well as to companies and their ability to create value.[548] Preserving and restoring nature is therefore not only highly sensible for pure climate protection reasons.

In the context of climate protection, the promotion of nature-based solutions makes use of nature's ability to absorb CO_2 (CO_2 sink). Trees and soils, but also peatlands and oceans, store CO_2 when they are intact. Considering the loss of forest areas and the progressive degradation of soils, this storage capacity must be preserved or restored. In the status quo, nature stores about 20 billion tonnes of CO_2.[549] In addition, there is an additional storage potential of at least 10 billion tonnes of CO_2,[550] which corresponds to about a quarter of today's global CO_2 emissions in the energy-related sector. Other sources suggest that nature's additional storage potential could be expanded to 15 billion tonnes of CO_2 by 2050 if appropriate measures are taken.[551] In addition to this obviously indispensable contribution to climate protection (mitigation), nature also plays an important role in the area of climate adaptation.

[546] Cf. Friedlingstein et al. (2022), FAO (2022).
[547] Cf. WBCSD (2021).
[548] Cf. WEF (2022).
[549] Cf. Friedlingstein et al. (2022), FAO (2022).
[550] Cf. Girardin et al. (2021).
[551] Cf. UNEP (2022).

However, in order to tap the aforementioned additional storage potential of 10 or even 15 billion tonnes of CO_2 per year, a massive expansion of today's commitment is necessary. Current practice shows that afforestation and forest conservation projects are often promoted today. The fact that forest areas are still being lost on a large scale shows that much more commitment is needed in this area alone.[552] A future new theme is agricultural projects for soil restoration. Humus formation and plant charcoal are important elements in making soils more productive again and at the same time CO_2 sinks. In this context, the recent declaration of the 14th Berlin Conference of Ministers of Agriculture, according to which agricultural soils worldwide are to be taken into consideration and protected or restored in the interest of species and climate protection, gives cause for hope.[553]

Nature is also so interesting for climate protection because it even allows CO_2 to be permanently removed from the atmosphere. In this case, we speak of removals. In 2022, the IPCC formulated the urgent need for CO_2 removals from the atmosphere if the net zero targets are to be achieved.[554] It states that "*the deployment of carbon dioxide removals to counterbalance hard-to-abate residual emissions is unavoidable if net zero ... emissions are to be achieved*". The aim must be to permanently lock up CO_2 removed from the atmosphere in carbon sinks. If this is achieved and permanence is assured, we speak of Carbon Dioxide Removals (CDR). In the voluntary CO_2 markets and also in the current standards, the topic of carbon removals is becoming increasingly important. According to these standards, it is no longer sufficient to be active exclusively in the area of (temporary) CO_2 avoidance and reduction. [555]

The term 'removal' is used with varying degrees of rigour. In a recent UNEP study, the potential removal contribution of all project types in the field of nature-based solutions is stated. It is about the aforementioned amount of approx. 15 billion tonnes of CO_2 per year, if the potential is fully tapped.[556] The following figure illustrates how this is made up:

[552] Cf. Statista (2022a).
[553] Cf. BMEL 2022).
[554] Cf. IPCC (2022).
[555] Cf. SBTI (2021).
[556] Cf. UNEP (2022).

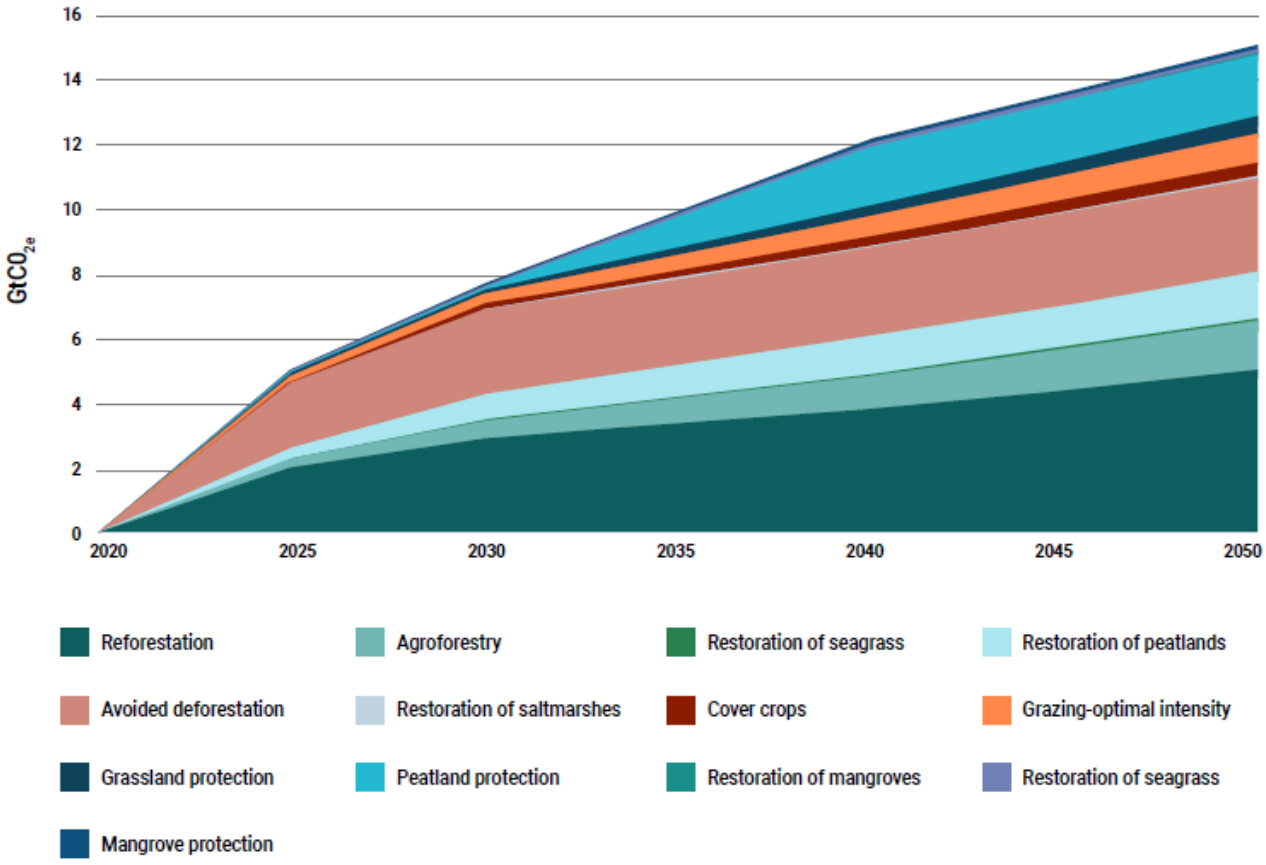

Figure 179: Removal potential of various NbS from 2020 - 2050;

Source: UNEP

Strictly speaking, however, only those activities that permanently remove CO_2 already in the atmosphere count as removals.

So when it comes to reforestation projects with subsequent use of the wood, it must be ensured that the wood is used in a cascade-like manner over many years, e.g. in the area of construction. This makes it clear that pellet heating, which has been highly praised for many years, is not an optimal solution in terms of climate protection because the CO_2 is released back into the atmosphere when the pellets are burned. The fact that it is biogenic CO_2 does not prevent its negative impact on the climate. It would be a better alternative to capture and store the CO_2. This is called bioenergy with CO_2 capture and storage (BECCS).

Another option to permanently remove CO_2 from the atmosphere is the pyrolysis of biomass that is not needed for nutritional purposes but would be burnt, e.g. crop residues. The CO_2 is broken down into solid carbon and oxygen and plant carbon is produced. This in turn is an important input for restoring degraded soils and increasing their yield.

The fact that 30 % of the world's soils are already degraded today shows how great the need, but also the potential of such an approach is and how diverse the possible positive effects are.

Not only is CO_2 permanently removed from the atmosphere. Jobs are created in the process described and the yield capacity of the soils is improved. If the farmers are paid the equivalent value of the emission certificates traded in the OECD for each tonne of CO_2 sequestered, this represents a significant source of income in addition to the yields from the fields. This is a win-win situation: in Europe, abatement costs fall and money flows into the developing countries to finance climate protection.

2.10.3 Nature as the basis of economic development

Nature-based solutions are predestined to enable development in the sense of the 2030 Agenda in addition to positive climate impacts.[557] In many countries, and especially in developing and emerging countries, agriculture and forestry are important value-added segments that could be decisively strengthened by scaling up nature-based solutions. Jobs are created and food security is improved. In addition, there are positive contributions to the preservation of biodiversity, which, along with climate protection, is the second pressing ecological challenge of our time.

Promoting nature-based solutions therefore makes sense for far more reasons than just climate protection.[558] With no other category of measures is it so possible to combine the two major concerns of sustainable development already laid down in the Brundtland definition of sustainability, namely catch-up economic development and environmental and climate protection. [559]

Agriculture and forestry are important economic sectors. In global terms, they account for just under 5 % of world GDP.[560] This corresponds to a good 4 trillion US dollars. While the share of agriculture and forestry in GDP is lower in industrialised countries, it is much higher in developing and emerging countries and thus crucial for the well-being in the country. In some countries, the share even exceeds 50 %, e.g. in Sierra Leone (59.5 %) and Chad (54 %).[561] It is thus clear that promoting nature-based agricultural and forestry solutions is an important lever for improving the economic situation in developing countries. According to estimates by the World Economic Forum, targeted support and framework conditions for nature-based solutions in these sectors could create 10 trillion US dollars in new value added and 395 million new jobs by 2030.[562] It is often the case that as a result of fertilisation with biochar, the yield

[557] Cf. Smith et al. (2019)
[558] Cf. ILO, UNEP & IUCN (2022).
[559] Cf. Herlyn (2021).
[560] Cf. Statista (2022b).
[561] Cf. Destatis (2022).
[562] Cf. WEF (2020).

power of the fields increases, which in turn leads to the nature-based solutions even becoming self-sustaining.

Nature can be understood in a much more fundamental way as the basis for value creation. If it is described in economic terms as natural capital, it becomes clear what is meant. Like other types of capital, e.g. financial, physical and human capital, it is a necessary precondition for any form of value creation, even beyond agriculture and forestry. The following figures illustrate the extent to which total value creation is dependent on nature: According to the World Economic Forum, more than half of the world's gross domestic product, i.e. more than 44 trillion dollars, depends on nature, i.e. on forests, oceans and other habitats.[563] Against this background, some voices estimate the danger of biodiversity loss for the stability and prosperity of humankind as probably greater than climate change.[564] Stabilising ecosystems must therefore be the order of the day.

2.10.4 Existing challenges

Funding is still scarce today

The problem of lack of funding runs like a red thread through the debate on implementable solutions in the energy and climate sector. This is particularly true for nature-based solutions, and it is especially tragic because of the many not only positive but even vital contributions that nature provides.

For years, the UN has repeatedly pointed out that large 9-digit sums are missing, for example, to preserve the rainforest, reforest forests or restore degraded soils. In a UNEP study published at the end of 2022 on the occasion of the World Conference on Nature COP15, the full extent and drama of the underfunding and misfunding that still exists today becomes clear.[565]

Today, a good 150 billion US dollars per year are invested in nature-based solutions worldwide. If the goal is to limit climate change to a manageable level, to stop the loss of biodiversity and to prevent the proportion of degraded soils from increasing further, 384 billion US dollars per year will be needed by 2025 and 484 billion US dollars per year by 2030.

Even more serious are the calculated total amounts of funding required for nature-based solutions until 2050, if the (illusory) 1.5°C target or the 2°C target is to be achieved: 11 trillion US dollars are needed to achieve the 1.5°C target, and insignificantly less at 9.5 trillion US dollars

[563] Cf. Gelinsky (2022).
[564] Cf. IPBES (2019).
[565] Cf. UNEP (2022).

for the 2°C target. In addition to the amounts involved, another message stands out: action must be taken immediately if the damage to nature is not to become irreparable.

If one considers all the positive effects that go hand in hand with nature-based solutions, it is hard to understand why the financing situation is so bad in the area of nature-based solutions. These seem to be a blessing in disguise, as they succeed in overcoming the major conflicts of objectives in sustainable development: While on the one hand they contribute to climate protection and the preservation of biodiversity, they also promote the well-being of people, for example by creating jobs and improving food security. If one thinks in terms of natural capital, their contribution is much greater and more fundamental.

Large-scale special programmes to conserve and restore nature and to promote sustainable agriculture and forestry worldwide, supported by state AND non-state actors, should no longer be delayed for a variety of reasons.

Competing situations with regard to land and biomass use

When we talk about nature-based solutions, we are talking about the use of land and biomass for climate protection. In an overall view, however, one finds that in the area of land use as well as in the area of biomass use, there are different options for use that lead to competitive situations and to the question of which form of use is the most effective, taking into account all relevant criteria. It is a typical phenomenon of the "full" world, which is characterised, among other things, by the fact that more and more people are striving for prosperity on less and less intact, non-degraded land as a result of climate change. [566]

In addition to climate protection, there are a number of other concerns that are pursued in the context of land use. These are nature conservation, food production and infrastructural use - the latter for energy provision, for example, but also for transport and settlement construction. In the same way, there are competing uses in the context of biomass use that can be derived from the alternatives for land use: Should food, building material (e.g. wood) or biomass for energy use (production of climate-neutral fuels, input for biogas plants, pellets) be produced?

Hints on how to deal with these competitions can be found in the German biomass strategy that is currently being developed.[567] There, the overarching goal is stated as "contributing to the achievement of climate protection and biodiversity goals as well as the energy transition". The strategic goal is to "*steer biomass flows while taking into account food security, climate protection, biodiversity, environmental protection, energy and raw material supply security*". It

[566] Cf. von Weizsäcker (2022).
[567] Cf. BMUV (2022).

is obvious that no clear guidelines for the use of limited biomass can be derived from such broad targets.

Against this background, the following plausible guiding principles have been formulated:

- Prioritise material use over energy use (for permanent carbon storage).
- Priority of multiple use
- Priority for cultivated biomass and forest wood for higher-value material uses (only residual and waste materials for energy use)

Against the background of the described multiple concerns that exist in the area of land and biomass use, a well-considered handling of the limited areas and the biomass produced on them is indispensable. For the future, the development of holistic approaches to optimising land and biomass use is desirable. This is a multidimensional optimisation task that should take into account the criteria of climate protection, biodiversity, food security and value creation potential.

2.10.5 Solution modules of the GES reference model

Taking into account all the contents described above, there are four building blocks in the GES reference solution that can be assigned to the nature-based solutions. Against the background of the competition for land described above, the focus is on degraded land and its rehabilitation. Various independent sources suggest that more than 2 billion hectares of degraded land with restoration potential exist worldwide.[568] Of central importance are also the remaining forests and especially the tropical rainforests.

2.10.5.1 Conservation of the remaining tropical rainforests

Of great importance is a broad-based programme to preserve the remaining tropical rainforests.

From the point of view of climate protection, it is a matter of preserving their CO_2 storage capacity. The tropical rainforest stores up to 700 tonnes of CO_2 per hectare. Another rule of thumb is 1 tonne of CO_2 per cubic metre of rainforest. On average, forests store 400 t CO_2 per hectare.

[568] Cf. WVI (2022), WRI (2022).

In recent years, an average of 10 million hectares of forest have been lost per year,[569] including around 4 million hectares of tropical rainforests.[570] A good 10 % of global emissions are due to deforestation.[571] They amount to about 4 billion tonnes of CO_2.

Today, the world still has about 1 billion hectares of tropical rainforest.[572] Conservatively estimated (500 t of stored CO_2 per hectare), preserving this would correspond to a CO_2 emission avoidance of about 900 billion tonnes of CO_2.

Preserving the remaining forests, and especially the rainforests, is therefore an indisputable imperative. In addition, there are further arguments that underpin this absolute necessity. Forests and especially rainforests are not only the "hotspots" of biodiversity, but also the basis of life for 1.6 billion people worldwide.[573]

2.10.5.2 Reforestation on 1 billion hectares of degraded land

Another component is the afforestation of 1 billion hectares of degraded soils for the long-term storage of 5 billion tonnes of CO_2, which will be achieved in a ramp-up of 25 years by 2050 (afforestation).

It is about commercial forests and thus about the production of cultivated biomass, which should be used cascade-like, i.e. several times over many years, in order to achieve permanent CO_2 binding. The wood should not be burnt, but pyrolysed into biochar at the end of its life cycle and incorporated into the soil. In this way, genuine CO_2 removals are created. The CO_2 is permanently removed from the atmosphere.

It goes without saying that such a programme generates added value and creates many jobs. The extensive development effects resulting in addition to the positive climate effect underline the importance of such an approach for the overall solution.

2.10.5.3 Restoration of 1 billion hectares of degraded soils

Another component is the restoration of 1 billion hectares of degraded soils for the long-term storage of 5 billion tonnes of CO_2, which will be achieved in a ramp-up over a period of 25 years until 2050 (Soil Improvement).

[569] Cf. FAO (2022)
[570] Cf. Statista (2022c).
[571] Cf. BMZ (2017).
[572] Cf. FAO (2022).
[573] Cf. BMZ (2017).

It is about humus formation and the incorporation of plant carbon into soils. The plant carbon is produced by pyrolysis of preferably crop residues and other biogenic waste materials that are not needed in the food sector. In this way, genuine CO_2 removals are created. The CO_2 is permanently removed from the atmosphere.

The impact of such a programme can hardly be overestimated. As in the area of afforestation, value is created and jobs are created. In addition, a major contribution is made to food security because the yield capacity of the soil is decisively improved.

2.10.5.4 Short-rotation plantations on 150 million hectares

Another component that cannot be described as a nature-based solution in the narrower sense, but which also relies on nature's CO_2 storage capacity, is the establishment of short-rotation plantations on degraded land of 150 million hectares. The CO_2 storage potential of such plantations is up to 20 t CO_2 per ha.[574] Fast-growing plants should be cultivated on these plantations, e.g. eucalyptus, which serve the production of climate-neutral fuels. The biomass obtained is gasified, cf. also chapter 2.7.

Of course, short-rotation plantations alone will not make a significant contribution to the preservation of biodiversity. In an overall view, it is necessary to design land use in such a way that, on the one hand, biodiversity is guaranteed, but on the other hand, land is also set aside for industrial biomass production. These are necessary in order to fulfil prosperity ambitions.

2.10.6 Outlook

A sad reality is that to this day it has not been possible to tap the enormous potential of nature-based solutions. On the contrary, rainforests continue to be lost and soils continue to degrade. No one knows how the pledge made at the last Biodiversity Conference that 30% of the world's land should be placed under nature conservation by 2030 is to be realised.[575] Implementing the four measures described above would be a quantum leap. It is possible, but many things would have to change compared to the status quo.

The reasons for the lack of confidence in the past are complex. The previously mentioned gigantic financing gaps are a crucial point, but not the only one.[576] Another problem is unresolved land use rights. No donor will get involved if the legal situation is unclear.

[574] Cf. UNFCCC (Panna Siyag).
[575] Cf. CBD (2022)
[576] Cf. UNEP (2022)

In addition, there are fundamental difficulties in measuring nature. The CO_2 effect of nature cannot be measured precisely in the same way as is the case with technological solutions. Uncertainties and inaccuracies have to be dealt with. This repeatedly leads to questioning methodologies for certifying projects and thus their impact, most recently in a large-scale study by DIE ZEIT and the Guardian.[577] As a result, private donors fear losing their reputation and, in the worst case, withdraw from financing nature-based solutions. Here, a commitment by the United Nations could create reliability and security of reputation.

Furthermore, the voluntary CO_2 market is in a state of flux. The question of whether international climate protection contributions can be counted if they are made in countries that have themselves formulated a national climate target within the framework of the Paris Climate Agreement is discussed again and again. In many places, the problem of double counting is mentioned, which will presumably lead to a step-by-step departure from the idea of climate neutrality and instead develop in the direction of so-called contribution claims: A non-state actor from an industrialised country then makes a contribution so that the developing country in which the project takes place can achieve its climate goal. This non-trivial debate also leads to great uncertainty on the part of the non-governmental donors whose funds are so urgently needed.

For the future, it is to be hoped that pragmatic approaches will finally be developed and accepted so that nature-based solutions can be given the much-needed scaling up and the issues of climate change mitigation and biodiversity conservation that are so pressing can be addressed in the appropriate manner. An example of a pragmatic approach is to provide annual figures for rainforest conservation by referring to the sheer size and number of hectares. Thus, at the end of a year, 50 - 100 € per hectare of rainforest could be paid out if it is proven by geo-information system that the rainforest is still standing. This does not correspond to the logic of permanence that is widespread today. However, since tipping points are in danger of being exceeded, every year in which the rainforest is preserved should be considered a gain when viewed realistically.

The four measures described are very ambitious. However, there are no reasons in principle that speak against their realisation. For the future, it is to be hoped that pragmatic approaches of the kind described will be found in clever cooperation between governmental and non-governmental actors, which will contribute to the implementation of nature-based solutions reaching a new level and overcoming previously existing obstacles. Corresponding proposals are part of the GES reference solution.

[577] Cf. Fischer, Knuth (2023)