Facts on the economics of land degradation and climate change

- Between 10 – 20% of drylands and 24% of usable land on Earth is degraded, creating an estimated economic loss of USD 40 billion per year.[1]
- 52% of land used for agriculture worldwide is moderately or severely affected by soil degradation. On a **global scale,** annual losses of 75 billion tons of soil costs about US$400 billion per year.[2]
- Agricultural investments of at least US$30 billion per year are needed to feed a globally growing population.[3]
- Effects from climate change such as droughts and desertification cause an annual loss of 12 million hectares, whereas 20 million tons of grain could have been grown instead. The percentage of Earth's land area stricken by serious drought has more than doubled from the 1970s to the early 2000s.[4]
- More than one third of the land in Africa is under threat of desertification. On the southern edge of the Sahara, a once productive area the size of Somalia has been entirely degraded over the past 50 years.[5]
- Numerous African countries depend on agriculture, fisheries, and livestock management for 40 % of their national GDP, which in turn depend on productive lands.[6]

Land Degradation as cause of Climate Change

- Changes in climatic conditions at the local and global levels is one of the main drivers of land degradation.
  Land degradation is widely considered as a cause of climate change: Historically, total global loss of carbon from agricultural soils is 55 gigatons[1], which is converted to CO_2 by respiring micro-organisms, highlighting the large offset potential in agriculture. Globally, **croplands bear a carbon sequestration potential of 0.43 to 0.57 gigatons/year**.[7]
- Soil is the second largest source of carbon storage next to the oceans. Land degradation reduces soil's capacity as carbon stock, creating a negative feedback loop.[8]
- Land degradation also negatively affects water availability, poverty, food security, environmental migration, gender rights, deforestation, biodiversity, and climate change and some 50 million people are facing displacement within the next 50 years as a result of desertification.[9]

[1] 55 gigatons = 55,000,000,000 tons

Options for Mitigation and Adaptation

- After fossil fuel combustion, agriculture and land use changes represent the second largest share of greenhouse gas emissions.[10]
- Agriculture, forestry and other land uses are estimated to be **responsible for around 17 – 31% of anthropogenic GHG emissions**. There is **significant potential to reduce these emissions**, largely through reduced CO_2 emissions from agriculture, avoiding deforestation and forest degradation, creating net carbon sequestration in soil and vegetation, and the provision of renewable, low carbon energy bioenergy through sustainable land management. **Land use is therefore a critical component of any climate change solution.**[11]

Mitigation potential of land and soils

- The annual economic losses due to deforestation and land degradation are estimated at 1.5-3.4 trillion Euro in 2008, equaling 3.3%-7.5% of the global GDP in 2008.[12]
- This includes a startling **loss of grain worth $1.2 billion USD yearly**.[13]
- For example, closing yield gaps and reaching 95% of potential maximum crop yields (assuming the adoption of SLM practices) could create an additional 2.3 billion tons of crop production per year[14], equivalent to $1.4 trillion USD.
- **Proper management of agricultural and forestry are amongst the lowest-cost actions** to reduce global warming.[15]
- Most of these actions are either **neutral cost or of positive net profit to society,** requiring no substantial capital investment. […] However, the uncertainty around the abatement potential is significant […]."[16]
- Through combination of forestry and agriculture potentials from the fourth assessment report from the IPCC, **total mitigation potentials** for the *Agriculture, Forestry and Other Land Use* sector are estimated to be **~3 to 7.2 $GtCO_2e$/year in 2030, at 20 and 100 USD/tCO_2e**. While the highest mitigation potential in the mid-range of investments (up to 20 to 50 USD) relates to cropland management, **restoration of cultivated organic soils has the highest mitigation potential of ~1250 $MtCO_2e$/year when investing up to 100 USD/tCO_2e.**[17]

Possible **GHG mitigation measures** from the *Agriculture, Forestry and Other Land Use* sector:

1. Reductions in direct nitrous oxide or net methane emissions from agriculture of: 600 Mt $CO_{2\text{-eq.}}$ yr^{-1} in 2030 according to bottom-up estimates and 270-1900 Mt $CO_{2\text{-eq.}}$ yr^{-1} according to top-down models (Smith et al. 2008);
2. Potential reductions in GHG emissions from energy use in agriculture and forestry, estimated to be 770 Mt $CO_{2\text{-eq.}}$ yr^{-1} in 2030 (Smith et al. 2008);
3. Provision of biomass with low-GHG emissions;

4. Positive changes in albedo and evapotranspiration;
5. Reduction in carbon losses from biota and soils; and,
6. Enhancement of carbon sequestration in biota and soils.[18]

Agriculture

- Enhancement of carbon sequestration in biota and soils has the potential to reduce net GHG emissions by increasing their carbon stocks. The **technical mitigation potential for carbon sequestration in agricultural soils** was estimated at **4.8 Gt CO_2-eq./year for 2030**, with economic potentials of 1.5, 2.2, and 2.6 Gt CO_2-eq./ yr at carbon prices of 0–20, 0–50, and 0–100 USD t CO_2-eq. respectively.[19]

  Enhancing carbon stocks through soils alone creates potential value as high as 480 billion USD annually through carbon markets

Carbon Price	*Potential*
0-20 USD	96 billion USD
0-50 USD	240 billion USD
0-100 USD	480 billion USD

Land management strategy	**Amount of C sequestered (Gigaton Carbon/yr)**
Soil erosion control	0.08-0.12
Soil restoration	0.02-0.03
Conservation tillage and residue management	0.150-0.175
Improved farming/cropping systems	0.18-0.24
Total	0.43-0.57

Table 1: **C sequestration potential of arable land management strategies**[20]

- The **average costs of abatement for all measures is very low, at around 1€ per tCO_2e in 2030**. Most measures are inexpensive, as they imply small changes in agricultural practices without significant capital investments. **Soil restoration requires significant implementation and opportunity costs, but are balanced by large CO_2 abatement potential per hectare**. For example, in organic soils, **implementation costs for restoration are about 227€/ha**, with potential carbon sequestration estimated at 30-70 t CO_2e/ha. These cost calculations exclude transaction costs.[21]

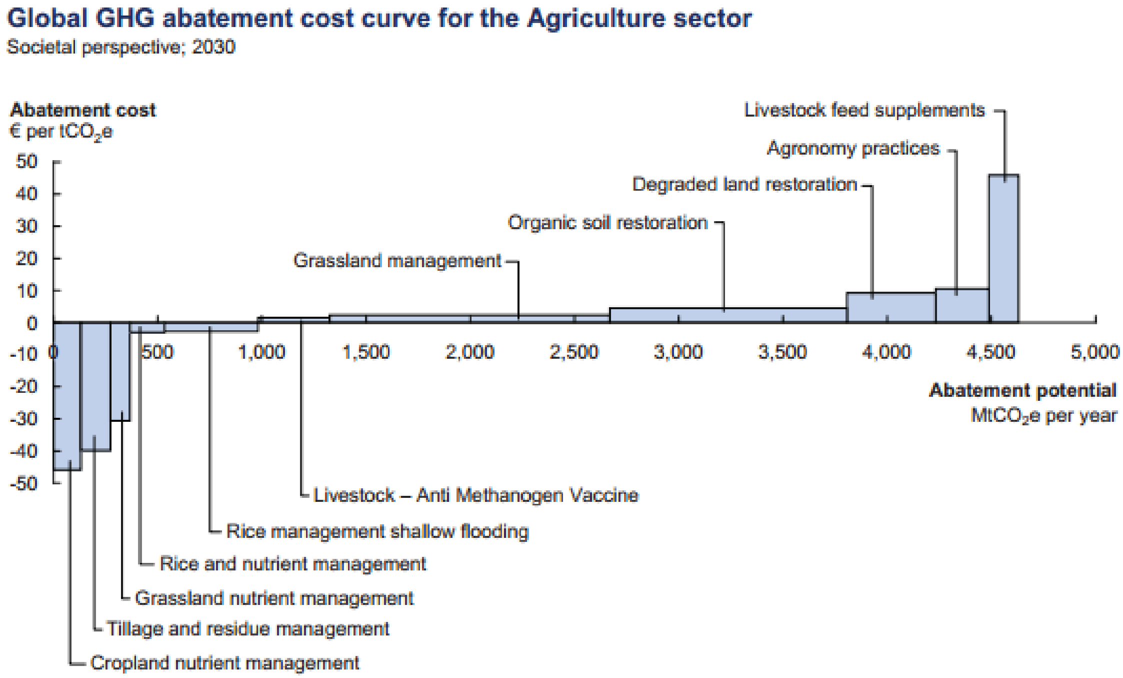

Figure 1: **GHG abatement cost curve for agricultural sector**[22]

Management option	Abatement potential (% related to global agric. abatement potential)
Pastureland	- 1.3 $GtCO_2e$/year - 29% - 0.4 tCO_2e/hectare out of 3,250 million hectares (global total)
Land restoration	- 1.6 $GtCO_2e$/year - 34%
Cropland management	- 1.2 $GtCO_2e$/year - 27% - 0.7 tCO_2e/hectare out of 1,750 million hectares (global total)
Livestock management	- 0,5 $GtCO_2e$/year - 10%

Table 3: **Abatement potential of different land management options related to agriculture until 2030**[23]

- The large impact in agriculture worldwide suggests that public investments (planned adaptation) of about $8 billion annually are needed between 2010 and 2050 to restore development gains in nutritional levels, especially for children, to levels without climate change.[24]

Table 1 Estimates of costs of adaptation at a global scale (updated from [13])

Assessment	Cost of adaptation	Time frame	Methods
World Bank [8]	US$ 9–41 billion per year	Present	Based on analyses of official flows exposed to climate risk
Stern Review [2]	US$ 4–37 billion per year	Present	Update of World Bank study
Oxfam [9]	At least US$50 billion per year	Present	World Bank study, plus extrapolation of cost estimates from NAPAs and NGO projects
UNDP [60]	US$86–109 billion per year	2015	World Bank study plus costing of targets for adapting poverty reduction programmes and strengthening disaster response systems
UNFCCC [10]	US$28–67 billion per year	2030	In-depth costing of specific adaptations in some sectors, less detailed in others.
UNFCCC [10]	US$44–166 billion per year	2030	Infrastructure adaptation costs overlap with costing in coastal zones and water resources
Project Catalyst[11]	€12–29 billion per year	2020–2030	Focused on 'particularly vulnerable' countries adapting to at least 2°C warming
World Bank [12])	US$70–100 billion per year	2010–2050	Improvements to earlier cost estimates, particularly in coastal zones. Also include adaptation to extreme events

Table 4: **Estimates of costs of adaptation at a global scale**[25]

Forestry

- Afforestation of marginal pasturelands and croplands could create sequestrations of 1.0 $GtCO_2e$/year until 2030. This incremental afforestation of 92 million hectares in 20 years (4.6 m ha/year) is comparable to an area larger than Denmark.[26]

- The potential for net sequestration of carbon through afforestation, reforestation, forest restoration, and improved **forest management** (but excluding reduced deforestation – see above) was estimated to be **2.3 – 5.7 Gt CO_2-eq./year** [adding global values for forestation and sustainable forest management (Nabuurs et al., 2007)].[27]

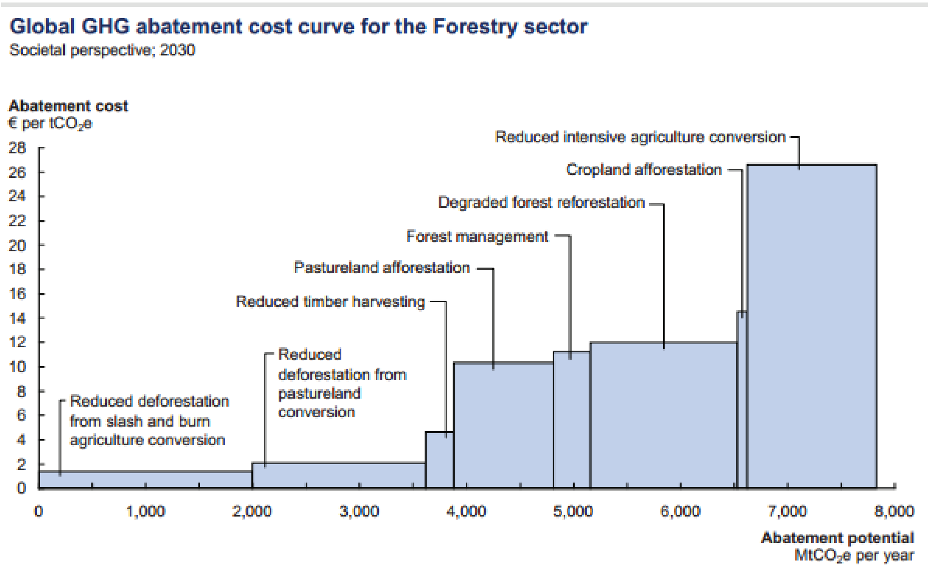

Figure 2: **GHG abatement cost curve for forestry sector**[28]

Outlook and Policy Options based on ELD Research and publications

- There are clear economic and environmental actions that can prevent and/or reverse land degradation. **Adoption of sustainable land management (SLM) could deliver up to USD 1.4 trillion in increased crop production.**[29]
- SLM practices and land restoration can result in additional payment streams that contribute to local livelihoods as well as national and global economies – and thus impact on the net cost of mitigation.[30]
- SLM, **especially in drylands**, is cost-effective and involves no future hard trade-offs with policies, making the natural resource use more resilient and less susceptible to the influence of climate change.
- **Economic rates of return** (from 12% to over 40%) have been found for a number of projects including soil and water conservation (Niger), farmer-managed irrigation (Mali), forest management (Tanzania), farmer-to-farmer extension (Ethiopia) and valley-bottom irrigation (northern Nigeria and Niger). Returns of over 40% are on record for small-scale, valley bottom irrigation.
- Evidence from India and China indicates that economic rates of return to public investments may be higher in rain-fed dryland regions than in irrigated and more humid regions.
- High economic benefits for farmers who invest in the protection and management of on-farm natural regeneration (an internal rate of return of around 30%).[31]
- The economic benefits from taking action to prevent and/or reverse land degradation and obtained from investing in and applying SLM practices are commonly higher than the costs of action.[32]
- The establishment of carbon markets provides additional benefits to land managers: the price per ton of CO_2 in 2030 is estimated around USD 25.00 (low case scenario) to USD 70.00 (high case scenario).[33]
- **Returns from ecosystem restoration** are 50% for tropical forests, 20% for other forests, 42% for shrublands, 79 for grasslands over a 40 year time horizon.[34]
- In Botswana, communal area production per hectare is three times higher than per hectare returns on commercial ranches (De Ridder & Wagenaar, 1986).[35]
- Game farms adjacent to South Africa's Kruger National Park generate 15 times greater returns through tourism than cattle farming and employ 25 times more people.[36]

ELD Initiative Case Study Examples

1. Hima-restoration approach in the Zarqa River Basin, Jordan

Large-scale adoption of Hima restoration on lands within the Zarqa River Basin can deliver net benefits to Jordanian society of 172 - 347 million EURs. **Including the**

benefits of enhanced carbon sequestration, this could amount to 170 - 387 million EUR of net benefits for the global society, for one region in one country alone. Pastoral communities benefit directly, but the largest share of benefits is allocated to society as a whole.

2. SLM through agroforestry within the watershed of Al Gedaref State, Eastern Sudan

Agriculture is the largest economic sector in Sudan, but causes serious environmental problems. Substantial net benefits can be gained by reversing current trends in land degradation through agroforestry and reforestation using native legume trees.

An applied integrated sustainable land use and reforestation scenario developed by IUCN shows potential for an **additional 10 tonnes of below and above ground CO_2 equivalent sequestration per hectare per year**. Their analysis suggests the **avoided damage cost** to the global society is in the order of **766 EUR per hectare**.

Although farmers can benefit significantly from the uptake of agroforestry and reforestation efforts, the broader society benefits substantially from enhanced ground water recharge, and global society from carbon sequestration. Left on its own, the market fails to provide optimal dedication to SLM practices. Thus, there is a **policy case for creating an environment conducive to SLM investment, including climate change adaptation and mitigation**.

3. Agroforestry and land restoration in the Kelka forest in Mopti, Mali

In the face of low agricultural productivity, forest products - especially firewood - provide complementary income to community members in the Kelka, who are heavily reliant on them. However, the **forest is under threat due to insufficient restoration and conservation practices. Interventions promoting agroforestry and restoration of bare or degraded land** can improve the resource base.

In Mali, the returns per ha of agroforestry are higher, as farmers may (at least in principle) appropriate a greater share of the products produced by the trees on their farm. Our results indicate a benefit to cost ratio of 5.2:1 at a 10% discount rate, or 500USD/ha over a 25 year time horizon.

Restoration benefits are derived from additional firewood, carbon sequestration, and its joint contribution with agroforestry practices to groundwater infiltration. **Carbon sequestration accounts for the majority of benefits of reforestation (2.4 million USD)**.

Benefits to the global society through carbon sequestration or to the larger Kelka society through ground water infiltration are external to farmers, and therefore **ignored in farmers decision-making processes.** Strong institutional arrangements are necessary to ensure communities have sufficient incentives to undertake such initiatives.

Policy relevance:

- A clear UNFCCC framework for reporting will be an essential part of cooperative climate policy, not only as currently obligatory, of CO_2 emissions, but of a **comprehensive set of policy indicators by both developed and developing countries**. This increases confidence in the effectiveness of international cooperation, and enhances the willingness of developed countries to provide resources, e.g., using auction revenue from national emissions trading schemes, or international aviation and shipping trading schemes.[37]
- Attaining a **balance between mitigation options and other societal goals,** including food security and preservation of ecosystem services, requires understanding the dynamics of land governance as land is a crucial platform for sustenance, livelihoods, and environmental, political, and cultural stability. It is necessary to **assess the role of different social actors under different land management options** as well as potential impacts of various incentives mechanisms, financing schemes, technological access, and land tenure agreements. Such an assessment, combined with understanding of the climate mitigation potential, would **form the basis for international agreements as well as national legislations** aimed at maximizing societal and environmental benefits of land management.[38] The multi-stakeholder approach integrated into and promoted by the ELD Initiative serves this purpose.
- Another ELD Initiative global case study[39] identified the concentration of **rural populations on less favoured and degrading agricultural lands and areas as a predominantly developing country problem**. The continuing expansion of this demographic lacking market access increased from nearly 300 million in 2000 to over 330 million in 2010, and deleterious issues will be exacerbated with global warming.
- However, an encouraging trend is population growth in developing countries on improving agricultural lands, even in remote areas. In 2000, there were 1.3 billion people on improving agricultural land, which included 155 million people without market access. By 2010, over 1.5 billion people were on improving agricultural land in developing countries, and in remote areas this increased to 169 million people (36% and 4% of rural populations respectively).
- In all ELD Initiative case studies, land is identified as a policy area with important bearing on climate adaptation activities. **Land tenure systems affect poverty outcomes directly** - for example, priority adaptation investments are expected to include investments in water infrastructure (including irrigation) to cope with growing freshwater scarcity. However, the greatest impacts of such irrigation investments on poverty reduction have been found in countries with low levels of inequality in land holdings (Hussain 2005). Land inequity is greatest for women.[40]

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