Working Paper:

The risks of large-scale biosequestration in the context of Carbon Dioxide Removal

Abstract

The explicit reference to "a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases" (Art. 4) in the 2015 Paris Agreement has given a strong impetus to Carbon Dioxide Removal (CDR) proposals that aim to remove greenhouse gas emissions through bioenergy and carbon capture and storage (BECCS). While actual implementation of BECCS is still in a state of "infancy" according to the latest Intergovernmental Panel on Climate Change (IPCC) report, large-scale biosequestration in the form of monoculture tree plantations for carbon sequestration and/or bioenergy production is already supported with climate finance, including through the voluntary forest carbon offset market and the Forest Investment Program.

The paper will describe existing trends in the field of large-scale biosequestration and how current climate finance for it is geared towards industrial monoculture tree plantations, owing to global governance structures and a growing emphasis on private sector involvement. As such, biosequestration approaches that have significant negative rather than positive impacts are being prioritised. The potential risks and impacts of these CDR approaches on biodiversity, hydrological flows, land degradation, agrochemical contamination, albedo effects and the Earth System, and social impacts like elite resource capture, land grabbing, rural (un)employment, and gender-specific impacts, are described.

There are ways to sequester carbon in terrestrial ecosystems that impact communities and the ecosystems they are based in positively, but they differ greatly from the types of approaches currently supported by climate finance. They are rights-based, community-led and gender sensitive. However, current enthusiasm from policy-makers and the private sector for CDR and BECCS is contributing towards a trend where the urgency of the climate crisis is used to prioritise unproven and potentially harmful approaches instead.

Global Forest Coalition

HEINRICH BÖLL STIFTUNG

Photo: Stuart Demmer/Flickr

Contents

The risks of large-scale biosequestration in the context of Carbon Dioxide Removal

Published in October 2017 by Global Forest Coalition & Heinrich Böll Foundation
Authors: Coraina de la Plaza, Oliver Munnion, Simon Fischer & Simone Lovera
Editor: Oliver Munnion
Graphic design: Oliver Munnion
Cover photo: Ben Beiske/Flickr

This publication was made possible due to generous support from the Heinrich Böll Foundation.

This document has been produced with a financial contribution from the Swedish International Development Co-operation Agency (SIDA) through the Swedish Society for Nature Conservation (SSNC). The views herein shall not necessarily be taken to reflect the official opinion of SSNC or its donors.

1. Introduction:
Carbon Dioxide Removal post-Paris

The Paris Agreement has set an ambitious target of limiting global temperature rise to 1.5°C. But the explicit reference to achieving "a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases" has put a strong focus on Carbon Dioxide Removal (CDR) as a mitigation approach. According to the Intergovernmental Panel on Climate Change (IPCC), the primary CDR methods are bioenergy with carbon capture and storage (BECCS) and afforestation, [1] both falling under the category of "large-scale bio-sequestration". The majority of the scenarios modeled by the IPCC that keep global temperature increases to 2°C rely on BECCS to one extent or another.

BECCS is referred to as a "negative emissions" technology, and implementing it at the scale envisaged would require a significant increase in global bioenergy use, with CO_2 being captured from biomass combustion or biofuel production and then sequestered underground. Afforestation and reforestation involve the large-scale planting of trees to sequester carbon. Due to the lack of an adequate definition of "forests", where natural forests are distinguished from tree plantations, reforestation and afforestation often involve monoculture and/or invasive and non-native tree plantations. Such CDR approaches aim to intervene in and alter the earth system on a large-scale, and are collectively described as climate geoengineering.

There is significant support for BECCS, reforestation and afforestation as they are envisaged to play key roles in compensating for carbon budget overshoots, as countries globally struggle to reduce greenhouse gas emissions. However, the IPCC has also concluded that these approaches involve a high level of uncertainty and significant risks. [2]

Whilst BECCS implementation is still in a state of infancy and discussions relating to CDR as a climate mitigation strategy are similarly in their initial stages, industrial tree plantations, which would produce the raw materials for BECCS, are rapidly growing globally. With a growing interest in engaging and leveraging funds from the private sector, the first plantation projects supported by climate finance are emerging, including through the voluntary forest carbon offset market and the Forest Investment Program (FIP). As long as the definition of "forests" [i] used by Parties to the UN Framework Convention on Climate Change (UNFCCC) does not exclude plantations, [ii] any policy support for BECCS, reforestation or afforestation could therefore translate into a significant gearing-up of new industrial tree plantations. This could happen regardless of the likelihood of technologies like BECCS actually being rolled out commercially, or large-scale biosequestration successfully mitigating future greenhouse gas emissions.

This paper looks at the global governance structures that are determining current CDR approaches, and how a reliance on private-sector involvement is prioritising industrial tree plantations over alternative rights-based, community-led approaches, that would prove less harmful to people and the planet. It then looks at the reality of large-scale biosequestration currently, describing the climate finance mechanisms that have started to support tree plantation schemes, and country-specific case studies of where this has happened. BECCS as a mitigation technology in theory and in practice is then anaylsed, followed by an examination of the likely ecological and socio-economic impacts of large-scale biosequestration in the form of tree monocultures, with a case study on the impacts of climate change and industrial tree plantations in Portugal. Finally, the paper concludes with a brief look at community-based forest restoration in Nepal, and how such positive examples of biosequestration involve completely different approaches to governance.

[i] Definition of a forest from the Convention on Biodiversity (1992) and the decisions of the 7th Conference of the Parties of the UNFCCC, an "Ecosystem with tree crown cover (or equivalent stocking level) of more than 10-30% with trees with the potential to reach a minimum height of 2-5 metres at maturity *in situ*."
[ii] A tree plantation can be established by planting or/and seeding. According to the FAO's Forest resource Assessment (1998) plantations are either: (a) of introduced species (all planted stands) or; (b) intensively managed stands of indigenous species, which meet all the following criteria: one or two species in the plantation, even age class, and regular spacing.

2. The governance of CDR policies and projects

Addressing global environmental crises like climate change requires global governance structures that facilitate adequate stewardship of the biosphere. Earth System Governance theory, [3] and other theories that emphasise polycentric or multi-scale governance, [4] including resilience theory, [5] have pointed out that non-State actors have an important if not indispensable role in global environmental governance.

Increasing awareness of this role has led to the creation of a large number and variety of so-called multi-stakeholder governance structures, including multi-stakeholder roundtables, public-private partnerships and a multitude of other participation mechanisms. The UNFCCC has actively promoted such processes in order to implement the often very generic and non-specific agreements that have been adopted by it. One clear example is the objective in the Paris Agreement to limit global warming to 1.5°C through a combination of greenhouse gas emission reductions and large-scale bio-sequestration ("negative emissions"). This objective is supposed to be implemented through polycentric, multi-stakeholder and multi-scale governance structures.

However, the strong desire expressed by policy-makers for polycentric governance has not been accompanied by sufficient scientific research on the economic interests of the different actors that participate in these governance processes, and to what extent these interests, and potential conflicts of interests, might influence the resulting policy options that are favoured.

For example, a study on the motivations of stakeholders that promote the UNFCCC sub-regime to reduce emissions from deforestation and forest degradation and enhance forest carbon stocks (REDD+) has revealed that powerful actors like corporations and conservation NGOs were inclined to promote policy options that neatly aligned with their own economic interests. For example, the aviation industry has been pushing the commercially attractive option of using monoculture tree plantations as carbon offsets, as it would allow the industry to continue to grow. The International Civil Aviation Authority has been promoting this approach as part of a "carbon neutrality" discourse that ignores the potential negative impacts of plantations, and the benefits of counterfactual land use scenarios. [6]

The study concluded that there was a clear need for more analysis of the economic incentives that might drive certain stakeholders. It would be problematic if stakeholders were prioritising policy options that suited their own economic interests, rather than prioritising environmental effectiveness, economic efficiency and social equity. [7]

A further conclusion was the need to distinguish stakeholder groups that merely have an economic stake or scientific interest in environmental governance, from rightsholder groups whose human rights might be affected by the outcome of certain governance processes. The latter include women, Indigenous Peoples, youth and children and farmers and workers, who have formally recognised sets of rights under international law, but who might be affected by certain policy options. [8]

These distinctions are particularly relevant to the debate on negative emissions and CDR, as many policy options focused on them, involving BECCS and large-scale biosequestration for example, would require massive amounts of land. Local rightsholder groups like pastoralists, Indigenous Peoples and small farmers often depend on large areas of land, but their rights to those lands are seldom formally recognised. [9] These groups tend to be politically and economically marginalised, which means they will be easily side-lined by more powerful actors in multi-scale and polycentric governance structures. [10]

There has also been a tendency to classify the lands used by groups such as pastoralists, Indigenous peoples and small farmers as marginal, especially where the land has been targeted for enhanced or alternative land use by other stakeholders. Similarly, women are still politically and economically marginalised in many parts of the world, and their land tenure rights are often not formally recognised either. [11] There is therefore an inherent risk that large-scale biosequestration approaches that are driven by global policy processes will overlook the rights and interests of local rightsholder groups like Indigenous Peoples, small farmers and women.

The increasing emphasis on Public Private Partnerships and other forms of blended finance to implement climate action creates additional risks, as private investments need to be commercially viable. Biosequestration options like monoculture tree plantations can deliver economic profits to private investors, but as described below they tend to undermine local livelihoods and even destroy entire local communities through rural depopulation and unemployment, as tree monocultures are exceptionally labor-extensive.

Many multi-stakeholder governance structures have been based on an assumption of a level playing field between different actors and a respect for all knowledge systems, rights and interests. In practice though, this has often not been the case. [12] While multi-actor governance processes can have some equalising effect, politically and economically powerful actors will by definition have a much stronger influence on the outcome of such processes than other actors, in particular women. [13] This influence is even stronger when actors are invited to contribute financially, for example in a public-private partnership. [14] The financial dependencies created by such contributions will, by definition, lead to conflicts of interests. [15]

In the field of climate change and large-scale biosequestration the considerations outlined above are of utmost importance. In principle, addressing climate change through biosequestration requires multi-scale governance options that are able to translate a global environmental policy objective into local action. But global actors like transnational corporations, international financial institutions and powerful, hegemonic governments have far more political and economic power than local rightsholder groups like women and Indigenous Peoples. [16] These global actors have an economic interest in relatively cheap or even commercially profitable forms of biosequestration, and large-scale monocultures of trees and other crops tend to qualify well in that respect. These actors will subsequently be inclined to use arguments that align their economic interests with a discourse of global biosphere stewardship, claiming that large-scale biosequestration is one of the few remaining options to effectively address climate change.

These interests and arguments are juxtaposed with the rights and livelihoods of local rightsholder groups. Meanwhile, policy options that might be more effective, efficient and equitable in addressing climate change, like the rapid phase out of fossil fuels and halting deforestation, are often dismissed as they conflict with the interests of powerful players in multi-actor governance. [17]

Industrial tree plantations are attractive investments for the private sector. **Simone Lovera**

3. BECCS in theory and practice

BECCS is commonly referred to as a "negative emissions" technology, based on the contested assumption that bioenergy is inherently carbon neutral or very low carbon, with all of the carbon emitted during combustion being taken up by new plant growth. The theory is that capturing the CO_2 emitted from bioenergy and sequestering it will reduce the amount of CO_2 in the atmosphere. [iii]

However, as argued below, large-scale bioenergy is often inherently carbon-intensive, [18] putting direct and/or indirect pressure on natural forests and other natural ecosystems due to the requirements of large areas of land. Bioenergy feedstocks often involve monoculture plantations of trees or other crops that are produced specifically for energy use, which replace often less carbon-intensive forms of land use. [19, 20] Additionally, long-term and safe CO_2 sequestration cannot be guaranteed, [21] and CCS technologies are still far from being commercially feasible on a large scale, [22] with only very few exceptions, despite heavy investment.

How viable is BECCS as a climate mitigation technology?

BECCS remains a theoretical concept as there are no operational BECCS facilities in existence. So far only a small number of BECCS trials have taken place, such as at ethanol refineries that capture some of the CO_2 they produce for example at ADM's Decatur refinery in Illinois, USA. [23] However, these cannot be described as "carbon negative" as the amount of CO_2 captured is significantly smaller than the amount emitted through the process of operating the refineries. [24] A trial was also conducted at a test facility at the Klemetsrud Waste Incinerator, Norway, to capture some CO_2 emissions, a proportion of which would have been produced from the incineration of biological material, but this trial has since ended. [25]

Technologically, capturing CO_2 from ethanol fermentation is widely achieved at a commercial scale, often being sold for Enhanced Oil Recovery or for the production of fizzy drinks, but none of the other methods of CO_2 capture proposed for bioenergy facilities involving either pre or post combustion capture have been trialled.

Another issue in applying CCS to bioenergy would be the energy penalty involved. Compared to coal, biomass combustion releases more CO_2 per unit of energy, meaning that even more of the energy generated in a BECCS plant would be used to capture CO_2. SaskPower's Boundary Dam coal-fired power station in Canada, for example, uses some 40MW of its 120WM capacity to capture CO_2 and another 10MW to compress and transport the CO_2 to its end user, an Enhanced Oil Recovery site. [26] Losing such a significant amount of energy on carbon capture makes BECCS operations even less economically attractive, and casts further doubt on the future feasibility of the technology.

Carbon accounting for bioenergy is flawed

In many spheres bioenergy is automatically considered low or carbon neutral. For example, the International Energy Agency assumes that "emissions from biomass combustion are considered to be CO_2 neutral". [27] This is similarly reflected in national and regional policy making on bioenergy. [28] However, the premise that bioenergy is low or carbon neutral has been highlighted as a serious carbon accounting error by a growing volume of peer-reviewed studies showing that the life-cycle greenhouse gas emissions associated with bioenergy are commonly no lower than those of fossil fuels, and are often even greater. [29]

Carbon accounting for bioenergy is often restricted to process emissions, for example from the fossil fuels used to power a biofuel refinery, to make wood pellets, or to transport biomass to a power station. But comprehensive examinations of life-cycle greenhouse gas emissions must also include emissions from carbon stock reductions and foregone carbon stock reductions as a result of logging, N_2O emissions from fertiliser use, methane emissions from woodchip storage, and from direct and indirect land-use change. Further indirect impacts of bioenergy could come from, for example, diverting wood residues from

[iii] For an in-depth analysis of BECCS see "Last-ditch climate option or wishful thinking? Bioenergy with Carbon Capture and Storage", published by Biofuelwatch and Heinrich Böll Foundation in 2016

existing markets, which in turn results in more logging. [30]

Searchinger et al. (2017) argue that estimates of the carbon impacts of plantations for bioenergy and other uses cannot be made without taking into account the counterfactual or "alternative" scenarios for these plantations. Where they replace either a natural ecosystem or agricultural land, as they often do, more ecologically diverse land is therefore lost directly or indirectly, that was already sequestering carbon, and would have continued to do so had it not been replaced. [31] Under existing policy mechanisms, the significant sources of emissions described above are being ignored.

Where would BECCS feedstock come from?

Policies promoting the expansion of bioenergy have already led, both directly and indirectly, to increased deforestation and forest degradation, and to widespread biodiversity destruction. [32] They have resulted in increased greenhouse gas emissions from land conversion, soil carbon losses, and other sources. [33]

At the scale being proposed, BECCS would require vast new bioenergy generation, and hence land. It is very likely that the land requirements for BECCS implementation would vastly accelerate the loss of primary forest and natural grassland. It has been predicted that a dependence on BECCS could cause a loss of terrestrial species perhaps worse than the losses resulting from a temperature increase of around 2.8°C above pre-industrial levels." [34]

Another estimate suggests that using BECCS to limit the global temperature rise to 2°C would require crops to be planted solely for the purpose of CO_2 removal on up to 580 million hectares of land, equivalent to around one-third of the current total arable land globally. Planting at such scale, at least initially, is predicted to involve more release than uptake of greenhouse gases due to the impacts of land clearance, soil disturbance and use of fertilisers. [35]

Most modeled BECCS scenarios also rely on the use of agricultural and forestry "residues", in addition to dedicated energy crops. [36] Large and reliable quantities of agricultural residues are generally only provided by industrial monocultures, such as palm oil and sugar cane, and tree plantations. Such monocultures are responsible for significant ecosystem conversion, carbon emissions and biodiversity loss. [37, 38, 39] Excessive removal of forestry and agricultural residues also depletes soil carbon and nutrients and leaves soils more vulnerable to erosion and drying, and subsequently reduces future plant growth and opportunities for carbon sequestration. [40, 41] Furthermore, the existence of sufficient quantities of agricultural and forestry residues is also highly questionable, and would more likely only account for a fraction of required feedstocks. [42]

There is a mismatch between the evidence that global bioenergy studies can provide in terms of available feedstocks, and the desire from policymakers for estimates of feedstock availability that can help to guide policy targets. [43] Consequently, optimistic estimates of feedstock availability for BECCS could prove to be seriously inaccurate. However, the issue of feedstock availability is likely to remain entirely academic, as the prospects for large-scale BECCS deployment are so small due to its lack of feasibility, as explained above.

A more useful use of land

Searchinger et al. (2017) show how basic carbon opportunity cost calculations explain why alternative uses of any available land are likely to do more to combat climate change than bioenergy, and advocate that currently, policy should not support bioenergy from energy crops and other dedicated uses of land. Their calculations suggest that for every 100 ha of land available for bioenergy feedstock production, generally at least as much energy and at least 100 times more carbon mitigation could be provided if just 1 ha were used for solar energy generation, and the remaining 99 used to restore and regenerate natural ecosystems, including forests. [44]

4. The reality of large-scale biosequestration: Climate finance for large-scale tree plantations

There are a wide variety of international climate finance mechanisms that operate at different governance levels. They can be broadly differentiated as i) UNFCCC financial mechanisms such as the Global Environmental Facility (GEF), the Adaptation Fund (AF) and the relatively new Green Climate Fund (GCF) and, ii) non-UNFCCC financial mechanisms such as UN-REDD, [iv] Forest Carbon Partnership Facility (FCPF) and the Climate Investment Funds (CIF). However, these funds are often developed by or have involvement from the same UN agencies such as the Food and Agriculture Organisation (FAO) (e.g. UN-REDD), they operate through the same Multilateral Development Banks (e.g. GCF and GEF) and are implemented by the same organisations, such as the World Bank (e.g. FCPF, CIF and GCF).

Under the UNFCCC, the role of forests to mitigate climate change has more recently been addressed under REDD+ (reducing emissions from deforestation and forest degradation to promote the conservation, sustainable forest management and the enhancement of forest carbon stocks). [45] The basic idea underlying REDD+ is to create economic incentives for developing countries to conserve forests, rather than cutting them down. [46] The Paris Agreement explicitly recognises activities related to REDD+.

A number of international funding mechanisms exist with the main aim of supporting countries in 'getting ready' for REDD+, including the Forest Carbon Partnership Facility (FCPF) and the Forest Investment Program (FIP) of the World Bank, and UN-REDD. [47] More recently, other mechanisms that provide further support for REDD+, such as the Green Climate Fund, have also emerged.

Consequently, REDD+ currently serves as a vehicle for a considerable amount of the international funding for forests and, because tree plantations are not excluded from REDD+ support, it is increasingly common that international climate-related funding mechanisms are, directly and indirectly, financing projects that include monoculture tree plantations. One of the main reasons for this is that the UNFCCC uses a definition of forest that does not exclude monoculture tree plantations. [48] The use of ambiguous terms such as "planted forests" by organisations like the FAO, where only palm oil plantations are excluded, [49] further complicates a proper legal distinction between forests and monoculture tree plantations.

Some climate funding mechanisms include provisions and safeguards relating to plantations. For example, the FIP explicitly mentions the need to avoid replacement of natural forests by tree plantations. [50] However, as the case studies below highlight, many projects endorsed by the FIP promote the expansion of monoculture tree plantations on what is assumed to be "degraded" or "marginal" land. But as has been pointed out, many of those lands could be used for either forest restoration or agriculture, meaning that there are direct or indirect land use change factors to consider. [51]

In addition, the rationale behind the funding of projects that are largely based on monoculture tree plantations is, in many cases, that they will replace abandoned and/or degraded agricultural lands, which will increase forest cover, and therefore carbon storage. However, even where land is degraded or abandoned, the establishment of plantations does not necessarily achieve this as there are many factors that must be considered. [52] For example, pastures are occasionally considered do be abandoned or degraded lands but studies have found that soil carbon stocks decline by an average of 10% when land use is changed from pasture to tree plantation. [53] The fact that local communities are sometimes reliant on these so-called abandoned/degraded lands is also often overlooked. [54] A detailed analysis of these factors or even an adequate definition of abandoned and

[iv] UN-REDD is a program established by the Food and Agriculture Organisation, United Nations Development Programme and United Nations Environment Programme to support countries to become "ready" for REDD+, by developing a REDD+ strategy.

degraded land is usually lacking from plantation projects.

The implementation of climate policies is increasingly dependent on private investments and public-private partnerships as well as other forms of blended finance, and it has been widely acknowledged that current levels of funding are far from sufficient to comply with the goals of the Paris Agreement. [55] International funding mechanisms have therefore started to increase involvement and engagement with the private sector, with the leverage and access to funding that it can bring being seen as one of the best solutions to a lack of funding. [56, 57] The forestry sector, REDD+ and the mechanisms aimed at supporting REDD+ are no exception to this trend, [58, 59] and the establishment of monoculture tree plantations is often an appealing means of attracting private sector investment. Commercial tree plantations are obviously seen as more profitable than forest conservation or restoration.

To highlight the impact that climate finance is having on the expansion of industrial tree plantations, and particularly the influence of private investment, six case studies are described below.

Brazil: Commercial reforestation of the Cerrado

This project proposal, which was part of Brazil's FIP Investment Plan, was approved in 2014 for a loan of US$15 million. The project aims to encourage the "development of forest plantation on modified habitat in the Cerrado biome by funding a direct intervention of a new forest product, teak grown over a short rotation...". The project will subsidise the planting of a total of 18,000 ha of teak by a private company, to help meet the expected increased demand for this type of wood product. At FIP Board discussions several concerns were raised about this project, such as the lack of proposed monitoring systems and specific environmental and social action plans to minimise the potential negative impacts of it, but it was nevertheless approved. [60]

Ghana: Public-private partnerships for the restoration of degraded forest reserves through "certified" plantations

This project was endorsed by the FIP in 2015 and involves a US$10 million loan. In 2017 the FIP and the African Development Bank agreed an additional US$14 million of co-financing with Form Ghana Ltd. The project aims to catalyse private sector involvement in a large-scale commercial teak plantation in areas of supposedly degraded forest in Ghana. It aims to expand an existing plantation, certified by the Forest Stewardship Council (FSC) and Verified Carbon Standard (VCS), from 5,000 ha to 11,700 ha. The project is aimed at meeting the expected rising global and domestic demand for teak. The composition of this plantation is only 10% indigenous trees species. Due to the involvement of Ghana's government through the Forestry Commission, this project is the first Public-Private Partnership in Ghana's forestry sector. [61]

Ivory Coast: FIP Investment Plan will involve large plantations

Ivory Coast's investment plan was endorsed by the FIP in 2016 with a promised funding of US$24 million, of which US$15.8 million will be a loan and the remaining US$8.2 million a grant. In the investment plan there are many references to industrial tree plantations, and the importance of the private sector for reforestation and long term supply of sustainable fuelwood and lumber is clearly stated, where the establishment of 100,000 hectares of tree plantation is an aim. The plantations will be established and operated by public and private investors and in some cases, public-private partnerships. [62]

Mozambique: Emissions reductions in the forest sector through planted forests

This project was approved by the FIP in 2017 for a total of US$1.85 million of grant funding. One of the main goals of the project is to facilitate the afforestation of over 200,000 hectares, mainly with eucalyptus. Portucel, a leading pulp and paper company is one of the private actors involved in this project, and in charge of expanding the plantation area. [63] The multilateral development bank involved in the project is International Finance Corporation, a member of the World Bank and one of the largest international development institutions, which also focuses on the private sector.

Paraguay: PROEZA project (Rejected)

This project was submitted to the Green Climate Fund by the Food and Agriculture Organization and would have involved subsidising 32,500 hectares of eucalyptus plantation, [64] to produce bioenergy for the soy sector, one of the main drivers of deforestation and greenhouse gas emissions in the country. [65] The project was rejected at the 18th GCF Board Meeting in October 2018, partly due to concerns raised by Global Forest Coalition activists and others about using public funding to support tree plantations.

Uganda: Plantations exclude communities from their land

In 1996, Green Resources, a Norwegian-registered plantation company, signed a 50-year permit with Uganda's National Forestry Authority to establish a plantation of around 12,000 hectares in Kachung and Bukaleba provinces, both in Uganda's Central Forest Reserves, owned by the government. In 2011, the Kachung project was registered under the Clean Development Mechanism (CDM) under the UNFCCC and was certified by the Forest Stewardship Council (FSC). The Swedish Energy Agency has been buying carbon credits from this plantation since 2012. [66] There are documented cases of forced evictions of farmers, denial of access rights of indigenous peoples, and pesticide pollution of watercourses. The plantations were established on land formerly used by many communities, that now have less land to graze cattle and grow food on. [67]

Communities have been removed from their land and denied access for animal grazing. **Carbon Violence**


Plantations have surrounded some communities and polluted water courses. **Carbon Violence**


Pine seedlings at at Green Resources plantation. **Carbon Violence**

5. Ecological impacts of large-scale biosequestration

Industrial monoculture tree plantations can cause significant harm to biodiversity and ecosystems by virtue of their extent alone. Often the largest impact of plantations on biodiversity is felt due to land conversion before planting, where ecosystems such as natural forests or grasslands are cleared and replaced with plantations.

Tree plantations place strain on natural environments throughout the globe. In tropical and subtropical countries, monoculture eucalyptus has become the principal form of industrial forestry development, oil palm constitutes the fastest growing monoculture, and rubber and pine trees are among the top four plantation crops in terms of surface area. [68]

Impacts of land clearance and deforestation for plantations

In 2001 the FAO reported that conversion to tree plantations accounted for around 7% of global tropical forest losses. [69] As an example, in Chile it is estimated that 31% of the native forest in the coastal region was converted to plantations between 1978 and 1987. [70] Equivalent figures from more recent FAO assessments are not available. [71] However, considering that the total area covered by plantations globally increased 66% between 2010-2015, [72] it is likely that conversion to tree plantations accounts for an even greater proportion of tropical forest losses today. In support of this is the fact that the FAO's 2015 Global Forest Resources Assessment clearly shows the continued decline of natural forests alongside the expansion of plantations (or "planted forests") in many countries. [73] Similarly, Searchinger et al. (2017) observe that the counterfactual or "alternative" scenario for tree plantations, for bioenergy generation or otherwise, tends to be either a natural ecosystem or a form of existing land use, such as agriculture. [74] This therefore means that for every hectare of new tree plantation, a hectare of more biodiverse land is lost, directly or indirectly.

Land clearance and conversion also results in significant carbon emissions. A study looking at the impacts of plantations for biofuel production estimated that it would take up to 93 years for the carbon emissions saved through use of the biofuel to compensate for the carbon lost through forest conversion. Where peatland is converted to biofuel plantations, the time taken to achieve a carbon balance jumps to more than 600 years. [75]

Impacts on biodiversity

Agricultural intensification and expansion such as the development of new tree plantations are principal drivers of habitat modification, environmental change, and biodiversity loss. [76, 77] The case of plantations for biofuel feedstock has been shown to drive agricultural expansion at the expense of native habitat and biodiversity, [78] offering a strong parallel to the threats posed by large-scale afforestation.

Plantations of eucalyptus and exotic pines have little or no intrinsic value in rainforest landscapes. They provide poor quality habitat for rainforest biota and will have negative impacts on biodiversity if they replace remnant forests or other natural ecosystems, provide habitat for invasive weeds, or if

Plantations often replace natural forests, such as this palm oil plantation in Peru.
Mathias Rittgerott/Rainforest Rescue

Eucalyptus trees outcompete other species, put pressure on water resources and leave soils vulnerable to erosion. **Winfridus Overbeek**

the tree species used in plantations spread invasively into native forests. In Australia for example, eucalyptus plantations have been found to support far fewer birds than rainforests in the same area, with as little as a fifth of the species being recorded. [79]

The establishment of plantations in ecosystems such as grasslands totally alters them, impacting many different ecosystem factors, such as litterfall and decomposition rates, fire behaviour, nutrient cycling, and overall energy balance. [80] This is primarily caused by the obvious change in species make-up and species diversity, and changes in nutrient cycling that occur when grasslands and scrublands are replaced or invaded. Most impacts are harmful to the invaded ecosystems and threaten the sustained functioning of them. [81]

Where tree plantation species are exotic and non-native, invasion into surrounding environments can have further consequences for biodiversity. Pine invasions for example, have severely impacted large areas of grassland and scrub-brushland in the southern hemisphere by causing shifts in life-form dominance, reduced structural diversity, increased biomass, disruption of prevailing vegetation dynamics, and changing nutrient cycling patterns. The unavoidable negative impacts of forestry with alien species therefore spill over into neighbouring areas. [82]

Similarly, the South African NGO Geasphere has observed the impacts of pine plantations and invasions on grasslands. It states that: “The grasslands which these monoculture plantations have replaced contain an estimated 4000 plant species – none of which can survive in an exotic timber plantation compartment”. [83]

Further comparisons can be drawn between oil palm plantations for biofuel production and other monoculture tree plantations. The former have been found to support species-poor communities, and it is likely that in striving to meet obligations to reduce carbon emissions under international agreements, countries may simultaneously fail to meet their obligations under the Convention on Biological Diversity, and may be exacerbating climate change. Researchers have concluded that reducing deforestation is likely to represent a more effective climate change mitigation strategy than converting forest for biofuel production, and it may in turn help nations meet their international commitments to reduce biodiversity loss. [84]

Impacts on hydrological flows

Afforestation through tree plantations, especially involving species such as eucalyptus and pines, is likely to have a large impact on water resources. Studies have shown that such plantations can decrease stream flow by over 50%, with some water courses drying up completely. This is due to the fact that higher biomass productivity results in greater transpiration and rainfall interception, especially for evergreen species like eucalyptus. [85]

Evidence shows that water use and tree growth rate are correlated, with eucalyptus in particular being a very fast-growing tree, and therefore consuming substantial quantities of water. Fast-growing plantations tend to destabilise water cycles, causing reduced water flow throughout the year and the drying-up of streams during the dry season. [86]

Significant reductions in runoff can be expected following the afforestation of grasslands and shrublands, on average by 44% and 31% respectively, with eucalyptus having a larger impact than other species in afforested grasslands, reducing runoff by 75%. This effect may be most severe in drier regions, where areas with existing low natural runoff could result in a complete loss of it. [87] More often than not, where trees replace non-forested land uses, groundwater levels are lowered and stream yields are reduced, both effects being more pronounced during the dry season. [88]

The hydrological cycles of catchments invaded by invasive tree plantation species are also altered, especially during the dry summer months when water needs are greatest, where it can be reduced to zero, converting perennial streams to seasonal ones. Besides the obviously negative impacts on aquatic biota, the reduced streamflow also has serious implications for water production in the affected region, especially where there are existing water shortages, [89] and contributing to drought potential. [90]

In Espirito Santo, Brazil, for example, over 150 lakes and numerous rivers are alleged to have dried up as a result of eucalyptus plantations, depriving local people of fish and reducing farm yields. [91]

Despite recognition of higher evapotranspiration rates in plantations, the likelihood that this will reduce water yield has not always been acknowledged, [92] particularly within the context of afforestation programs for carbon sequestration. The possibility that afforestation could cause or intensify water shortages in many locations is a trade-off that should be explicitly addressed in them. [93]

Impacts on land degradation and nutrient availability

Where land is cleared for plantations, soils may be left bare and exposed to sun, wind, and rain for a number of years, leaving them vulnerable to degradation, erosion, and landslides. The loss of soil organic matter content affects properties such as soil structure, aeration, water holding capacity, soil microorganisms, decomposition, and nutrient cycling processes. Compaction by heavy machinery also can negatively affect soil, as can the practice of clearing by burning that occurs in some plantations. [94]

The increased biomass production of plantations requires extra nutrients, which is likely to lead to nutrient depletion, and reduced soil fertility, as well as increased soil acidity. [95] Eucalyptus plantations in particular are characterised by huge nutrient demand. [96]

Eucalyptus plantations are also known for their hydrophobic soils [97] and for reducing the growth of annual or perennial vegetation in and around them. This means that the soil remains almost bare during the whole year, creating favorable conditions for overland flow and erosion in the wet season. Soils which are reforested with exotic tree species such as eucalyptus are therefore more likely to experience intense erosion than soils left under natural vegetation. [98]

Similar to water yield, soil fertility is another likely trade-off of increased carbon sequestration through plantations. [99]

Impacts of agrochemical contamination

Monoculture tree crops such as eucalyptus, pines, rubber tree and oil palm are managed intensively, and generally involve the use of agrochemicals and cloned or genetically modified trees. [100] The use of pesticides is likely to have a potential negative impact on other species and therefore to reduce biodiversity in areas affected by their application. [101] These chemicals can accumulate in water supplies and animal species too. [102]

Impacts on albedo and radiative forcing

Another major impact of tree plantations is change in surface albedo, where less reflective planted forests can cause an increase in net absorbed radiation and localised surface warming, because forests are typically less reflective than the landscapes that they replace. This climatic impact of afforestation and tree plantations is still not completely understood, though the effect is almost certainly enhanced in northern high latitudes where the presence of snow cover exacerbates the albedo difference. Several studies have predicted warming with afforestation owing to this effect. [103]

One study in particular has predicted that in the case of tree plantations for biomass, the albedo-induced increase in temperature is as large as the mitigation by CO_2 sequestration for plantations in the Northern Hemisphere, although this is less likely to be the case in the tropics. The study also predicted that atmospheric circulation changes due to the effects of planted forests could weaken the supply of moisture from the oceans to North Africa and central Eurasia, in turn decreasing annual mean precipitation over North Africa by up to 10%, and further increasing summer temperatures over Eurasia. [104]

Similar modeling of the regional impacts of tree plantations in the US suggests that climate feedbacks would be unlikely to offset water losses due to the plantations, and could exacerbate them instead. The warming effect of high-latitude afforestation with pine plantations in the Northern Hemisphere through associated albedo changes would outweigh cooling through carbon sequestration. [105]

5.1 Case study: Industrial tree plantations and climate change in Portugal

Summer 2017 in Portugal will be remembered for its extreme heatwave, its severe drought, and its catastrophic forest fires. In a fire season that could quickly become "the new normal" [106] for Portugal, so far the total area burned stands at 6 times the average area of the previous 8 years. Relatively tiny in size compared to its Southern European neighbors, more of Portugal has burned so far this year than in any other European country. [107]

Portugal leads Europe in another statistic: it has more land planted with eucalyptus than any other country. Roughly 10% of Portugal's land area, or almost a quarter of all forest areas, are planted with *Eucalyptus globulus*, an exotic, highly invasive, fast-growing sub-tropical tree. [108] In absolute terms, only Brazil, India, Australia and China have more eucalyptus – relative giants compared to Portugal. But proportionally, Portugal has by far the largest land area planted with eucalyptus in the world. [109, 110]

The harm caused by fires in Portugal so far in 2017 has been unprecedented. On June 17th, 64 people lost their lives near Pedrogão Grande, in the district of Coimbra, central Portugal, in what has been described as Europe's first "firestorm". Climatic conditions conspired to create an inferno that eventually covered almost 50,000ha in one fire alone, and that took a week and vast fire-fighting resources to extinguish. In the days before the fire, temperatures had reached 40+ degrees during a heatwave, with much of the country already experiencing severe to extreme drought conditions. A meteorological phenomenon called a "downburst" resulted in a dry lightning storm that ignited multiple fires, and strong winds quickly spread the fires across a huge area. [111] The extreme heatwave in Southern Europe in June has been clearly linked to climate change, with researchers finding that the conditions in Portugal were 10 times more likely to have occurred due to global warming. [112]

Satellite mapping of the infamous Pedrogão fire has shown that eucalyptus and pine plantations covered around 70% of the burned area, and that these areas experienced high fire severity. [113] Both eucalyptus and pine have evolved to deal with fire. They are resinous trees that burn very easily and give off volatile oils that can even spontaneously combust in high temperatures. The bark of eucalyptus trees moves the fire quickly up the trunk and into the highly flammable leaves, both of which can be projected hundreds of metres, spreading the fire quickly. [114] Compounding this is the fact that Portugal's plantations are often illegal and unregulated, meaning that adequate firebreaks and zoning are not in place to prevent fires spreading easily.

From a biodiversity perspective, Portugal's eucalyptus plantations have sometimes been referred to as "green deserts". In a native oak forest in Portugal you could expect to find at least 70 or 80 species of plant, whereas in a eucalyptus forest you'd be lucky to find more than 15. [115] Eucalyptus leaves give off oils that inhibit soil microorganisms and prevent the growth of other plant species, by preventing the development of root systems and inhibiting seed production. Eucalyptus leaves aren't easily broken down by soil microorganisms (not even goats will eat eucalyptus leaves) and there are fewer invertebrates, fungi and herbaceous plants in eucalyptus plantations. [116]

Soils in eucalyptus forests are also highly hydrophobic, which prevents water penetration into the ground and leads to large seasonal fluctuations in water courses, resulting in greater flood risk in winter and drier conditions summer. This means that similar to soils, the numbers of organisms in water courses in eucalyptus plantations are lower than water courses in mixed, deciduous forests. [117] Eucalyptus plantations also place a significant strain on water resources, [118] which for a country like Portugal, experiencing frequent severe drought conditions on top of

Eucalyptus monocultures cover 10% of Portugal's land area and are described as "green deserts", owing to their impacts on biodiversity and water resources. **Allysse Riordan**

Destructive "rip ploughing" planting practices are hugely damaging to landscapes. **Ashlesha Khadse**

Fire-fighters tackled hundreds of out-of-control blazes all throughout the summer months. **Margus Kurvitis**

Tradgically, 64 people lost their lives in the first huge fire of the summer, in Pedrogão Grande, central Portugal. **Domingos Patacho**

long, hot, dry summers, has spelled disaster for many rural communities.

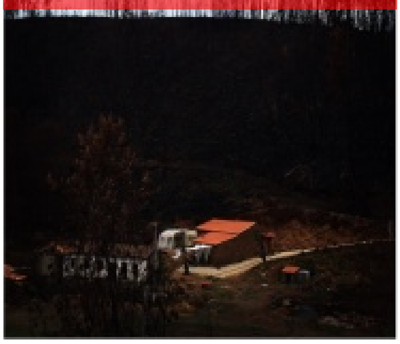
Compounding the ecological harm caused by eucalyptus plantations is the way in which they are planted, especially where the land is terraced before planting. [119] Where land has been cleared for new plantations, whether an existing pine plantation, scrubland or regenerating forest, heavy machinery is brought in to terrace the land by ploughing it on contour. This causes significant soil erosion [120] as it effectively scrapes away any topsoil and vegetation, leaving bare, exposed subsoil. Eucalyptus saplings will grow in these conditions, but it takes years for other vegetation to establish itself, to the extent that little additional land clearing is needed between the eucalyptus trees before the first cut is made, some 12 years later.

Locally, a lack of a coherent forestry policy and the absence of effective management of forest areas has lead to unregulated planting of eucalyptus in Portugal. [121] On a national level, subsidies and other public supports have incentivised planting further. This year alone, Portugal's government made 18 million Euros available to increase the productivity of plantations, which was announced alongside a 125 million Euro investment by Altri, a leading pulp and paper company. [122] Furthermore, 9 million Euros of funding from the EU was made available via a rural development programme to support the replanting of eucalyptus where plantations had already been cut three times. These areas are considered to be high risk in terms of fires. [123] The application process for this funding opened in the week before the Pedrogão fire. [124]

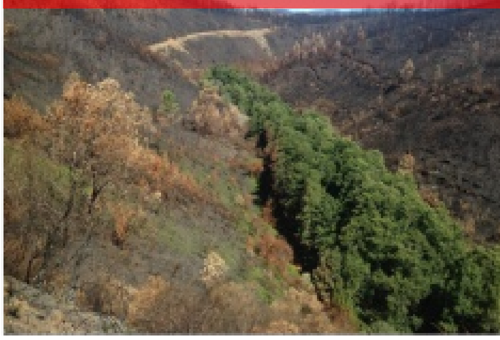
Effective implementation of the regulation governing where and how eucalyptus can be planted in Portugal would, in theory, help to prevent fires seen on the scale of this year, or at least protect urban areas and communities. For example, the requirement for adequate fire breaks between plantations, mandatory planting of certain indigenous and fire-resistant species alongside eucalyptus, as well as 50 metre and 10 metre buffer zones around houses and roads respectively are simply ignored, with no repercussions for land owners. Corruption also plays a significant role, where for example common lands ("baldios" in Portuguese)


The aftermath of the Pedrogão fire: burned eucalyptus plantations stretch to the horizon. **Domingos Patacho**

Vast fire-fighting resources were required to tackle the fires. **Anon**


Hundreds of people lost property. **Working with the 99% co-op**



Some communities were protected by barriers of less flamable, native trees, such as cork oaks. **Nuno Antunes**

While the plantations burned, pockets of native tree species survived. **Annabell de la Panouse**


are planted with eucalyptus by local authorities, or through the consent of local officials. [125] To highlight the extent of illegal planting, the Portuguese forest association "Acréscimo" has pointed out how, in 2014 and 2015, some 32 million eucalyptus trees were estimated to have been planted in officially sanctioned plantations in Portugal. However, nurseries will have produced 60 million trees over the same period. Acréscimo asks the question: what happened to these extra trees? [126]

The shocking tragedy of the Pedrogão fire has galvanised public opinion against eucalyptus plantations and in favor of replanting native forests. However, the worsening impacts of climate change, with severe droughts and extreme heatwaves, will undoubtedly mean that without significant positive change to forestry policy and the enforcement of it at the national and local levels, forest fires will continue to worsen.

Examples of positive change since the fires have come from the impacted communities themselves. Villages such as Ferraria de São João [127] and Casal de São Simão, [128] both affected badly by fires in June, have taken matters into their own hands, and agreed to remove all fire-prone eucalyptus and pine trees within a 500 metre boundary of houses in the villages, creating "Village Protection Zones". They have united all of the landowners within the boundary, tracked down absent ones, and agreed to replant the areas with more fire-resistant, native species of oak, chestnut and walnut.

Throughout Portugal, recognition of the important role played by native trees is growing, in contrast to the clear negative impacts of plantation species. Manuela Raposo Magalhães, a landscape architect and professor at the Lisbon Superior Institute for Agronomy asks: "Have you noticed that southern Portugal, especially the Alentejo, is much hotter than the north, but rarely burns? Why do you think that this is? The cork oak is abundant in the south and it is a fire retardant species, even when the cork has been removed from the trunk... Similar to deciduous trees, cork oaks have broader leaves, which accumulate more humidity, and hinder the combustion process." [129]

6. Socio-economic impacts of large-scale biosequestration

The socio-economic impacts of the introduction of tree plantations are often closely related to their ecological impacts. [130] Where plantations put pressure on water resources, reduce biodiversity and reduce nutrient availability, people are impacted by water scarcity, decreased harvests rates, and a reduction in suitable grazing areas. [131] The effects of droughts and famine can also be exacerbated and accelerated by large-scale monocultures. [132]

Industrial monoculture tree plantations are often associated with conflicts between private companies, government actors and the rural population, mainly in the tropics and subtropics, where control of lands and displacement are usually the root causes of conflict. [133] Indigenous Peoples are involved in many of these conflicts as they often do not have legal rights to their land. Such conflicts have been documented in, amongst other places, Borneo, Chile, Brazil and Papua New Guinea. [134] In Chile for instance, the Mapuche have lost access to large areas due to privatisation of land and the expansion of monoculture tree plantations. [135] Indigenous Peoples and local communities often do not have the resources to represent their interests effectively or participate in consultation processes. Women are also particularly impacted by conflicts over land due to the traditional gender division of labour, and they are more rapidly and directly affected by changes in land access and resource rights. [136]

Plantations are introduced to land which has experienced a different previous land use, and their establishment often results in significant social impacts. It is often assumed that plantations are established on “degraded” land with limited human activity, but there is no clear definition of the term, and it is often politically and economically marginalised people that depend on these areas. [137]

Plantations can be established on private or state-owned land, and usually involve changes to land ownership and decision-making structures. Local communities, Indigenous People, small farmers and landless people are often impacted the most, with fewer rights of access to land, and fewer resources at their disposal to oppose development. Where land is state-owned, people often have customary rights to use it, such as for grazing cattle or growing food. However, if state-owned land is sold to private companies then access rights are restricted, which has a dramatic impact on the people that depend on it. As well as a loss of access rights, people can be forcibly removed from their land, and suffer violence at the hands of plantation companies, landowners and state authorities. Consequently, there is also a loss of traditional knowledge. [138]

Where land is privately owned, landowners can be put under enormous pressure to sell it to plantation companies or simply leave, often through coercive means. [139] This includes practices such as restricting access to land which was formerly used commonly, exposing livestock, crops and people to pesticides and isolating communities by surrounding them with plantations. Pressure from plantation developers can eventually lead to people migrating away from their land, and ending up among the urban poor. [140]

Land owners with larger estates have considerably more power and can become large plantation owners themselves. The economic viability of a plantation increases with its size, incentivising landowners to convert large areas of land for a maximum return on investments. In Indonesia for example, the optimal size for industrial tree plantations is between 30,000 to 50,000 hectares. [141] In the southern US, plantations cover thousands of hectares in order to supply paper mills. [142] Such large plantation sizes results in high concentrations of control over land by a small number of landowners. [143]

Proponents of tree plantations argue that they come with economic development and job opportunities for local people. But these claims tend to lack a proper comparison with a realistic counterfactual scenario. Industrial tree plantations provide relatively few jobs per area compared to other forms of land use, such as agriculture. Eucalyptus cultivation for example, requires most labour during the planting and harvesting stages, while the comparatively long growth period in between hardly requires any at all. [144] Further still, the establishment and operation of plantations often requires qualified labour which may not be available from the local population. [145] More often than not, mainly male workers from outside the area are hired, which can trigger social tensions and the spread of sexually transmitted illnesses. [146] The few jobs that plantations do provide are characterised by bad working conditions due to the use of fertilisers and pesticides. [147]

Significantly, the expansion of industrial tree plantations is associated with higher levels of poverty [148] and areas with large plantation areas have higher poverty rates, through a combination of high unemployment, competition for land for cattle grazing and agriculture, and consequent emigration. Decreasing population can in turn lead to isolation and diminishing social services and infrastructure for the people that stay. [149]

This community in Brazil has been completely surrounded by eucalyptus plantations for bioenergy generation. **Ivonete Gonçalves de Souza**

7. Conclusion

Large-scale biosequestration schemes, in practice and as envisaged, are seriously problematic and more often than not default to monoculture tree plantations. At the root of this is poor governance, with an emphasis on top-down, multi-stakeholder partnerships with strong involvement from the private sector. As the examples of proposed climate finance for biosequestration in Brazil, Ghana, Ivory Coast, Mozambique, Paraguay and Uganda show, support from global institutions is already being directed towards industrial tree plantations, led by strong private sector involvement, and with the stated aim of supplying demand for forestry products rather than restoring ecosystems.

As the example of rights-based community forest restoration in Nepal shows, there are different ways to sequester carbon in natural terrestrial ecosystems that are beneficial both for the people that live in and depend on them, and for the planet in terms of contributing towards the ecosystems themselves and efforts to meet global warming targets. But to be effective, they require a substantially different form of governance, with a much greater emphasis on rights-holders and avoiding corporate-capture of climate policies.

Rights-based and community-lead biosequestration could, in theory, involve many positive schemes that, put together, would help to mitigate climate change on a large scale. There are vast areas of deforested and degraded lands that could be restored through bottom up, gender sensitive approaches. In many parts of the world such schemes are already being practiced by people in their every day lives. Natural ecosystem regeneration, agro-ecology, and indeed many forms of peasant agriculture do restore and conserve terrestrial ecosystems, sequestering carbon on many different scales. Supporting these kinds of practices should be at the forefront of climate mitigation strategies.
Conversely, the urgency of the climate crisis is being used to justify unproven and potentially dangerous technological "solutions", such as BECCS. The idea that negative emissions technologies and large-scale biosequestration can allow the world to overshoot carbon budgets by drawing carbon back out of the atmosphere at a later date, distracts policy-makers from focusing climate policies on more effective and proven strategies, such as drastic and immediate reductions in carbon emissions, and a complete end to deforestation.

This community mangrove restoration project in Samoa is helping to restore a damaged ecosystem. **OLSSIN**

Agro-ecology systems can involve livestock and put carbon back into soils and forests. **Simone Lovera**

Rights-based community forest restoration in Nepal

Community forest management in Nepal is a unique example of a rights-based approach to forest conservation and restoration. It has been a cornerstone for forest conservation and restoration in many areas, and is a key ecosystem-based adaptation strategy for the country. Approximately 35% of forest land is under a community-based forest management system. Community forest user groups, including some of the poorest and most vulnerable communities in the mountain ecosystems of Nepal, have played a central role in halting forest loss and promoting forest restoration, and the associated enhanced ecosystem-based climate resilience. The Ministry of Forests and Soil Conservation for example has acknowledged that community conserved forests have contributed significantly to controlling forest encroachment and subsequent ecosystems restoration. [150] The United Nations Development Programme has also highlighted how soil erosion, landslides and floods in the Panchase region have been significantly reduced by community conservation. [151] The customary rights of communities to manage their own forests for the production of timber and non-timber forest products are explicitly recognised in Nepal's 1993 Forest Act, although community access rights to forest resources remains one of the most contentious policy issues in Nepal.

There is obviously still much room for improvement, especially in areas without community-based forest management systems, and in strengthening the roles and positions of women in these systems. But the success of community-based forest management in Nepal shows that rights-based, bottom up and community-led ecosystem restoration is possible on a large scale, without the need for private-sector involvement and monoculture tree plantations.

Members of a community forest user group managing their community forest in Nawalparasi district, Nepal. **Nawalparsi/FECOFUN**

Community members assessing the threats to community conservation during a community assessment. **Dil Raj Khana/FECOFUN**

Women members of a community forest user group in Morang district, Nepal. **FECOFUN**

References

[1] IPCC 5th Assessment Report 2014 [Last accessed on October 4th 2017 at https://www.ipcc.ch/pdf/assessment-report/ar5/syr/AR5_SYR_FINAL_SPM.pdf]

[2] The availability and scale of these and other Carbon Dioxide Removal (CDR) technologies and methods are uncertain and CDR technologies and methods are, to varying degrees, associated with challenges and risks (high confidence) [Last accessed on October 4th 2017 at https://www.ipcc.ch/pdf/assessment-report/ar5/wg3/ipcc_wg3_ar5_summary-for-policymakers.pdf]

[3] Biermann, F., 2007. 'Earth System Governance' as a crosscutting theme of global change research. Global Environmental Change 17, 326-337. See also Schroeder, H., 2010. Agency in international climate negotiations: The case of Indigenous Peoples and avoided deforestation. International Environmental Agreements 10, 317-332.

[4] See for example Ostrom, E. and Nagendra, H., 2006. Insights on linking forests, trees, and people from the air, on the ground, and in the laboratory. Proceedings of the National Academy of Sciences 103(51), 19224-19231 and Sunderlin, W.D. et al., 2016. REDD+ at a critical juncture: Assessing the limits of polycentric governance for achieving climate change mitigation. International Forestry Review 17(4), 400-413.

[5] Folkes, C., 2006. Resilience: The emergence of a perspective for social–ecological systems analyses. Global Environmental Change. Vol. 16, No. 3, 2006, pp. 253-267

[6] Doc 10075, Assembly Resolutions in Force (as of 6 October 2016) Order Number: 10075. ICAO [[Last accessed on October 4th 2017 at icao.int/Meetings/a39/Documents/Resolutions/10075_en.pdf]

[7] Lovera-Bilderbeek. S, 2017. Agents, Assumptions and Motivations behind REDD+. UvA-DARE, University of Amsterdam. 242 pp.

[8] Lovera-Bilderbeek, 2017, ibid.

[9] White, A. and Martin, A., 2002. Who owns the world's forests? Forest tenure and public forests in transition. Forest Trends and Center for International Environmental Law, Washington, D.C., USA, 32 pp., Agrawal, A., 2007. Forests, governance, and sustainability: Common property theory and its contributions. International Journal of the Commons 1(1), 111-136. Sunderlin, W.D., Hatcher, J. and Liddle, M., 2008. From exclusion to ownership? Rights and Resources Initiative, Washington, D.C., USA, 64 pp.

[10] Agrawal, A. and Gibson, C., 1999. Enchantment and disenchantment: The role of community in natural resource conservation. World Development 27(4): 629-649.

[11] See for example FAO, 2007. Gender Mainstreaming in Forestry in Africa. Forest Policy Working Paper 18, FAO, Rome, Italy, 61 pp.

[12] See for example Lawlor, K., Madeira, E.M., Blockhus, J. and Ganz, D.J., 2013. Community participation and benefits in REDD+: A review of initial outcomes and lessons. Forests 4, 296-318 and Gupta, J., 2014. The history of global climate governance. Cambridge University Press, UK, 262 pp.

[13] Agrawal, A. and Gibson, C., 1999. Enchantment and disenchantment: The role of community in natural resource conservation. World Development 27(4): 629-649, Sikor, T., 2011. Financing household tree plantations in Vietnam: Current programmes and future options. Working Paper 69, CIFOR, Bogor, Indonesia, 40 pp. and World Bank, 2009. Gender in agriculture sourcebook. The World Bank, Washington D.C., USA, 764 pp.

[14] Backstrand, K. and Kylsater, M., 2014. Old wine in new bottles? The legitimation and delegitimation of UN public–private partnerships for sustainable development from the Johannesburg Summit to the Rio+20 Summit, Globalizations 11(3), 331-347.

[15] Lovera, S., 2017. SDG 15, Trends in the Privatization and Corporate Capture of Biodiversity. In: Adams, B., Bissio, R., Chee, Y.L., Donald, K., Martens, J., Prato, S. and Vermuyten, S., 2017. Spotlight on Sustainable Development 2017, Reclaiming Policies for the Public. Report by the Civil Society Reflection Group on the 2030 Agenda for Sustainable Development. Beirut/Bonn/Ferney-Voltaire/Montevideo/New York/Penang/Rome/Suva. pp. 136 – 142.

[16] See for example: Schroeder, H., 2010. Agency in international climate negotiations: The case of Indigenous Peoples and avoided deforestation. International Environmental Agreements 10, 317-332.

[17] Lovera-Bilderbeek, 2017, ibid.

[18] See for example: Searchinger T. (2012) Global Consequences of the Bioenergy Greenhouse Gas Accounting Error. In: Inderwildi O., King S. (eds) Energy, Transport, & the Environment. Springer, London and Searchinger T. et al (2008) Fixing a critical climate accounting error. Science Vol 326

[19] Abolins. J. & Gravitis. J., 2015. Limits to Sustainable Use of Wood Biomass. . 2015: 199-206

[20] Danielsen, F., et al., 2008. Biofuel Plantations on Forested Lands: Double Jeopardy for Biodiversity and Climate. Conservation Biology 23(2): 348 – 358.

[21] See for example: Leakage of CO2 through abandoned wells: role of corrosion of cement. Scherer, G. et al. Carbon Dioxide Capture for Storage in Deep Geologic Formations – Results from the CO2 capture project. 2005; The Role of Existing Wells as Pathways for CO 2 Leakage 2010. Celia, M. Search and Discovery Article #80093. 2010; Natural Leaking CO2-charged Systems as Analogs for Geologic Sequestration Sites. Evans, J. et al., 2004

[22] Kruger. T., 2017. Conflicts over carbon capture and storage in international climate governance. Energy Policy 100: 58-67

[23] Global CCS Institute (2016). Illinois Industrial Carbon Capture and Storage Project [Available at https://www.globalccsinstitute.com/projects/illinois-industrial-carbon-capture-and-storage-project. Accessed September 13, 2017]

[24] Yeo. S. & Pearce. R. 2016. Analysis: Negative emissions tested at world's first major BECCS facility. Carbon Brief [Accessed on September 30th 2017 at https://www.carbonbrief.org/analysis-negative-emissions-tested-worlds-first-major-beccs-facility]

[25] Klemetsrud (Oslo) waste management and energy recovery CCS project. Zaeroco2.no [Accessed on September 30th 2017 at http://www.zeroco2.no/klemetsrud-oslo-waste-management-and-energy-recovery-ccs-project]

[26] Figure confirmed by SaskPower President Mike Marsh during side event "Carbon Capture and Storage (CCS): Achievements and Opportunities for Developing Country Involvement" which took place at COP21, in Paris. He said of the 120MW unit capacity, 40MW was used for CCS, and at least another 10MW for CO2 compression and piping

[27] Potential for Biomass and Carbon Dioxide Capture and Storage. International Energy Agency (IEA), July 2011 [Accessed on September 30th 2017 at https://www.eenews.net/assets/2011/08/04/document_cw_01.pdf]

[28] See for example UK Bioenergy Strategy, April 2012 [Last accessed on October 4th 2017 at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/48337/5142-bioenergy-strategy-.pdf]

[29] See for example Searchinger et al., 2017. Energy Policy; Victor Nian, Applied Energy, October 2016; Mirjam Röder et.al., Biomass and Bioenergy, August 2015; Limits to Sustainable Use of Wood Biomass, Janis Abolins and Janis Gravitis, Sustainable Development, Knowledge Society and Smart Future Manufacturing Technologies, World Sustainability Series 2015, April 2015; Ter-Mikaelian, M et al, 2015. The Burning Question: Does Forest Bioenergy Reduce Carbon Emissions? A Review of Common Misconceptions about Forest Carbon Accounting. Journal of Forestry Vol 113

[30] Searchinger T. (2012) Global Consequences of the Bioenergy Greenhouse Gas Accounting Error. In: Inderwildi O., King S. (eds) Energy, Transport, & the Environment. Springer, London and Roder et al (2015) How certain are greenhouse gas reductions from bioenergy? Life cycle assessment and uncertainty analysis of wood pellet-to-electricity supply chains from forest residues. Biomass and bioenergy, Vol 79 and Ter-Mikaelian, M. et al (2015) The Burning Question: Does Forest Bioenergy Reduce Carbon Emissions? A Review of Common Misconceptions about Forest Carbon Accounting. Journal of Forestry, Vol 113

[31] Searchinger. T. D., et al., 2017. Does the world have low-carbon bioenergy potential from the dedicated use of land? Energy Policy 110: 434–446

[32] Danielsen, F., et al., 2008. Ibid

[33] Achat. D. L. et al. 2015. , Scientific Reports 5: 15991

[34] Williamson. P., 2016. Emissions reduction: Scrutinize CO2 removal methods. Nature 530: 153–155

[35] Williamson. P., 2016. Ibid

[36] Vaughan. N. E. & Gough. C., 2015. Synthesizing Existing Knowledge on the Feasibility of BECCS: Workshop Report. AVOID 2, 2015 [Last accessed on September 4th 2017 at http://avoid-net-uk.cc.ic.ac.uk/wp-content/uploads/delightful-downloads/2015/09/Synthesising-existing-knowledge-on-feasibility-of-BECCS-Workshop-Report-v1-AVOID-2-WPD1b.pdf]

[37] Danielsen, F., et al., 2008. Ibid

[38] Versfeld. D.B. & van Wilgen. B. W., 1986. Impact of woody aliens on ecosystem properties. 1986:239-246

[39] Food and Agricultural Organization (FAO), 2001. Global Forest Resources Assessment 2000. FAO, Rome.

[40] Achat. D. L. et al. 2015. Ibid

[41] Achat. D. L. et al. 2015. Ibid

[42] Azar. C. et al., 2010. The feasibility of low CO2 concentration targets and the role of bio-energy with carbon capture and storage (BECCS). Climatic Change 100(1): 195–202

[43] Vaughan. N. E. & Gough. C., 2015. Ibid

[44] Searchinger. T. D., et al., 2017. Ibid

[45] Lovera-Bilderbeek, 2017. Ibid.

[46] de la Plaza Esteban et al., 2014. The Legitimacy of Certification Standards in Climate Change Governance. Sust. Dev. 22: 420–432

[47] de la Plaza Esteban. et al., 2014. Ibid

[48] Definition adopted by the 7th Conference of the Parties of the UNFCCC, 2001: "Forest" is a minimum area of land of 0.05–1.0 hectare with tree crown cover (or equivalent stocking level) of more than 10–30 per cent with trees with the potential to reach a minimum height of 2–5 metres at maturity in situ. A forest may consist either of closed forest formations where trees of various storeys and undergrowth cover a high proportion of the ground or open forest. Young natural stands and all plantations which have yet to reach a crown density of 10–30 per cent or tree height of 2–5 metres are included under forest, as are areas normally forming part of the forest area which are temporarily unstocked as a result of human intervention such as harvesting or natural causes but which are expected to revert to forest"

[49] FAO, 2015. Forest Resource Assessment Terms and Definitions. Working Paper 180 FAO, Rome. [Last accessed on October 4th 2017 at http://www.fao.org/docrep/017/ap862e/ap862e00.pdf]

[50] "Safeguarding the integrity of natural forests. Consistent with its objectives, the FIP should safeguard natural forests and should not support the conversion, deforestation or degradation of such forests, inter alia, through industrial logging, conversion of natural forests to tree plantations or other large-scale agricultural conversion. In particular, the FIP should safeguard high conservation value forests. Special consideration should be given to the national circumstances, including development needs of countries" with high forests cover and low deforestation rates" (http://siteresources.worldbank.org/INTCC/Resources/Final_Design_Document_July_7.pdf)

[51] Searchinger. T. D., et al., 2017. Ibid.

[52] Andersson. K et al., 2015. More Trees, More Poverty? The Socioeconomic Effects of Tree Plantations in Chile, 2001–2011. Environmental Management 57(1)

[53] Guo. L. B. & Gifford. R. M. 2002. Soil carbon stocks and land use change: a meta analysis. Global Change Biology 8(4): 345–360

[54] Industrial Tree Plantation Invading East & Southern Africa, 2006. WRM – International Secretariat and Timberwatch Coalition (South Africa) [Last accessed on October 2nd 2017 at http://wrm.org.uy/fr/files/2016/10/2016-10-Plantations-in-ES-Africa-TW-WRM-med-screen.pdf]

[55] Money for Climate,2017. Nature Climate Change 7, 455 [Last accessed on September 23rd 2017 at https://www.nature.com/nclimate/journal/v7/n7/full/nclimate3343.html]

[56] Forest Investment Review, 2009 [Last accessed on October 2nd 2017 at https://www.forumforthefuture.org/sites/default/files/project/downloads/forestinvestmentreviewfull.pdf]

[57] Climate Finance, World Resources Institute [Last accessed October 2nd 2017 at http://www.wri.org/our-work/project/climate-finance/climate-finance-and-private-sector]

[58] The Role of the Private Sector in REDD+: the Case for Engagement and Options for Intervention, 2013. UN-REDD

[59] Broadening REDD+ to Bring New Opportunities for Private Sector Investment in Forests, Climate Change Mitigation and Green Growth, 2015. Climate Investment Funds [Last accessed October 2nd 2017 at https://www.climateinvestmentfunds.org/blog/broadening-redd-bring-new-opportunities-private-sector-investment-forests-climate-change-0]

[60] Common Format for Project/Program Concept Note for the Use of Resources from the FIP Competitive Set – Aside, 2012. http://www.climateinvestmentfunds.org/sites/default/files/meeting-documents/ifc_proposal_fip_set_aside_public.pdf [Last Accessed on 30th September 2017]

[61] Forest Investment Program Ghana: Public-.Private Partnership for the restoration of degraded forest reserve though VCS and FSC certified Plantations, 2016. https://www.climateinvestmentfunds.org/sites/default/files/meeting-documents/fip_-_form_ghana_project_proposal_-public_document-_august_2016.pdf [Last Accessed on 30th September 2017]

[62] Investment Plan for Forest Investment Program in Ivory Coast, 2016: https://www.climateinvestmentfunds.org/sites/default/files/meeting-documents/fip_cote_d_ivoire_ip.pdf [Last Accessed on 30th September 2017]

[63] Investment Plan for Forest Investment Program in Mozambique, 2016: https://www-cif.climateinvestmentfunds.org/sites/default/files/meeting-documents/mozambique_fip_investment_plan.pdf [Last Accessed on 30th September 2017]

[64] Funding Proposal Package F055 PROEZA http://www.greenclimate.fund/documents/20182/820027/GCF_B.18_04_Add.10_Rev.01_-_Funding_proposal_package_for_FP055.pdf/111e9560-113f-4753-9b59-e93115039a0a [Last accessed on 30th September 2017]

[65] Darby, M. 2017. UK vetoes two South American climate finance bids. [Last accessed on 4th October 2017 at http://www.climatechangenews.com/2017/10/03/uk-vetoes-two-south-american-climate-finance-bids/]

[66] Green Resources. Uganda plantations http://dev.greenresources.no/Plantation/Uganda. [Last accessed on 30th September 2017]

[67] Impacts of Green Resources' tree plantations at Kachung, Uganda. The Forest Project

[68] Gerber, J.F., 2009. Conflicts over industrial tree plantations in the South: Who, how and why? Global Environmental Change, 21, 165–176

[69] Food and Agricultural Organization (FAO), 2001. Global Forest Resources Assessment 2000. FAO, Rome.

[70] Gerber, J.F., 2009. Ibid

[71] Grainger, A., 2007. The Influence of End-Users on the Temporal Consistency of an International Statistical Process: The Case of Tropical Forest Statistics. Journal of Official Statistics; 553.

[72] Keenan. R. J., et al., 2015. Dynamics of global forest area: Results from the FAO Global Forest Resources Assessment. Forest Ecology and Management 352: 9-20

[73] FAO (2015). Global Forest Resources Assessment. How are the world's forests changing? 2nd Edition

[74] Searchinger. T. D., et al., 2017. Ibid

[75] Geist, H. J. & Lambin, E. F., 2002. Proximate Causes and Underlying Driving Forces of Tropical Deforestation. BioScience 52(2): 143-150

[76] Tilman et al, 2001. Forecasting Agriculturally Driven Global Environmental Change. Science 292(5515): 281-284

[77] Geist & Lambinl, 2002. Proximate Causes and Underlying Driving Forces of Tropical Deforestation. BioScience 52(2):143-150

[78] Danielsen. F. et al., 2008. Ibid

[79] Kanowski. J. et al, 2005. Consequences of broad scale timber plantations for biodiversity in cleared rainforest landscapes of tropical and subtropical Australia. Forest Ecology and Management 208(1-3): 359-372

[80] Versfeld. D.B. & van Wilgen. B. W., 1986. Impact of woody aliens on ecosystem properties. 1986 pp.239-246

[81] Richardson. D. M., 1998. Forestry Trees as Invasive Aliens. Conservation Biology 12(1):18-26

[82] Richardson. D. M., 1998. Ibid.

[83] Overbeek W, Kröger M, Gerber J-F. 2012. An overview of industrial tree plantation conflicts in the global South. Conflicts, trends, and resistance struggles. EJOLT Report No. 3, 100

[84] Danielsen. F. et al., 2008. Ibid

[85] Jackson. R. B. et al., 2005. Trading Water for Carbon with Biological Carbon Sequestration. Science 310(5756): 1944-1947

[86] Gerber. J. F., 2009. Ibid

[87] Farley. K. A. et al., 2005. Effects of afforestation on water yield: a global synthesis with implications for policy. Global Change Biology 11: 1565–1576

[88] Hamilton. L. S. & King. P. N., 1983. Tropical forested watersheds: hydrologic and soils response to major uses or conversions. Nat. Hist. Bull. Siam Soc 32(2):127-130

[89] Richardson. D. M., 1998. Ibid.

[90] Sargent, C., 1992. Plantation Politics: Forest Plantations in Development. Chapter 2

[91] Ricardo Carrere. R. & Lohmann. L., 1992. Pulping the South Industrial Tree Plantations in the World Paper Economy. Zed Books Ltd. London and New Jersey 7 Cynthia Street, London N1 9JF, UK and 165 First Avenue, Atlantic Highlands, New Jersey 07716, USA

[92] Vertessy R.A. & Bessard Y., 1999. Conversion of grasslands to plantations: anticipating the negative hydrologic effects. VIth International Rangeland Congress Proceedings

[93] Farley. K. A. et al., 2005. Ibid

[94] Heaton, K. 2005. Mitigating Environmental and Social Impacts of Intensive Plantation Forestry, Journal of Sustainable Forestry, 21:4, 75-9

[95] Jackson. R. B. et al., 2005. Trading Water for Carbon with Biological Carbon Sequestration. Science. 310 (5756): 1944-1947

[96] Laclau. J. P. et al., 2009. Biogeochemical cycles of nutrients in tropical Eucalyptus plantations Main features shown by intensive monitoring in Congo and Brazil. Forest Ecology and Management 259(9): 1771-1785

[97] Ferreira, A. J. D. et al., 2000. Hydrological implications of soil water-repellency in Eucalyptus globulus forests, north-central Portugal. Journal of Hydrology, Volumes 231–232, p165-177

[98] Kosmas. C., et al 1997. The effect of land use on runoff and soil erosion rates under Mediterranean conditions. CATEN A 29(1):45-59

[99] Jackson. R. B. et al., 2005. Ibid

[100] Gerber, J.F., 2009. Ibid

[101] Hartley. M. J., 2002. Rationale and methods for conserving biodiversity in plantation forests. Forest Ecology and Management 155: 81–95

[102] Forest Stewardship Council (FSC), 2004. Perspectives on Plantations: A Review of the Issues Facing Plantation Management. FSC, Bonn

[103] Mykleby. P. M. et al., 2017. Quantifying the trade-off between carbon sequestration and albedo in mid and high latitude North American forests. You have full text access to this content. Geophysical Research Letters 44(5)

[104] Schaeffer. M. et al., 2006. CO2 and albedo climate impacts of extratropical carbon and biomass plantations. Global Biochemical Cycles 20(2)

[105] Jackson. R. B. et al., 2005. Ibid

[106] Michael Le Page & Julia B. 2017. Living the Climate Change: Welcome to the New Normal. New Scientist [Last accessed on 30th September 2017 at]

[107] Portugal é o país da UE com mais área ardida Sistema Europeu de Informação sobre Incêndios Florestais, [Last accessed on September 30th 2017 http://sicnoticias.sapo.pt/pais/2017-08-11-Portugal-e-o-pais-da-UE-com-mais-area-ardida]

[108] Duro. J. S. 2017. Portugal é o país com maior área de eucalipto. Jornal de Leiria [Last accessed on September 30th 2017 at https://www.jornaldeleiria.pt/noticia/portugal-e-o-pais-com-maior-area-de-eucalipto-6816]

[109] João. C. & Patricia. N. 2017. Deadly fires in Portugal: the eucalyptus business and European austerity stand accused. Europe Solidaire Sans Frontières [Last accessed on September 30th 2017 at https://www.europe-solidaire.org/spip.php?article41543]

[110] Quercus e Acréscimo contrariam informações dadas pela Associação da Indústria Papeleira, 2017. Tinta Fresca [Last accesed on September 30th 2017 at http://www.tintafresca.net/News/newsdetail.aspx?news=35d3215b-5313-4777-99cf-40c0c34d9510]

[111] Downburst foi o fenómeno raro de vento que ajudou a propagar o incêndio, explica o IPMA ao governo, 2017. Observador [Last accessed on September 30th 2017 at http://observador.pt/2017/06/21/downburst-foi-o-fenomeno-raro-de-vento-que-ajudou-a-propagar-o-incendio-explica-o-ipma-ao-governo/

[112] European Heat, June 2017. Record June Temperatures in Western Europe [Last accessed on September 30 2017 at https://wwa.climatecentral.org/analyses/europe-heat-june-2017/]

[113] Area ardidad e danosprovados pelos incendios de Pegrgao Grande e Gois, 2017. Fogos Florestais [Last accessed on October 1st 2017 at http://www.fogosflorestais.pt/2017/07/area-ardida-e-danos-provocados-pelos.html]

[114] Três especialistas explicam porque incêndio foi tão mortífero, 2017. Cofina media [Last accessed on September 30th 2017 at http://www.sabado.pt/portugal/detalhe/tres-especialistas-explicam-porque-incendio-de-pedrogao-foi-tao-mortifero]

[115] Michaela McGuire. M. 2017. The Eucalypt Invasion of Portugal. The monthly [Last accessed on September 30th 2017 at https://www.themonthly.com.au/issue/2013/june/1370181600/michaela-mcguire/eucalypt-invasion-portugal]

[116] Camargo. J. 2017. Eucaliptugal, o ecocídio da floresta nacional. Visao [Last accessed on October 1st 2017 at http://visao.sapo.pt/ambiente/opiniaoverde/joaocamargo/eucaliptugal-o-ecocidio-da-floresta-nacional=f752575]

[117] Abelho. M. & Graca. M. A. S., 1995. Effects of eucalyptus afforestation on leaf litter dynamics and macroinvertebrate community structure of streams in Central Portugal. Hydrobiologia, 324(3): 195–204

[118] Farley. K. A. et al., 2005. Ibid

[119] Quercus, 2011. Uma visão comun sobre o problems das plantações de eucalipto

[120] Shakesby. R. A. et al, 1996. Limiting the soil degradational impacts of wildfire in pine and eucalyptus forests in Portugal. Applied Geography 16(4): 337-3.5.5

[121] Quercus, 2011. Ibid

[122] Costa. A. 2017. Governo disponibiliza 18 milhões de euros para melhorar produtividade na plantação de eucalipto. Observador. [Last accessed on October 1st 2017 at http://observador.pt/2017/01/16/governo-disponibiliza-18-milhoes-de-euros-para-melhorar-produtividade-na-plantacao-de-eucalipto/]

[123] Lopes. M. 2017. Governo está a financiar renovação do eucaliptal em zonas como a de Pedrógão. Público [Last accessed on October 1st 2017 at https://www.publico.pt/2017/06/23/politica/noticia/governo-esta-a-financiar-renovacao-do-eucaliptal-em-zonas-como-a-de-pedrogao-1776653]

[124] Governo lançou programa de 9 milhões para eucaliptos uma semana antes dos incêndios, 2017. Esquerda.net [Last accessed on October 1st 2017 at http://www.esquerda.net/artigo/governo-lancou-programa-de-9-milhoes-para-eucaliptos-uma-semana-antes-dos-incendios/49380]

[125] Personal comments to author from residents of areas where this has happened

[126] Sobre o controlo das plantações ilegais com eucalipto, 2016. Acrésicmo [Last accessed on October 1st 2017 at http://acrescimoapif.blogspot.pt/2016/09/sobre-o-controlo-das-plantacoes-ilegais.html]

[127] Aldeia de Penela já está a cortar eucaliptos, reflorestação arranca em Outubro, 2017. Público [Last accessed on October 1st 2017 at https://www.publico.pt/2017/07/28/sociedade/noticia/aldeia-de-penela-ja-esta-a-cortar-eucaliptos-reflorestacao-arranca-em-outubro-1780642]

[128] Casal de São Simão (Aguda) deixa políticos a falar e segue exemplo de Ferraria de São João arrancando eucaliptos, 2017. Jornal de Leiria [Last accessed on October 1st 2017 at https://www.jornaldeleiria.pt/noticia/casal-de-sao-simao-aguda-deixa-politicos-falar-e-segue-exemp-6721]

[129] Incêndios: 29 perguntas que já têm (algumas) respostas, 2017. Obersvador [Last accessed on October 1st 2017 at http://observador.pt/especiais/incendios-25-perguntas-que-ja-tem-algumas-respostas/]

[130] Andersson, K., et al., 2016. Environmental Management 57: 123.

[131] Farley, K. A., et al., 2005. Effects of afforestation on water yield: a global synthesis with implications for policy. Global Change Biology, 11: 1565–1576.

[132] Li, Y., M. Zhao, et al., 2016. Potential and Actual impacts of deforestation and afforestation on land surface temperature, J. Geophys. Res. Atmos., 121, 14,372–14,386

[133] Gerber, J. F, 2009. Ibid

[134] Gerber. J. F, 2009. Ibid

[135] Andersson. K. et al., 2015. Ibid

[136] Gerber. J. F, 2009. Ibid

[137] Lovera-Bilderbeek. S, 2017. Ibid

[138] Charnley, S., 2005. Industrial Plantation Forestry. Journal of Sustainable Forestry. Vol. 21. No.4, 2005, pp.35-57

[139] See for instance Clapp, R.A., 1998. Regions of refuge and the agrarian question: peasant agriculture and plantation forestry in Chilean Araucania. World Development 26 (4), 571–589

[140] Gerber. J. F, 2009. Ibid

[141] Hall, D. 2003. The international political ecology of industrial shrimp aquaculture and industrial plantation forestry in Southeast Asia. Journal of Southeast Asian Studies 34 (2): 251-264

[142] Joshi, M. L., et al., 2000. Investing in industry, underinvesting in human capital: Forest-based rural development in Alabama. Society and Natural Resources 13: 291-319.

[143] Charnley, S., 2005. Ibid

[144] Williams, K., R. Nettle, and R. J. Petheram. 2003. Public response to plantation forestry on farms in south-western Victoria. Australian Forestry 66 (2), 93-99.

[145] Navarro. M. R. et al., 2005. Contexto económico y social de las plantaciones forestales en Chile: el caso de la Comuna de Lumaco, región de la Araucanía: agosto de 2005. Movimiento Mundial por los Bosques Tropicales, Montevideo, Uruguay.

[146] Norris, A. H., et al., 2017. Prevalence of sexually transmitted infections among Tanzanian migrants: a cross-sectional study, International Journal of STD & AIDS, 28(10): 991 - 1000

[147] Gerber. J. F, 2009. Ibid

[148] Andersson et al., 2016. Ibid

[149] Charnley, S., 2005. Ibid

[150] Ministry of Forests and Soil Conservation, 2016. Conservation Landscapes of Nepal, Kathmandu, Nepal. http://d2ouvy59p0dg6k.cloudfront.net/downloads/conservation_landscapes_of_nepal.pdf [Last accessed on October 2nd 2017]

[151] UNDP Nepal 2015, Ecosystem-based Adaptation in Mountain Region in Nepal, Annual Progress Report 2015, Kathmandu, Nepal. https://www.iucn.org/sites/dev/files/content/documents/iucn_nepal_annual_review_2015.pdf [Last accessed on October 2nd 2017]