MAJOR ECONOMIES AND CLIMATE CHANGE RESEARCH GROUP

LBJ School of Public Affairs | The University of Texas at Austin

Agriculture and Land, Land Use Change and Forestry

Bilal Bawany | Katy Wang | Stephen Farshing
http://blogs.utexas.edu/mecc/

Supervisor : Dr. Joshua Busby
busbyj@utexas.edu

ACRONYMS AND ABBREVIATIONS

CAIT	Climate Analysis Indicator Tool
CAR	Central African Republic
CDM	Clean Development Mechanism
CGIAR	Consultative Group on International Agricultural Research
CH_4	Methane
CO_2e	Carbon Dioxide equivalent
COP	Conference of the Parties
COS	Conversion of Organic Soils
DRC	Democratic Republic of Congo
FAO	Food and Agriculture Organization
FCPF	Forest Carbon Partnership Fund
GHG	Greenhouse Gases
$GtCO_2e$	Gigatonnes of Carbon Dioxide Equivalent
Ha	Hectares
IPCC	Intergovernmental Panel on Climate Change
LUCF	Land Use Change and Forestry
LULUCF	Land Use, Land Use Change, and Forestry
MHa	Millions of hectares
MRV	Monitoring, Reporting, and Verification
$MtCO_2e$	Metric tonne of Carbon Dioxide equivalent
N_2O	Nitrogen Dioxide
NAPCC	National Action Plan for Climate Change (India)
NFC	Net Forest Conversion
NGOs	Non-governmental organizations
PES	Payment for Ecosystem Services
REDD	Reducing Emissions from Deforestation and Degradation
REDD+	Reducing Emissions from Deforestation and Degradation "plus"
SAPCC	State Action Plans for Climate Change (India)
SFM	Sustainable Forest Management
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
WRI	World Resources Institute
WWF	World Wildlife Fund

TABLE OF CONTENTS

EXECUTIVE SUMMARY

This report discusses the potential for reduction of greenhouse gas (GHG) emissions from land use, land use change, and forestry (LULUCF) and agriculture related activities. The LULUCF and agriculture sectors have been repeatedly identified as sectors where global efforts to reduce carbon emissions can achieve quick and easy wins. To explore this claim, this report examines specific carbon emissions producing activities, evaluates technical interventions and highlights those with the greatest potential for emissions reductions. The report goes on to analyze the costs, benefits and barriers associated with these selected interventions and examines their implementation scope, highlighting specific countries where each intervention is most likely to yield the greatest emission reduction.

Key Findings

(1) **Plausible actions:** Our analysis identifies 4 agriculture-related actions and 8 forestry-related actions that can increase abatement levels given existing technical, market and governance barriers. Considering varying levels of proposed implementation, we estimate these actions to reduce GHG emissions by 29% or 4.38 GtCO2e from projected BAU emissions for 2030.

(2) **Forestry sector gap:** The gap between full technical potential and our proposed potential is largely due to the forestry sector. This demonstrates both the importance of forests in the efforts to reduce GHG emissions but also the difficulty to realize full abatement potential. Brazil remains the single most important country in the forestry sector- accounting for over half of the abatement potential but faces high costs.

(3) **Agriculture cost efficiency:** Although agriculture interventions contribute a smaller portion of the emissions reductions for LULUCF, they offer greater benefits to costs than forestry interventions. Two of the four strategies selected are cost saving for all countries. The top 50% of emissions reductions from agriculture are from China, the US, Russia and developing Asia (mainly Indonesia).

(4) **Abatement potential time paths:** Agriculture abatement potential will fall more dramatically earlier on and rise steadily between 2025 and 2030. This is due to low projections for full implementation in the near future and the future growing importance of agriculture in relation to forestry. Forestry abatement potential is expected to rise at a more even pace as technical capacity and governance capacity continues to grow.

Barriers

(1) **Multiple barriers:** Both the agriculture and forestry sector face financial, technical, institutional, political, as well as cultural barriers that discourage sustainable and responsible use of land and forests. These are discussed at length in the report.

(2) **Uncertainty and Risk:** *In agriculture*, uncertainty, risk, and high upfront costs for smallholders act as barriers to adoption of low-tech mitigation strategies.

(3) **Subsidies:** Politically motivated subsidies distort the market can encourage practices that have detrimental long-term environmental effects. Subsidies also reduce efficiency and, as a result, stifle innovation. The political barriers are the cause for substantial losses in abatement potential, particularly in agriculture on the African continent.

(4) **Technical capacity:** Lack of locally appropriate knowledge and poor research and development (R&D) prevent the adoption of innovative and sustainable land management practices.

(5) **MRV:** In forestry, the difficulty in institutionalizing and devolving Monitoring, Reporting and Verification (MRV) practices inhibits private sector funding for sustainable forestry projects.

(6) **Contradicting national policies:** Physical and financial pressures from land-use regulation and macroeconomic policies increase the opportunity cost of preserving forests. This makes it difficult for local level actors to conform to national level policy.

(7) **Governance challenges:** Technical and governance barriers such corruption and fragmented political systems discourage private sector investment.

Recommendations

(1) **Comparative abatement potential:** Although abatement potential is higher in the forestry sector, the financial gains make agriculture a more attractive sector to focus current efforts. However, this is contingent on behavioral change, which is slow and difficult to incentivize.

(2) **Concentrating efforts:** The concentration of abatement potential in select countries and regions indicates that we should direct funding, research, technical assistance and capacity building to these areas. In agriculture, these include China, India, Indonesia and USA. In forestry, these include Brazil and Indonesia.

(3) **Leveraging benefits:** *In agriculture,* the gains to individual farmers in crop productivity and low technicality of activities can garner public support and facilitate rollout of agriculture abatement activities. Smallholder farmers can be incentivized to extend their decision horizons by increasing access to credit, drought insurance, and information on weather and market volatility from the international community.

(4) **Highlighting co-benefits:** The DRC and CAR possess tremendous abatement potential, but due to political instability and social unrest, full implementation is lost. The GHG emissions reduction potential in the region is crucial and should be highlighted as a co-benefit to international efforts for peace building in the region.

(5) **Promoting CSR:** Governments can incentivize environmentally responsible corporate behavior through taxation policies and NGOs can lobby for specific areas for improvements in the supply chains of global food and beverage companies.

(6) **Supporting technology:** *In forestry,* continuing and increasing funding for technology transfers and MRV, including Landsat forest cover monitoring systems, at all levels remain critical for decreasing forestry related emissions. Federal governments can incentivize public-private partnerships at subnational level to realize national level plans.

(7) **Expanding mandates:** Expanding the CDM's mandate to apply to other LULUCF-related activities, apart from afforestation, would allow individual sub national level projects to be funded, thus filling the current gap in REDD+ funding.

(8) **Timing matters:** In the short-to-medium time frame (to 2030), we recommend focusing on immediate efforts on the agriculture sector in order to maximize the cost-savings opportunities. Given the sheer volume of GHG emissions from forestry, efforts to continue pushing for change in forestry are essential in the long-term. It is clear that without some action now and efforts to build a better system for financing and MRV, the efforts to battle to reduce global greenhouse gases will be lost.

INTRODUCTION & SECTORAL OVERVIEW

The United Nations Climate Change Secretariat defines land use, land use change, and forestry (LULUCF) as "a greenhouse gas inventory sector that covers emissions and removals of greenhouse gases resulting from direct human-induced land use, land use change and forestry activities."[1] Terrestrial ecosystem vegetation and soils can serve as a natural sequestration mechanism for carbon thus slowing the rate of CO_2 buildup in the atmosphere. Such natural land mechanisms that remove greenhouse gas (GHG) from the atmosphere are referred to as "LULUCF sinks." For the purpose of this paper, countries have been separated into two emissions categories: agriculture and land use, land use change and forestry (LULUCF). Agricultural activities include enteric fermentation, synthetic fertilizer use, crop residue burning through slash and burn agriculture, and production of monocrops such as rice and sugar cane. LUCF activities include the conversion of forest or peatlands to agricultural land, logging, and mass infrastructure development.

According to the Global Carbon Project, deforestation and other land use change activity-induced CO2 emissions averaged 0.9 ± 0.5 GtC per year from 2003-2012. This accounted for approximately 8% of all human activity-induced emissions.[2] According to the WRI's Climate Analysis Indicators Tool (CAIT 2.0), agricultural and land use-net forest conversion emissions accounted for 14% and 6% of total GHG emissions in 2010.[3] Table 1 highlights agricultural emissions by specific activity, showing each activity's contribution to agricultural and global emissions. For example, rice cultivation represents 10.65% of total world agricultural emissions and 1% of all global GHG emissions in 2010. While LULUCF produces emissions of multiple GHGs (carbon dioxide, methane, and nitrous oxide), this paper aggregates all emissions into CO_2 equivalent.

Table 1. Emissions by Agricultural Activity (2010)

Activity	$GtCO_2e$	% of Total Global Agricultural Emissions	% of Total Global Greenhouse Gas Emissions
Enteric Fermentation	2.018	43.05	4.03
Manure left on Pasture	0.764	16.30	1.53
Synthetic Fertilizers	0.683	14.57	1.36
Rice Cultivation	0.499	10.65	1.00
Manure Management	0.340	7.26	0.68
Crop Residues	0.153	3.28	0.31
Manure applied to Soils	0.111	2.37	0.22

[1] United Nations Framework Convention on Climate Change, 2014.
[2] Schlamadinger et al., 2007.
[3] WRI, CAIT 2.0. 2013.

Cultivated organic soils	0.0971	2.07	0.19
Burning crop residues	0.021	0.46	0.04
Total	4.689	100	9.36

Source: FAOSTAT database, 2013.

EMISSIONS BY COUNTRY

Table 2. Emissions by Agricultural Activity (2010)

Country	GtCO2e	% of Total Agricultural Emissions	% of Global GHG Emissions
China	0.664	14.16	1.33
India	0.609	12.99	1.22
Brazil	0.411	8.76	0.82
USA	0.353	7.54	0.71
Indonesia	0.152	3.26	0.30

Source: FAOSTAT database, 2013.

In terms of major emitters, countries have been divided into two categories of emissions: agriculture and LULUCF. The countries that have the highest agricultural emissions are China, India, Brazil, the United States, and Indonesia, as shown in Table 2. Table 3 shows the top emissions from LUCF by adding net forest conversion emissions and cultivated organic soils emissions[4] with the highest emitters being Brazil, Indonesia, Nigeria, Australia, and the Democratic Republic of the Congo (DRC). Brazil has the highest LUCF emissions particularly due to its net forest conversion rates. Indonesia also has high net forest conversion rates as well as cultivated organic soil rates, which increase its share to 1.25% of total GHG emissions (resulting from LUCF). Overall, including cultivated organic soils increases the share of LUCF emissions from 3.58% to 4.14% of total GHG emissions. Combining agricultural and LULUCF activities, Brazil and Indonesia are responsible for 2.76% and 1.55% of total GHG emissions, respectively.

[4] Because cultivated organic soils account for 22% of all LUCF emissions, we have included them in our measurement of LUCF. However, net forest conversion and conversion of organic soils are measured independently of one another.

Table 3. LULUCF Emissions (2010)

Country	Net emissions/removal from Net Forest Conversion (GtCO2e)	% of Global NFC Emissions	% of Global COS Emissions	% of Global LUCF Emissions	% of Global GHG Emissions
Brazil	0.973	37%	0.005%	28.71%	1.94%
Indonesia	0.346	13%	37.10%	18.44%	1.25%
Nigeria	0.180	7%	0.000%	5.31%	0.36%
Australia	0.149	6%	0.410%	4.49%	0.30%
DRC	0.145	5%	0.004%	4.28%	0.29%
Total	1.794	68%	37.52%	61.23%	4.14%

Source: FAOSTAT database, 2013

SINKS BY COUNTRY

Table 4. Net Forest Conversion (Major Sinks)

Country	Net emissions/removal (GtCO2e)	% of Global NFC Emissions	% of Global GHG Emissions
China	-0.304	11.52	0.61
USA	-0.089	3.40	0.18
Vietnam	-0.038	1.44	0.08
Turkey	-0.031	1.20	0.06
India	-0.021	0.83	0.04

Source: FAOSTAT database, 2013

In 2005, the IPCC estimated the total amount of carbon stored in world forests to be 638 $GtCO_2e$, an amount higher than all of the carbon in the atmosphere. While global carbon sinks have grown overall since the 1990s, the year-on-year variability has been substantial due to weather patterns and human activity changes. From 1959-2012, land sinks have removed 28% of total CO_2 emissions. While this number reached 39% in 2011, it dropped to only 23% in 2012, in part explaining the growth in CO_2 emissions in 2012. The largest LULUCF sinks (refer to table 4) are China, the United States, Vietnam, Turkey, and India. Overall, sinks in China and the U.S. are responsible for 0.61% and 0.18% reductions in global GHG emissions, respectively. It is important to note however, that despite having the largest sink potential China also has the highest agricultural emissions. As economic pressures including food demand continue to increase, China and the U.S.'s sink potentials are expected to decline.

By combining agriculture emissions and LUCF activities (including sinks), the top five non-Annex I country emitters are Brazil, Indonesia, India, China, and DRC. Therefore, our emissions analysis will focus on these countries specifically. The reason for excluding the United States, the only Annex I country that would have made it to the top five emitters, is twofold. First, the rate of emissions growth in developing countries such as Indonesia, China, and DRC has been much higher than that of the U.S. Second, we believe these developing countries, however lacking capacity to do so, do have political opportunities for implementing mitigation measures. They also have a higher volume of potential reductions, especially for agriculture-related interventions. From 2000-2010, agriculture emissions from Brazil increased by 25%, 17% in Indonesia, and 15% in India. This is in stark contrast to the U.S., whose agriculture emissions increased by a mere 3%. In the same time period, Indonesia decreased its LUCF emissions by 64% and Brazil by 24%, whereas China increased its sink by 39%. Non-Annex I countries have a higher total volume of emissions as well as higher reduction potential, making them the focus of this study.

EMISSIONS SOURCES AND PROJECTIONS BY COUNTRY

CHINA

Table 5. Agricultural Emissions by Sector – China (2010)

Activity	Emissions (GtCO2e)	% of total agriculture emissions (in China)
Synthetic Fertilizers	0.226	34.07
Enteric Fermentation	0.160	24.10
Rice Cultivation	0.111	16.73
Manure left on Pasture	0.067	10.13
Manure Management	0.057	8.61
Crop Residues	0.026	4.00
Manure applied to Soils	0.012	1.89
Burning crop residues	0.0027	0.42
Cultivated organic soils	0.002	0.03
Total	0.664	

Source: FAOSTAT database, 2013

While China does classify as the largest net sink in terms of LUCF emissions, its agricultural emissions remain the world's highest at 0.664 $GtCO_2e$ or 1.33% of global GHG emissions (China's sink is almost entirely accounted for by its forests and grasslands stock). Similar to India and Brazil and noted in table 5, synthetic fertilizer use and enteric fermentation account for nearly 60% of China's agricultural emissions, while rice cultivation and manure-related activities account for another 37%, approximately. According to McKinsey Solutions Climate Desk, China's agricultural emissions are expected to rise from 1.278 $GtCO_2e$ in 2005 to 1.435 and 1.547 $GtCO_2e$ in 2020 and 2030, respectively under the BAU scenario.

INDIA

Table 6. Agricultural Emissions by Sector – India (2010)

Activity	Emissions (GtCO2e)	% of total agriculture emissions (in India)
Enteric Fermentation	0.300	49.41
Synthetic Fertilizers	0.106	17.54
Rice Cultivation	0.0819	13.45
Manure left on Pasture	0.0710	11.66
Manure Management	0.0246	4.05
Crop Residues	0.0167	2.76
Manure applied to Soils	0.0033	0.55
Burning crop residues	0.0027	0.44
Cultivated organic soils	0.0008	0.14
Total	0.609	

Source: FAOSTAT database, 2013

India is a net forest sink but its agricultural emissions are second highest in the world, only behind China. Accounting for 13% of total agricultural emissions and, India's agricultural activity is responsible for approximately 1.22% of global GHG emissions. Distribution of emissions by source within agriculture can be found in table 6. Enteric fermentation accounts for nearly half of all agriculture related emissions while synthetic fertilizer use, rice cultivation, and manure-related activity almost account for the other half combined. Emissions from rice cultivation are a function of crop duration, water regimes, and organic soil composition. Therefore, rice cultivation and synthetic fertilizer use are mutually reinforcing emissions sources.[5] India's agricultural emissions are expected to increase only modestly over the next fifteen years; the McKinsey Climate Data tool[6] projects that under the BAU scenario, India's

[5] Ibid.

[6] McKinsey Solutions Climate Desk; 2005 base year.

agricultural emissions will rise from 0.409 $GtCO_2e$ in 2005 to 0.484 $GtCO_2e$ in 2020 and 0.532 $GtCO_2e$ in 2030.

In terms of LUCF emissions, India is a net sink of -0.022 GtCO2e. This is significant as this accounts for 0.83% of total global GHG emissions in all sectors. Forests and land converted to forests account for approximately 30% and 60% of India's LUCF sink, respectively.[7] Remaining grassland accounts for a significant portion of India's sink as well. These grasslands are likely to come under pressure from urbanization, resource extraction, or conversion to agriculture.

BRAZIL

Table 7. Agricultural Emissions by Sector – Brazil (2010)

Activity	Emissions (GtCO2e)	% total agriculture emissions (in Brazil)
Enteric Fermentation	0.262	63.66
Manure left on Pasture	0.100	24.55
Synthetic Fertilizers	0.0184	4.48
Manure Management	0.009	2.22
Crop Residues	0.0084	2.05
Manure applied to Soils	0.0075	1.81
Rice Cultivation	0.0037	0.90
Burning crop residues	0.0013	0.32
Cultivated organic soils	0	
Total	0.411	

Source: FAOSTAT database, 2013

Brazil, the third largest agricultural emitter, generates a substantial amount of GHG emissions through enteric fermentation. Direct N_2O emissions from crop residue management and manure management and fertilizer use are also major sources (refer to table 7). As noted earlier, Brazil is the largest emitter in terms of LUCF due to its high levels of deforestation. Brazil's LUCF emissions total 0.673 $GtCO_2e$. Conversion of grassland to pasture and biomass burning are also major contributors to its LUCF emissions.

[7] Ibid.

The World Bank's Energy Sector Management Assistance Program projects LULUCF emissions in Brazil to rise to 0.879 $GtCO_2e$ per year by 2030.[8] Within this, LUCF via deforestation accounts for 0.533 $GtCO_2e$ while direct emissions from agriculture amount to 0.346 $GtCO_2e$ on average. Less than 1% of Brazil's total LULUCF emissions are offset by natural carbon sequestration. These projections are based on additional land that will be acquired for expansion of agriculture and livestock with a base year of 2006.

Again using 2005 as a base year with the McKinsey tool, Brazil's agricultural emissions are expected to rise substantially from 0.588 $GtCO_2e$ in 2005 to 0.722 and 0.820 $GtCO_2e$ in 2020 and 2030 respectively under the BAU scenario.

INDONESIA

Table 8. Agricultural Emissions by Sector – Indonesia (2010)

Activity	Emissions (GtCO2e)	% of total agriculture emissions (in Indonesia)
Rice Cultivation	0.058	38.51
Cultivated organic soils	0.029	19.37
Enteric Fermentation	0.019	12.59
Synthetic Fertilizers	0.017	11.77
Manure left on Pasture	0.011	7.24
Manure Management	0.0082	5.42
Crop Residues	0.0043	2.82
Manure applied to Soils	0.0027	1.80
Burning crop residues	0.0007	0.48
Total	0.152708	

Source: FAOSTAT database, 2013

In terms of agricultural emissions, Indonesia is the fifth largest emitter. Agriculture also represents 15% of GDP. The major sources of these emissions are rice cultivation, direct N_2O emissions from fertilizer and organic soils, and enteric fermentation from ruminants (see table 5). Together these account for 83% of Indonesia's agricultural emissions.[9] Accounting for 13.13% of all global forest conversions, Indonesia ranks second highest in the world behind Brazil. The major emissions sources in LUCF are forest and grassland conversion, peat fires,

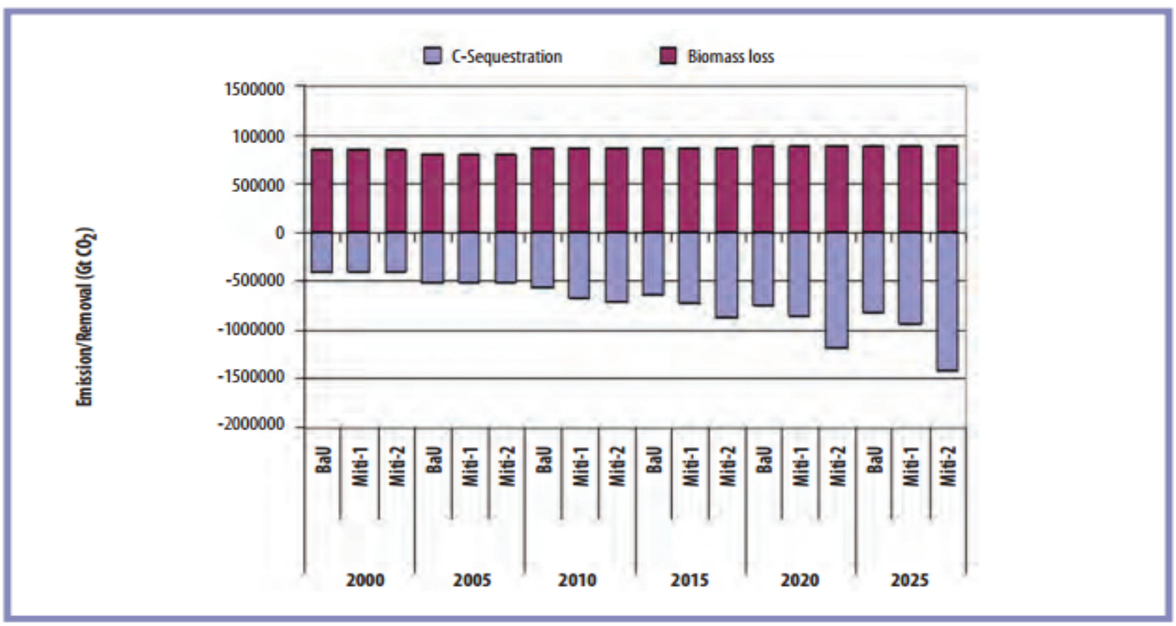
[8] World Bank Energy Sector Management Assistance Program, n.d.
[9] Government of Indonesia, 2011.

and peat oxidation (i.e. emissions from organic soils).[10] Together these activities account for 95% of its LUCF emissions while palm oil and timber plantation establishment account for the remaining 5%.

Under the Business as Usual (BAU) scenario for LUCF outlined in Indonesia's Second National Communication under the United Nations Framework Convention on Climate Change (UNFCCC), emissions from future deforestation rates are assumed to be constant at a rate of about 0.898 $GtCO_2e$ per year. Despite the projected sequestration rates increasing from 0.505 $GtCO_2e$ per year in 2005 to 0.753 $GtCO_2e$ in 2020 and secondary forestation the LUCF sector in Indonesia will remain a net emitter.

Currently, the government has outlined two possible mitigation scenarios that aim to increase carbon sequestration by afforestation. Strategy 1 (Miti-1) targets an increase in the rate of planting from 198 thousand hectare per year to 500 thousand ha per year, while Strategy 2 (Miti-2) sets an ambitious target of increasing the rate to 1.6 and 2.2 Mha per year.

Figure 1. Rate of BAU Carbon Sequestration and Emissions and two mitigation scenarios in Indonesia



Indonesia's peatland emissions, which currently account for 0.56% of global GHG emissions, "may reach 1.4 $GtCO_2$ in 2020, about approximately four times the 2000 peat emissions."[11]

[10] Ibid.
[11] Ibid

Agriculture is Indonesia's third highest emitting sector after net forest conversion and peatland removals. Agricultural carbon emissions are mostly not carbon dioxide but other GHGs like methane and nitrogen oxide. We estimated Indonesia's future agricultural emissions projections by multiplying Indonesia's share of GHG emissions (35.4%) with all of developing Asia, to find its approximate share of future projections.[12] Emissions are expected to rise from 0.282 GtCO_2e in 2005 to 0.324 GtCO_2e in 2020 and 0.356 GtCO_2e in 2030 under BAU. There is no estimate for forestry emissions projections for any country from the McKinsey tool.

DEMOCRATIC REPUBLIC OF THE CONGO (DRC)

Table 9. Agricultural Emissions by Sector – DRC (2010)

Activity	Emissions (GtCO2e)	% of total agriculture emissions (in DRC)
Enteric Fermentation	0.001	37
Manure Management	0.00019	7.04
Rice Cultivation	0.0002	7.52
Synthetic Fertilizers	0	0.86
Manure applied to Soils	0.0001	3.61
Manure left on Pasture	0.001	34.10
Crop Residues	0.0002	5.39
Cultivated organic soils	0	0.11
Burning crop residues	0.00012	3.92
Total	0.002791	

Source: FAOSTAT database, 2013

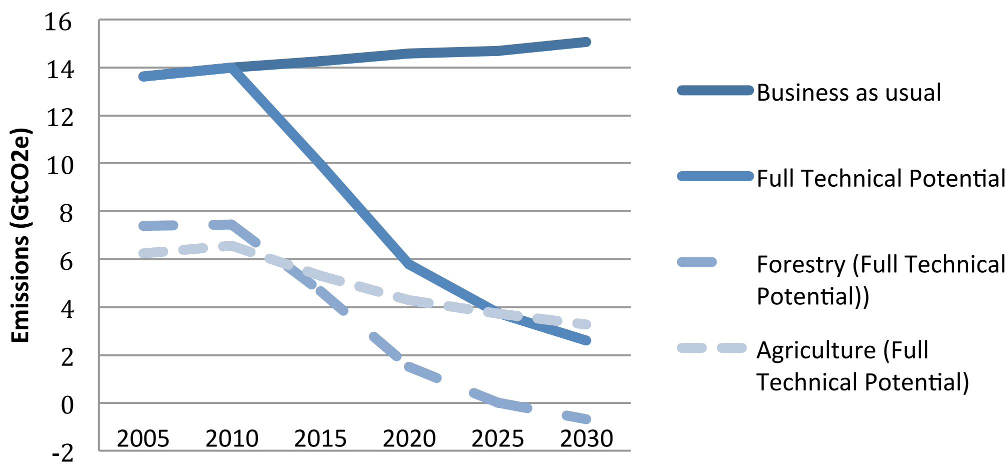
The Democratic Republic of Congo ranks as the fifth largest source of emissions due to LUCF activities with a total of 0.145 GtCO_2e emissions in 2010. This amounts to about 5.5% of total global emissions due to forestry related activities and 0.3% of global GHG emissions from all sources. In terms of agriculture, enteric fermentation, manure-related activities, and crop residue management and burning account for almost all of DRC's emissions. Due to the insignificance of the DRC's emissions from agriculture and lack of data availability, projections for agricultural emissions are not provided.

[12] McKinsey Solutions Climate Desk; 2005 baseline.

ABATEMENT POTENTIAL & RATIONALE

Generally, LULUCF abatement solutions are natural, readily available,[13] and unlike some of the other sectors, can be implemented with existing technology.

Figure 2. Agriculture & Forestry Emissions (All Levers: BAU vs. Full Technical Potential)



Source: McKinsey Abatement Curve

According to the McKinsey Solutions Climate Desk, all LULUCF and agriculture measures have full global technical potential[14] of 2.6 $GtCO_2e$ per year by 2030, 12.46 $GtCO_2e$ less than projected BAU levels or equivalent to an 82.7% reduction. However, this includes emissions related to short-lived gases. Removing levers associated with short-lived gases, full global technical potential is 4.37 $GtCO_2e$ per year worldwide by 2030, 10.69 $GtCO_2e$ less than projected BAU levels or equivalent to a 71% reduction. Of this, agriculture contributes a reduction of 3.53 $GtCO_2e$ while forestry contributes 7.16 $GtCO_2e$ reduction.

However, political instability, weak government capacity and little financing for greenhouse gas reduction activities hinder the potential to fully capture the "low hanging fruit" of the LULUCF and agriculture sector. The following abatement analysis is broken down between agriculture and forestry activities and is modified from existing models and abatement cost curves. Building off of existing models, analysis focuses on three major factors that hinder full technical potential.[15] These include:

---

[13] Ellison et al., 2012.
[14] Fully capturing all abatement potential.
[15] Fully capturing all abatement potential.

- Removing impact of short-lived gases. Land-related GHG emissions include carbon dioxide (CO_2), nitrous oxide (N_2O),[16] methane (CH_4), perfluorochemicals (PFCs), hydrofluorocarbons (HFCs) and sulfur hexafluoride (SF_6), this section focuses only on CO_2 and N_2O emissions. For strategies that included components of the short-lived gases, a percentage (α[17]) of emission reduction was subtracted based on percentage breakdown of emission types per activity.

- Political stability or fragmentation of governance structures to enforce mitigation strategies. Many countries that contribute, and therefore have the greatest potential for reduction in the land-related sectors, face either political instability or weaker governance capacity for enforcement of environment laws. These include countries in Africa (namely the Central African Republic and Democratic Republic of Congo), parts of Southeast Asia (namely Indonesia and Malaysia) and South America (namely Brazil). Furthermore, decentralization of landowners and small plots poses another challenge to large-scale success. Analysis uses the following guideline to apply a percentage reduction from full technical potential to factor in political or governance challenges:

	Reduction due to Capacity Challenges (β)
High	0%
Medium	25%
Low	50%
None	100%

- Financial feasibility in each country to finance each lever according to:

	Reduction due to Financial Challenges (δ)
High	0%
Medium	25%
Low	50%
None	100%

[16] Globally, 40% of N2O emissions are human-induced. N2O emissions from agriculture are emitted through the use of synthetic fertilizers. N2O particles remain in the atmosphere for over 120 years before being removed through a sink or destroyed by a chemical reaction. The warming impact of 1 pound of N2O is 300 times that of CO2. (*Source: http://epa.gov/climatechange/ghgemissions/gases/n2o.html*)

[17] The percentage of emissions per activity that comes from short-lived gases.

As such, each lever is taken as a percentage of full technical potential such that our proposed greenhouse gas emissions reduction per strategy, per country is calculated as:

$$\textbf{Proposed Potential} = \textbf{Full Technical} * (1 - \alpha - \beta - \delta)$$

Based on these considerations, our analysis identified 12 levers for greenhouse gas emissions within the LULUCF sector: 4 agriculture-related actions and 8 forestry-related actions.[18] These assumptions reveal a more modest estimate for potential abatement in the LULUCF sector.

Table 10. Potential Global Emissions Reduction from LULUCF

	Strategy	Implementation Assumption	Full Technical Potential ($MtCO_2e$)	Full Technical Potential ($GtCO_2e$)	Proposed Potential ($MtCO_2e$)	Proposed Potential ($GtCO_2e$)
AGRICULTURE (4)	1. Farmland Management (CO_2 & N_20)[19]	25 – 100%	272.86	0.273	102.33	0.102
	2. Grassland Management (CO_2)[20]	25 – 100%	1437.32	1.44	96.55	0.097
	3. Organic soils restoration (CO_2 & N_2O *marginal increase in methane)[21]	25 – 50%	1137.78	1.138	42.13	0.042
	4. Degraded land restoration (CO_2 & N_2O)	25-100%	425.50	0.426	862.55	0.863
	Total (Agriculture)		3273.46	3.27	1896.27	1.90
FORESTRY (8)	5. Reduced deforestation from slash and burn agriculture conversion	25%	1996.61	2.00	499.15	0.50
	6. Reduced deforestation from pastureland conversion	25%	1622.07	1.62	439.27	0.44
	7. Reduced deforestation from timber harvesting	50-100%	261.93	0.26	111.38	0.11
	8. Pastureland afforestation	50-100%	261.93	0.26	116.69	0.12
	9. Forest management	25-100%	342.52	0.34	210.78	0.21
	10. Degraded forest reforestation	100%	1378.12	1.38	1293.22	1.29

[18] The four levers excluded from LULUCF analysis include: 1) Rice Nutrient Management, 2) Rice Management - Shallow Flooding, 3) Anitimethonogen vaccine for livestock and 4) Livestock Feed Supplement. These strategies focus on reducing methane emissions.
[19] African, Middle East and Rest of OECD Pacific do not contribute to any abatement.
[20] Japan does not contribute to any abatement.
[21] Italy, Rest of OECD Europe, Japan, South Africa and the Middle East do not contribute to any abatement.

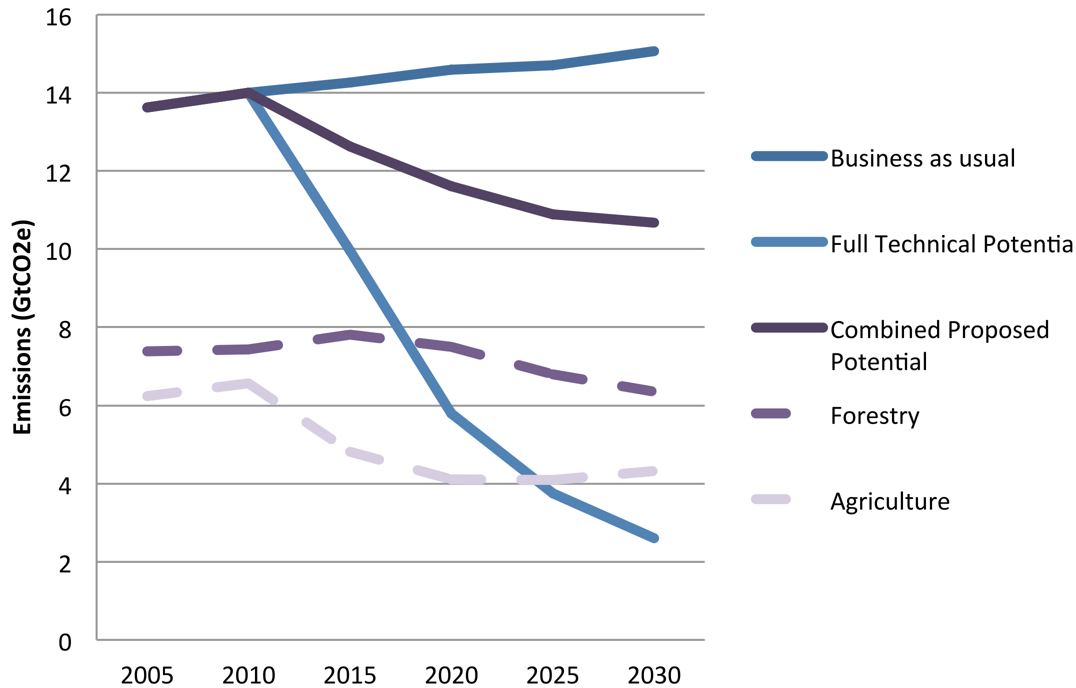
	11. Cropland afforestation	100%	89.08	0.09	22.27	0.02
	12. Reduced deforestation from intensive agriculture conversion	100%	1208.28	1.21	302.07	0.30
Total (Forestry)			7160.54	7.16	2994.83	2.99
Total			10434.00	10.43	4891.10	4.89

As shown in table 10, our analysis generates emission levels of 10.68 $GtCO_2e$ worldwide by 2030, that is a 29% reduction from projected BAU emissions for 2030 or a potential abatement of 4.89 $GtCO_2e$. As seen in the table above, the gap between full technical potential and our proposed potential is largely due to the forestry sector. This is partly due to the significant reduction of greenhouse gases from agriculture relate to short-lived gases, but also demonstrates the tremendous importance forests play in the fight to reduce GHG emissions.

Table 11. Proposed Potential Abatement (2005 – 2030)

	2005	2010	2015	2020	2025	2030
Business as usual	13.626	13.997	14.266	14.586	14.703	15.06
Full Technical Potential	13.626	13.997	9.964	5.793	3.752	2.599
Combined Proposed Potential	13.626	13.997	12.63	11.62	10.89	10.68
Forestry	7.386	7.43	7.80	7.51	6.80	6.35
Agriculture	6.239	6.56	4.82	4.11	4.09	4.33

Figure 3. Potential Emissions Reductions



LULUCF and agriculture emissions are projected to fall between 2015 and 2030. Agriculture abatement potential is projected to decline sharply and rises steadily between 2020 and 2030. This is due to low expectations to reach full potential of abatement in areas where abatement is most prominent (mainly in developing Africa due to political instability and developing Asia due to challenges working with smallholder farmers). As agriculture abatement begins to increase, the role of forestry will slightly decline overall but remains the bigger contributor to abatement between the two sectors.

Table 12. Global Costs for Proposed Potential Global Emissions Reduction from LULUCF

	Year	2015	2020	2025	2030
AGRICULTURE (4)	1. Farmland Management (CO_2 & N_2O)	(5,702,332,415)	(11,634,801,354)	(11,703,765,037)	(11,768,422,062)
	2. Grassland Management (CO_2)	(107,164,718)	(171,471,928)	(236,506,601)	(311,288,030)
	3. Organic soils restoration (CO_2 & N_2O *marginal increase in methane)	790,386,967	1,596,850,301	2,429,768,858	3,246,821,995
	4. Degraded land restoration (CO_2 & N_2O)	736,071,452	1,409,230,604	2,102,489,472	2,795,541,779
	Total (Agriculture)	(4,283,038,715)	(8,800,192,377)	(7,408,013,308)	(6,037,346,318)
FORESTRY (8)	5. Reduced deforestation from slash and burn agriculture conversion	1,366,312,272	3,066,530,853	3,462,743,517	3,527,577,885
	6. Reduced deforestation from pastureland conversion	7,010,448	15,764,085	17,516,697	17,516,697
	7. Reduced deforestation from timber harvesting	584,379,933	1,301,952,108	1,451,989,557	1,561,727,277
	8. Pastureland afforestation	584,379,933	1,301,952,108	1,451,989,557	1,561,727,277
	9. Forest management	2,145,868,302	3,349,207,779	4,249,991,946	4,974,026,118
	10. Degraded forest reforestation	6,995,455,989	12,729,081,063	17,983,472,685	21,282,871,887
	11. Cropland afforestation	417,632,211	834,997,005	1,252,565,103	1,670,871,210
	12. Reduced deforestation from intensive agriculture conversion	15,993,728,826	35,779,323,900	39,757,614,756	41,507,943,387
	Total (Forestry)	28,094,767,914	58,378,808,901	69,627,883,818	76,104,261,738
	Total	23,811,729,199	49,578,616,524	62,219,870,510	70,066,915,420

AGRICULTURE MITIGATION STRATEGIES[22]

Although agriculture levers contribute a smaller portion of the emissions reductions for LULUCF, they offer greater benefits to costs than forestry levers. Two of the four strategies selected are cost saving for all countries. The net cost of all agricultural activities are positive for the 2015, 2020, 2025, and 2030 timeframes of projects. Under full technical potential, the top 50% of emissions from agriculture would be from Africa, China, Indonesia and Russia. However, taking into consideration barriers of implementation, the top 50% of emissions reductions in agriculture will be from Developing Asia, China, Russia and USA. For 2015 and 2030, developing Africa ranks in the top 5 emitters. This illustrates the sheer volume of potential abatement in the region, despite high barriers to implementation. A discussion of each individual lever follows[23]:

FARMLAND MANAGEMENT (0.199 GTCO_2E PER YEAR BY 2030)

Cropland nutrient, tillage and residue management provide significant cost-savings and require low technology. The key to achieving full potential is education and changing simple behaviors such as replacing nitrogen fertilizers to sulfate-based fertilizers or reducing land tillage and residue burning to minimize GHG emissions. Cost-savings and greater crop productivity ensure higher buy-in from small plot farmers; therefore our model assumes high potential implementation with the exception of developing Africa[24] and Asia[25]. Russia, China and the US offer the highest reductions in emissions (0.878 GtCO_2e per year by 2030) while also enjoying the highest total savings of $1.85 billion, $2.14 billion and $2.76 billion,[26] respectively, per year by 2030.

GRASSLAND MANAGEMENT (0.905 GTCO_2E PER YEAR BY 2030)[27]

More efficient grassland management through better nutrient management, increased grazing intensity, better irrigation and fire management practices also offer GHG emissions reduction while providing cost-saving opportunities in all countries. Therefore, our model assumes full potential implementation. The highest reduction in emissions will come from China (0.19 GtCO_2e), followed by developing Asia (0.108 GtCO_2e, likely Indonesia and Malaysia), USA (0.063 GtCO_2e) and Russia (0.045 GtCO_2e). The greatest savings will go to the US ($453 million per year by 2030[28]). It is important to note that while emission reduction contributions

[22] Refer to Appendix for full table of results.
[23] For detailed description of each lever, refer to the appendix.
[24] Due to political instability and decentralization of smallholder farms.
[25] Due to lack of financing and decentralization of smallholder farms.
[26] €1.43 billion, €1.66 billion and €2.14 million, based on Feb 2014 exchange rates.
[27] The breakdown between CO2 emissions and other gases is unclear. For the purpose of this study, it is assumed all emissions from this lever are CO2.
[28] €584 million, based on Feb 2014 exchange rates.

from European countries such as Italy are minimal, their lower unit costs of implementation indicate "low hanging fruit" for agriculture levers and should be explored fully.

ORGANIC SOILS RESTORATION (0.553 GTCO$_2$E PER YEAR BY 2030)

Organic soil restoration provides huge potential emissions, particularly in the area of peatlands - prevalent in Indonesia and Russia. Although organic soil restoration increases methane release, the offsets of CO_2 sinks created marginalize the effect. However, restoration of peatlands and restoring water table levels requires intense effort and relatively high costs. Therefore, analysis assumes low ability to capture full potential and assume 50% success. The greatest contributor to emission reductions would be Indonesia (0.193 GtCO_2e per year by 2030), but it would also face the highest costs of $1.7 billion by 2030.[29] Despite plans to increase peatland conversion to non-forest use, we believe international actors' willingness to finance activities (such as Norway under the REDD+ partnership) will continue to incentivize Indonesia to meet at least half of its potential reduction.

DEGRADED LAND RESTORATION (0.24 GTCO$_2$E PER YEAR BY 2030)

Although relatively expensive compared to the other options, lever 6 is relatively easier to implement. Therefore, our analysis assumed full technical potential for either richer, developed nations (Japan, Europe, Italy, Canada, UK, Germany, France, US and China) or those with a relatively lower per tCO_2e unit cost (Middle East). For the remaining countries (South Africa, Mexico, India, Rest of OECD Pacific, Russia, Brazil, the rest of Latin America and rest of developing Asia), lack of financing assumes 50% of full potential achieved. For developing Africa, the added barrier of political instability assume 25% of full potential achieved. The country with the biggest contribution to emissions reduction is China (0.055 GtCO_2e per year by 2030). Despite facing high unit costs, China's commitment to reducing its greenhouse gas emissions[30] and ability to encourage large-scale agricultural reforms allows it to still reach 50% of potential.

FORESTRY MITIGATION STRATEGIES[31]

Forestry remains the most important part of LULUCF - with the greatest potential as a sink but also as a contributor to emissions. Compared to agricultural levers, forestry levers are more expensive to implement and oftentimes, in the case of developing countries, requires combatting corruption and demand for forest products In the case of forest-related abatement levers. Forestry-related emissions are concentrated to two major emitters: Brazil and Indonesia. They account for over 50% of potential emission reductions.

---

[29] €1.257 billion, based on Feb 2014 exchange rates.

[30] as evidenced by "Sloping Land Conversion Program", established in 2000 and aims to return more than 37 million acres of cropland back to forests or grasslands.

[31] Refer to Appendix for full table of results.

Established in 2005, the United Nations Reducing Emissions from Deforestation and Forest Degradation (REDD) was developed as "an effort to create a financial value for the carbon stored in forests, offering incentives for developing countries to reduce emissions from forested lands and invest in low-carbon paths to sustainable development."[32] The mechanism generated optimism for action in reducing emissions from forestry. In practice, however, the rollout has not been as smooth as hoped and buy-in of REDD has been mixed.[33] For the purpose of our analysis, REDD (and REDD+) efforts are considered for potential implementation capacity. For a more detailed discussion of REDD, see Financial Barriers for Forestry Mitigation.

REDUCED DEFORESTATION FROM SLASH AND BURN AGRICULTURE CONVERSION (0.5 $GTCO_2E$ PER YEAR BY 2030)

Due to the difficulty of enforcement, monitoring and weak government capacity to control slash and burn activities, low capacity to reach full technical potential is assumed; we estimate countries will only reach 25% of full potential. The country with the greatest contribution is Brazil (0.13 $GtCO_2e$ per year by 2030).

REDUCED DEFORESTATION FROM PASTURELAND CONVERSION (0.439 $GTCO_2E$ PER YEAR BY 2030)

In addition to lack of financing and weak government capacity, pastureland conversion competes with agriculture and livestock industries. As such, we assume low potential (25%) to meet full capacity. Under the assumption of meeting 25% of full technical potential, once again, Brazil offers the greatest contribution to GHG emission reductions (0.282 $GtCO_2e$ per year by 2030, over 50% of all countries).

REDUCED DEFORESTATION FROM TIMBER HARVESTING (0.111 $GTCO_2E$ PER YEAR BY 2030)

Timber harvesting is a highly lucrative business that faces corruption, bribery of local officials and difficulty monitoring; the majority of countries will unlikely reach full technical potential for GHG emissions reduction. Under full technical potential, the African region is the greatest contributor; however, this is likely centered on the countries of CAR and the DRC, which as of late have become extremely unstable politically. An ambitious estimate of 25% full technical capacity would generate emission reductions of 0.014 $GtCO_2e$ per year by 2030 in the African region. Brazil would also offer similar levels of reductions at 0.013 $GtCO_2e$.

[32] UN-REDD, 2014. www.un-redd.org.
[33] Butler, 2008.

PASTURELAND AFFORESTATION (0.117 $GTCO_2E$ PER YEAR BY 2030)

Pastureland afforestation is cheaper in Mexico, Brazil and the rest of Latin America. Therefore, analysis assumes high potential to meet full technical capacity. High costs and political instability continue to cast doubt on reaching full potential in Africa and Asia, and therefore analysis looks at 25% of full technical potential emission reductions. Once again, Brazil tops the list as highest emission reduction at 0.052 $GtCO_2e$ per year by 2030.

FOREST MANAGEMENT (0.211 $GTCO_2E$ PER YEAR BY 2030)

Regions and countries facing weak governance and technical capacity (Eastern Europe, India, Latin America, China, Africa and Asia) are assumed to reach 50% of full abatement potential. Brazil, facing potential governance difficulties, was assumed to reach 75% of full potential. The biggest contributor would be in the African region (0.058 $GtCO_2e$ per year by 2030), however, political instability threatens even the ability to meet 50% of potential. As a relatively expensive measure, financing for this lever and those following will be key to achieving even partial potential.

DEGRADED FOREST RESTORATION (1.29 $GTCO_2E$ PER YEAR BY 2030)

With a moderately expensive unit cost and high emissions, as well as low opportunity costs of restoring degraded forests (which cannot easily be restored for other income-generating uses such as agriculture), our model assumes full technical potential, except for Africa (due to political instability and weak governance) which is unlikely to reach full potential - instead we assume 50% of potential. In this case, the Middle East is the greatest contributor (0.386 $GtCO_2e$ per year by 2030) of emissions reduction. Due to the relative ease of restoration and potential for higher abatement, we assume, despite being energy-focused, Middle Eastern countries will be willing to finance these activities.

CROPLAND AFFORESTATION (0.022 $GTCO_2E$ PER YEAR BY 2030)

With high costs and low yield of abatement potential, our model assumes most countries will not invest too many resources into this measure, only 25% of full potential.

REDUCED DEFORESTATION FROM INTENSIVE AGRICULTURE CONVERSION (0.3 $GTCO_2E$ PER YEAR BY 2030)

Like other strategies competing with agriculture, the opportunity costs are high, particularly with rising food demand. Therefore, our model assumes all countries will only meet 25% of potential. 81% of emission reductions will come from Asia and cost $9.06 billion. Again, financing will be crucial for even reaching 25% of this lever.

BARRIERS AND RECOMMENDATIONS

While many of the LULUCF abatement strategies are natural and comparatively inexpensive, a significant number of barriers exist in the sector that can threaten the implementation and success of these solutions. Barriers to successful abatement can be financial, technical, market-related, political, or cultural/behavioral. These barriers are especially salient and more difficult to overcome in developing countries. This section will analyze the barriers to success in the agriculture and LUCF sectors separately, illustrating them with international and country-specific examples. In addition, this section will consider possible remedies to these barriers and the likelihood of them being adopted.

AGRICULTURE: BARRIERS AND RECOMMENDATIONS

Many of the reforms and interventions discussed in the previous section have the potential to increase carbon stocks in the agricultural sector, thus mitigating GHG emissions. Many of these interventions are relatively low cost for society as a whole and provide other health and environmental benefits such as improved water quality, more nutrient-rich soils, and decreased erosion and soil degradation. Furthermore, these interventions improve long-term food production and serve to combat food insecurity. However, the implementation of many of these strategies requires developing country farmers (mostly smallholders) to bear uncertainty, risks and upfront costs. Thus the success of the interventions relies largely on influencing small farmer behavior, as they are the ultimate decision makers with respect to which mitigation options will be adopted.

FINANCIAL BARRIERS

Financial barriers to the implementation of sustainable agronomic practices stem from farm-level financial constraints that limit the adoption of new technology and/or farming techniques. Smallholder farms in the developing world usually have little or no access to credit, thus making it extremely difficult for farmers to think beyond a given growing season. This is a problem especially present in India where the average farm size is less than two hectares and subject to fragmentation from land ceiling acts.[34] Developing world agriculture, like in India and Sub-Saharan Africa including the DRC, already suffers from low investment and productivity. As a result, large up front investment costs for small farmers will discourage them from implementing sustainable land management practices that could be beneficial for GHG mitigation.

Developing world smallholder farmers also have extremely short-term planning horizons, which are easily affected by extreme circumstances such as flood, drought, or political instability. As the time periods for the benefits of sustainable land management practices to materialize are generally long-term, it is difficult to incentivize farmers with short-term horizons to adopt them.

---

[34] FAO, n.d.

Agricultural subsidies for inputs such as fertilizers, water, electricity, and fuel, as well as outputs to maintain stable agricultural systems represent another set of politically motivated financial barriers that exist in both developed and developing countries. Government subsidies distort the market for these products, which can cause over or underproduction, promote unsustainable farmland expansion, and can encourage use of fertilizers and other inputs that have detrimental long-term environmental effects. Brazil's agricultural subsidies have doubled from 2010-2013 and now total approximately $10 billion. From 2005-2011, India's subsidies for wheat and rice grew by 72% and 75%, respectively. India even subsidizes the cost of energy to pump irrigation water, which encourages farmers to use more water than needed.[35] In 2012, Indonesia earmarked $1.77 billion for agricultural subsidies, 90% of which went to fertilizers.[36] China's agricultural subsidies in the same year were estimated at $160 billion compared to the United States' $19 billion.[37] As a result, technological innovation is stifled in these countries and there is little or no focus on improving efficiency, let alone mitigating GHG emissions. In addition, these subsidies generally do not help small farmers but instead large-scale corporate farms and fertilizer (and other input) companies.

RECOMMENDATIONS TO OVERCOME FINANCIAL BARRIERS

In more developed countries focus should be on targeting large farmers and private organizations with greater influence on the production and supply chains of agricultural commodities. These private actors would also be much more open to adopting mitigation strategies, which would increase their sustainability and profitability in the long run. In countries like Sub-Saharan Africa, India and parts of China, emphasis should be to identify incentives to influence the behaviors of smallholder farmers. Oftentimes this includes funding low-cost education programs or providing microcredit to farmers for behavioral changes. For example, China has had some success in Gansu Province using microcredit loans for small businesses that are dependent on switching from coal furnaces to biogas furnaces. [38]

To combat farm-level adoption constraints and short-term planning horizons, strengthening insurance offerings and developing weather insurance could help overcome barriers. Expanding internationally supported credit and savings schemes and price supports could assist rural populations manage the increased variability in their environment and farms that results from the adoption of new sustainable practices.

Reducing subsidies especially in developed countries and countries in transition such as China and Brazil to reduce the use of fertilizers and limit the density of farm production is another effective strategy. Other incentive systems for developing countries could be implemented including subsidies for the adoption of sustainable land management technology transfers or practices that would otherwise be too expensive for farmers to adopt.

---

[35] Tushaar, 2012.
[36] The Jakarta Post, 2012.
[37] Clay, 2013.
[37] Ibid.
[38] Hodge, 2010.

Rationalizing input and output prices of agricultural commodities could also lead to more efficient use of input resources.

TECHNICAL BARRIERS

In terms of technical barriers to success in developing countries, a lack of locally appropriate knowledge or under-resourced research and development prevents the adoption of sustainable land management practices. Rural farmers in India and Indonesia do not have the capability to take soil samples to test for nutrient levels. Due to education and governance constraints, there is a general lack of access to information and trained human capital in rural areas, especially in India, Indonesia, and DRC. As a result, often there is no local production or availability of inputs (fertilizers, herbicides, etc.) that comply with the sustainable agricultural practices previously discussed. Because foreign investment and interest in developing country agriculture rarely go beyond trade, there is limited technology transfer between developed and developing countries. Although FAO has implemented numerous projects across the developing world to promote information sharing and sustainable land management, scaling up has remained a significant problem and technical barrier. The Consultative Group on International Agricultural Research (CGIAR) programs are becoming less effective as funding is slowing. While some of CGIAR's programs have demonstrated significant economic benefits - such as the introduction of a no tillage rice-wheat systems in India, which generated approximately $160m between 1990 and 2010 - CGIAR has failed to transfer capacity to national centers in developing countries.[39] As a result, when CGIAR leaves these national centers still lack access to information and are not aware of technologies or methods that best suit their national needs and conditions.

RECOMMENDATIONS TO OVERCOME TECHNICAL BARRIERS

As food security becomes more salient an issue, overcoming the lack of technical expertise will require a long-term solution. Governments should invest more heavily in agriculture technology universities and support field research work of local professors. The fact that there is no universal list of mitigation practices further exacerbates the need for country-specific technical solutions. For example, policies to reduce emissions from rice cultivation such as shallow flooding may be beneficial to China and Indonesia but will do little in Brazil where the majority of emissions comes from enteric fermentation and manure-related activities. Similarly, synthetic fertilizer use is responsible for most of China's emissions, but technological change in fertilizer will do less in Brazil, where fertilizer use accounts for less than 5% of agricultural emissions.

Moreover, expertise that exists in one country might be needed in another. Therefore, institutional linkages between countries with high technological standards should be bolstered through official engagements between ministries of agriculture and sciences. Cross-country information and technology sharing through institutions such as FAO and USDA could provide crucial knowledge transfer to achieving full potential.

---

[39] Renkow, and Byerlee, 2010.

INDUSTRIAL AND MARKET BARRIERS

In command-oriented economies such as China, business mobility is limited; policies and incentives regarding sustainable agriculture practices will be more difficult to implement. China's high level of subsidies as previously discussed illustrates this point. In contrast, more market-based or even mixed economies such as Indonesia, Brazil, and India may prove to be more receptive to market incentives or private sector investment in sustainable agriculture. Nonetheless, the agriculture industry favors agrochemical companies and large industrial farm structures in places like Brazil, Indonesia, and China. There are smaller markets for what are perceived as riskier practices, and investors in these places are less likely to encourage the abatement strategies discussed above. If a sophisticated market existed for farmers to adopt measures that reduce GHG emissions, such as a carbon-trading scheme for agriculture, these practices could become profitable. However, market mechanisms and economic incentives are in the end trumped by political realities and government issues and corruption. In this sense the markets come only after these issues are settled but even so, the weakness of the EU ETS highlights the difficulty of implementing carbon markets even in more politically stable regions.

Reduced public funding on new mitigation technology in agriculture has meant more private sector involvement. Protection of intellectual property rights, especially in developing markets, is weak for commercially developed seed and agribusiness companies. This leads to hesitation among private organizations to invest or transfer technology to developing countries that may lead to decreased agricultural emissions. One should also note the concerns that genetic and technological resources not previously considered intellectual property by private investors may receive patents though private investment. Lack of intellectual property rights therefore present a market barrier that leads to poor technology transfer. For example, strains of rice have been developed in the U.S. that would significantly reduce methane emissions but generic resources are easily replicated and transported.[40] Therefore, private sector investment is discouraged for fear of intellectual property right infringement and developing countries cannot share in the benefits of sophisticated R&D. Property rights, landholding structures, and the lack of clear single-party land ownership in developing countries may inhibit the implementation of sustainable land management practices. Thus, land rights reform is a key political barrier that stands in the way of success in the reduction of agricultural GHG emissions.

RECOMMENDATIONS TO OVERCOME INDUSTRIAL AND MARKET BARRIERS

To encourage private sector investment, governments of the technology providers (i.e. U.S., EU) can propel technology transfer through domestic arrangements with the private sector, such as tax breaks and other measures.[41] The U.S. government, for example, could push for legal and intellectual property reform in developing countries by providing technical expertise and investing in capacity building for better governance and regulation. However, this will likely face opposition from developing country actors who are likely to be suspicious of this

[40] Erda, 2010.
[41] Ibid.

sort of reform, as U.S. companies have often pushed for this in self-serving ways. Therefore, feasibility of implementing intellectual property reform may be a question.

POLITICAL BARRIERS

Weak political institutions for collaborative planning and management are a significant barrier to implementing sustainable agricultural practices. Indonesia and India are home to volatile policy and regulatory environments that can do little to promote the adoption of agricultural practices that mitigate GHG emissions. Politicians are more likely to respond to short-term pressures from special interest groups and industrial demands instead of long-term environmental protection strategies. For example, the Indonesian farm industry consistently exerts pressure on the government and is able to lobby against efforts to strengthen the forest moratorium.[42] DRC too suffers from these problems as well as extreme political instability, civil war, and terrorism. Government capacity in the DRC especially is extremely limited and little can be expected in terms of GHG abatement of a government currently occupied by concerns of the country and its citizens' survival. Although India has a strong state, its extremely fragmented bureaucracy and reporting system creates immense inconsistencies in policy and data collection. In addition, the central government in India, much like China, does not like to be told what it should or should not do in terms of development and emissions. Therefore, implementation in India is best sought out at the local and regional level. There is also a strong distinction to be made about the impact of fragmented federal systems on agriculture versus forestry emissions. For example, Brazil has had success in reducing forestry-related emissions through national level legislation. However, its fragmented federal system has made replicating the same success in agricultural emissions difficult, where the sector accounts for 25% of the economy and employs 35% of the labor force.[43] Private sector agribusiness firms enjoy more relative power in Brazil than in any of the other five countries this paper examines. Local companies like *SLC Agricola, JBS,* and *Cosan* as well as multinational firms dominate agriculture policy with strong lobbies and powerful influence in government.[44]

RECOMMENDATIONS TO OVERCOME POLITICAL BARRIERS

Long-term stable policies are central to reducing GHG emissions in agriculture. It is difficult for large federations to monitor and incentivize adherence to national level policy. However, improving transparency through independent information collection and monitoring can allow for better coordination and policy evaluation. In states where there is competition between regions for resources, improving transparency and ensuring policy consistency can reduce internal tensions. As national level policy will be more concerned with maintaining food security, it should use investments in abatement activities as an incentive to encourage policy conformity. These abatement incentives would include technology transfers as well as co-

[42] Redd Monitor, 2013.
[43] USDA Foreign Service, 2009.
[44] Gartlan, 2010.

benefits such as increasing productivity and decreasing soil degradation. In countries like China where decision-making is centralized, this can mean very quick policy changes to adopt these practices.

CULTURAL BARRIERS

Cultural and behavioral factors contribute significant barriers to success in agricultural emissions abatement as farmers or societies may not be accustomed to proposed solutions or practices. For example, in much of the developing world farmers prefer to use crop residues as forage for livestock as a cost-effective way of feeding animals. Using residues in this way increases emissions through enteric fermentation and will remain a difficult behavior to change especially in smallholder farms where farmers cannot afford animal feed other than leftover crop residues. Straw burning and slash and burn agriculture in general are equally, if not more important for carbon emissions. Burning is less labor intensive and thereby more cost-effective than manually removing crop residues. Burning also can help control weeds and prevent blights and other plant diseases. Therefore, most developing country farmers favor burning as an effective way to manage and protect their production, as they are not immediately concerned with the long-term effects of this activity. Smallholder farmers are in general more risk averse due to low capital, lack of credit, and poor investment opportunities. They may not be in a position to take on any unnecessary risk. This creates a psychological barrier to adopting unknown techniques. Uncertainty with respect to production, profitability, and implementation of conservation tillage and other sustainable land management practices are widespread. Interestingly, perceived risk of negative outcomes and uncertainty of profitability could represent the most difficult barriers to success to overcome in this sector. Cultural barriers by nature are persistent overtime and long-term thinking can only be affected by short-term actions that prove effectiveness and profitability.

LAND-USE CHANGE AND FORESTRY: BARRIERS AND RECOMMENDATIONS

As highlighted in the cost curve analysis (refer to table 12), reducing emissions from Land Use Change and Forestry (LUCF) and protecting carbon sinks have relatively high mitigation costs (compared to agriculture) - providing insight into why progress is so slow in this sector. However, other factors play into the lack of development in the sector. This section examines the barriers, opportunities, and implementation issues associated with policies affecting mitigation in the forestry sector.

The IPCC in its Fourth Assessment Report[45] identifies three major barriers countries face when enacting policies to reduce forest loss. First, profitability incentives often run counter to forest conservation and sustainable forest management;[46] second, many direct and indirect drivers of deforestation lie outside of the forest sector, especially in agricultural policies and

[45] IPCC, 2007.
[46] Tacconi et al., 2003.

markets;[47] and third, limited regulatory and institutional capacity and insufficient resources constrain the ability of many governments to implement forest and related sector policies on the ground.[48]

FINANCIAL BARRIERS

In general, the forestry sector faces physical and financial pressures from land use regulation and macroeconomic policies, which incentivize "conversion to other land uses such as agriculture, cattle ranching, and urban industry."[49] Technical and governance barriers, which will be discussed later, make private sector investment in forest mitigation unappealing and risky. Funding for forestry mitigation projects in non-Annex I countries largely comes from Annex I countries. One of the major funding mechanisms is the UN-REDD+ program. This initiative is "the United Nations Collaborative initiative on Reducing Emissions from Deforestation and forest Degradation (REDD) in developing countries. The Program was launched in September 2008 to assist developing countries prepare and implement national REDD+ strategies, and builds on the convening power and expertise of the Food and Agriculture Organization of the United Nations (FAO), the United Nations Development Program (UNDP) and the United Nations Environment Program (UNEP). The Program currently supports 44 partner countries spanning Africa, Asia-Pacific and Latin America, of which 16 are receiving support to National Program activities. UN-REDD Program countries not receiving direct support to national programs engage with the Program in a number of ways, including as observers to the Program's Policy Board, and through participation in regional workshops and knowledge sharing, facilitated by the Program's interactive online workspace."[50]

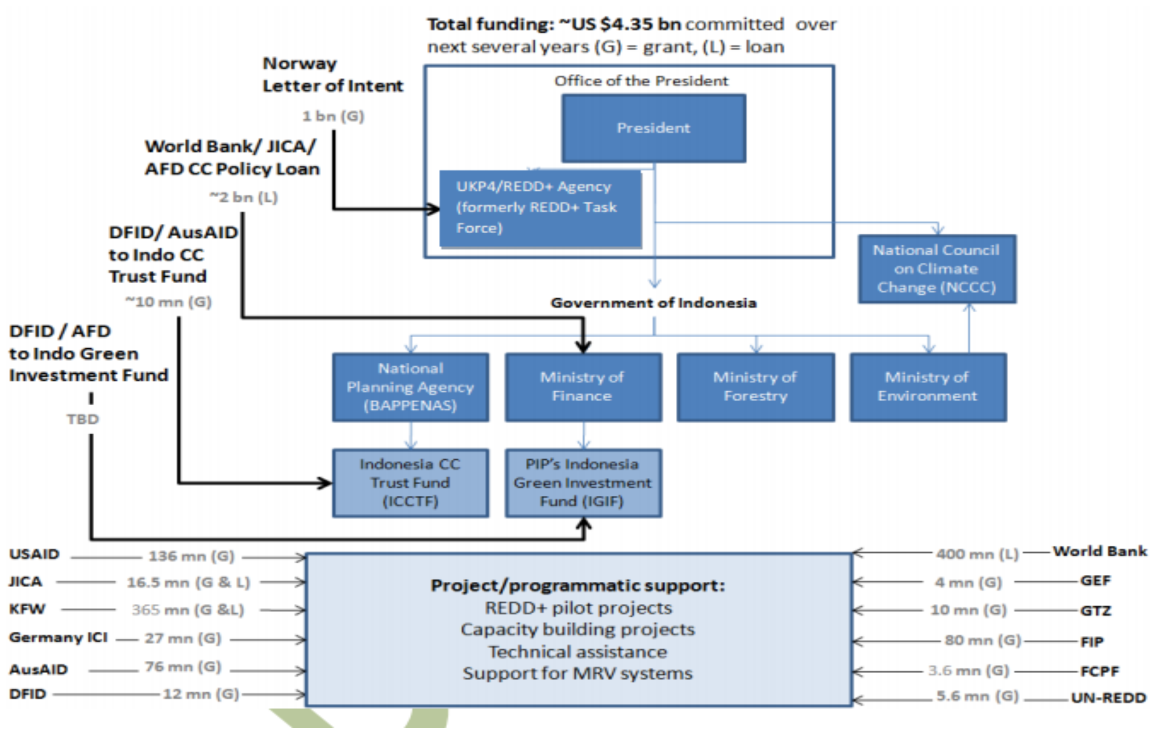
International organizations and NGOs, including public-private partnerships and development banks, work to make countries "REDD+ ready," and make standing forests more valuable. Technology and management systems are integral to major projects that are funded by bilateral/multilateral or commercial agencies. For example, Norway agreed to provide $1billion[51] to Indonesia in the form of a REDD+ Partnership to incentivize a two-year suspension of new concessions that converted natural forests and peatlands into plantations.[52]

---

[47] Wunder, 2004.
[48] Ibid.
[49] IPCC, 2007.
[50] UN-REDD, n.d.
[51] However, not all of this money was actually transferred to the Indonesian government.
[52] Lang, 2013.

Similarly the World Bank's Readiness Fund helps countries set up REDD+ national management arrangements including design, monitoring reporting and verification (MRV) systems, and environmental and social safeguards. An example of this was the World Bank Forest Carbon Partnership Facility (FCPF) grant given to Indonesia in 2011 which consisted of four main components: 1) analytical work; 2) support to readiness process; 3) assessment and measurement of GHG impacts of land use change; and 4) regional data collection and capacity building. The FCPF activities are directed to fill financing gaps and identify technical activities that are not covered by other donors and actors. Even well funded programs like this are not immune to implementation challenges. For the Indonesia-Norway partnership, domestic politics between the state and its provinces has been the main challenge and the reason why not less than half of the funding has been disbursed. This case is discussed in greater detail in the following pages.

Figure 4. Funding for Indonesia's REDD Readiness



Source: Indonesia FCPF Factsheet 2013.

RECOMMENDATIONS TO OVERCOME FINANCIAL BARRIERS

A recent win in this sector came at the UN talks in Warsaw 2013 in which Norway, the U.K., and the U.S. allocated $280m of their multi-billion dollar climate change finances to a new initiative aimed at halting deforestation. This money will be administered by the World Bank's BioCarbon Fund and used to fund sustainable farming and better land use in areas facing rapid deforestation. Overall however, REDD+ funding needs to be dramatically scaled up. In the meantime, expanding the CDM's mandate to apply to other LULUCF-related activities, apart from afforestation, would allow individual sub national level projects to be funded, thus filling the current gap in REDD+ funding.

"Payment for Ecosystem Services" (PES) schemes, in which countries are funding to refraining from deforestation have varying success because of "relatively high transaction costs and insecure land and resource tenures"[53] being a common challenge in most developing countries. The President of Ecuador's recent decision to scrap the Yasuni-ITT Initiative - a fund that was intended to generate revenue to prevent the country from selling oil block concessions from Yasuni National Park - is a salient example of a PES failure. For PES schemes to work, they need to account for poverty considerations and shortcomings associated with poverty (budget and capacity constraints) and must invest in background research in order to be cost-effective (including baseline setting, opportunity cost assessments, and leakage control).

INSTITUTIONAL BARRIERS

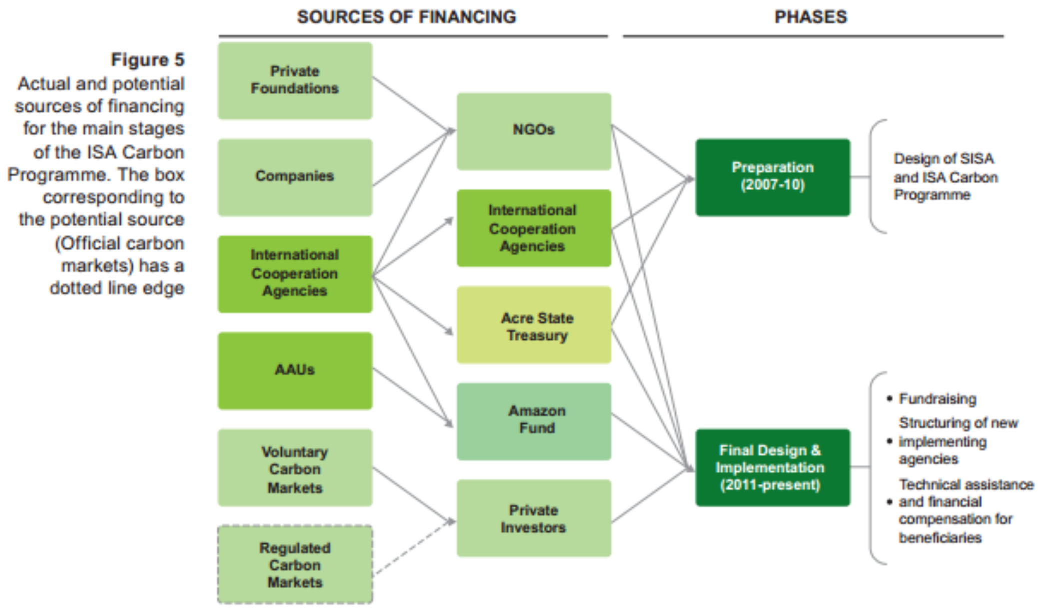
Another barrier stems from the fact that forestry and LULUCF activities other than afforestation/reforestation are not included in the Clean Development Mechanism (CDM), which "allows a country with an emission-reduction or emission-limitation commitment under the Kyoto Protocol (Annex B Party) to implement an emission-reduction project in developing countries."[54] As a result, no climate policies currently exist under the UNFCCC and the Kyoto Protocol to reduce emissions from deforestation or forest degradation in developing countries. This is because among the mitigation options, there is a higher degree of certainty on reforestation and afforestation, less on forest management, and even less on forest conservation. While Brazil and India both have national monitoring systems for deforestation, both still lack dedicated investment to reliably estimate carbon inventories. In addition, REDD+ does not fund individual projects but only provides money to national governments.

RECOMMENDATIONS TO OVERCOME INSTITUTIONAL BARRIERS

Countries cannot simply rely on REDD+ or CDM to support project development. They must be willing and creative to tap multiple sources of funding as Brazil did in Acre state to implement environmental zoning, expand protected areas, develop forest cover monitoring systems, and promote other sustainable forestry practices. Funding came from private investors, NGOs, the Acre State Treasury, and other international cooperation agencies. Diversification of funding is key to addressing institutional barriers.

[53] Grieg-Gran,2004.
[54] IPCC, 2007.

Figure 5. Funding sources leveraged by the State of Acre, Brazil for its Environmental Services Incentives System



Source: WWF Brazil Report 2013

TECHNICAL BARRIERS

The lack of technical capacity is cited by most international organizations and nonprofits as the focus of most efforts in making developing countries able to implement mitigation practices in forestry. Many developing countries have forest preservation and management policies that cascade down from the federal level. In terms of technical capacity, these countries lack the ability to generate critical information required for implementing mitigation strategies. This creates technical barriers to adapting international research to the local level. Mitigation measure and management systems are often specific to a particular forest type or economy. Therefore, technical barriers are much more pronounced in the LUCF sector than in other sectors. MRV are important elements in gaining the credibility needed to capture the potential benefits of the forestry sector. Monitoring involves measuring country progress from theoretically established mitigation baselines. Reporting can flow through either the national government, or independent review to allow for greater confidence. Verifying outcomes of particular mitigation strategies inspires mutual confidence in the international community. Significant barriers to MRV include: 1) choosing an acceptable baseline target; 2) agreeing on what standards of MRV to use; 3) implementing systems and getting reliable data; and 4) human resources such as training and education. In addition, MRV varies by country and by program.

Recent progress in technical capacity at the UN Warsaw talks includes a decision by parties to the Kyoto Protocol to establish three technical work programs including: 1) to explore more comprehensive accounting of LULUCF emissions by sources and removals by sinks; 2) to consider and, as appropriate, develop and recommend modalities and procedures for possible additional LULUCF activities under the CDM; and 3) to consider and, as appropriate, develop and recommend modalities and procedures for alternative approaches to addressing the risk of non-permanence under the CDM. This is an important step as LUCF-related abatement activities are not included in the CDM (as noted above) and LULUCF projects currently account for less than 1% of total CDM projects.

RECOMMENDATIONS TO OVERCOME TECHNICAL BARRIERS

To improve LUCF abatement, MRV and technical capacity need to be developed at the local, regional, and national levels. For example, Sustainable Forest Management (SFM) certifications have demonstrated communities' ability to benefit from sustainable forestry initiatives. In Nepal's Dolakha District, SFM certification goes beyond the political autonomy granted through existing legislation to enhance the economic autonomy of local communities and disenfranchised groups. In addition, expert consultancies like the International Partnership on Mitigation and MRV help countries like India develop MRV plans consistent with their own National Action Plan on Climate Change (NAPCC) and State Action Plans on Climate Change (SAPCC). In general, the reliance upon a bottom-up structure, such as sub-national REDD+ programs, to inform national REDD+ program design can aid the identification of future participation barriers and improve project efficacy.

MRV technical decisions must also be accompanied by cost benefit analysis. For some activities, the climate benefit of MRV may by less than the cost to monitor, serving as another technical and financial barrier. For example, emissions for land degradation have high monitoring costs and low climate/emissions benefit. Four additional concerns over GHG and carbon stock accounting include measurability, additionality, emissions leakage, and permanence. These concerns motivate the decision to exclude many types of LULUCF activities as CDM-eligible offset projects, as discussed above. While this is indeed a generic barrier to deforestation reduction initiatives, it also represents an opportunity for transferring technologies needed to monitor land-use change and carbon stocks and flows. An example of improved MRV is illustrated by Brazil's Acre state, which has witnessed a steady decline in deforestation rates and managed to protect 86% of its forest cover by employing Landsat satellite images. The local government employs higher resolution technology, which greatly increases monitoring effectiveness and lowers deforestation monitoring costs, making it an extremely viable mitigation option in Brazil.[55]

INDUSTRIAL AND MARKET BARRIERS

Market and industry barriers to LUCF abatement are largely found in carbon trading markets. The scale of the voluntary carbon market is relatively small. In 2011, 87 million tonnes of CO_2e were traded worldwide, or which only 7.7 million involved REDD+ projects - 60% less

[55] WWF, 2013.

than the volume registered in 2010.[56] The market for REDD projects collapsed by 59% in 2011 compared to the previous year (which in contrast was a record setting year that witnessed expansive, rapid growth in the REDD market) according to the 2012 Ecosystems Marketplace Report on the State of Voluntary Carbon Markets. This drop in transaction volume is mainly due to political and technical challenges as well as interest in lower priced credits.[57] There are currently few incentives for countries or the private sector to engage in carbon trading markets and to invest in REDD+ programs due to the failure to conclude a successful and legally binding GHG emission reduction agreements at the last three Conference of the Parties (COP) meetings.[58] The vast majority of the world's forests, especially in places like Brazil and DRC, remain outside the carbon accounting framework and are at best weakly incentivized in the current carbon accounting/trading framework. The plan for incorporating LULUCF into the international carbon trading system is especially underdeveloped with only the voluntary forest-based carbon market and the California Forest Protocol serving as meaningful frameworks to promote and fund REDD+ initiatives.[59]

Furthermore, the economic recession has significantly impacted REDD+ funding and negatively influenced carbon offsetting and trading markets development. As result, there is a glut in the market for carbon credits. Thus, there is even less incentive for countries to invest in carbon offsetting venues such as the CDM market.[60] In addition, the opportunity costs of not cutting forests for developing countries are high as there is a high demand for intensive agriculture (cattle grazing, etc.) and industrial activity (oil and mineral exploration, construction). The result is increased pressure on existing sinks.

RECOMMENDATIONS TO OVERCOME INDUSTRIAL AND MARKET BARRIERS

A possible remedy to these market barriers involves local level actors (governments, NGOs, etc.) partnering with the international market. An example of success is WWF's program in Indonesia's Kutai Barat Region, in which the local community and WWF engaged timber companies to reduce logging operations on the regions forest. By partnering with legal logging companies, the Indonesian government has secured 55,000 hectares of additional land for conservation, biodiversity safeguards and standards have been developed, and forest carbon stock has been certified. Logging companies have also started incorporating reduced impact logging practices.

[56] WWF, 2013.
[57] Stanley, and Hamilton, 2012.
[58] Ellison, 2012.
[59] Ibid.
[60] Ibid.

POLITICAL AND CULTURAL BARRIERS

Autonomy on the local level can also act as a barrier to preserving forests. This can be seen in Indonesia's Aceh province where the governor's plan to revise land-use regulations and rezone protected forests as "production zones." While this rezoning will pave the way for economic development and investments from the palm oil, mining and logging companies, it will make flash floods, landslides and animal habitat destruction very likely and be against the federal government policy. Aceh's case is instructive as the region has enjoyed a special autonomy after 2005 peace accord between the Indonesian government and "free Aceh" rebels.[61] This tension between the central government's and local governments' agendas can act as a powerful inhibitor to mitigation strategy implementation. Local initiatives much be driven within a strong national agenda to create successful mitigation policies.

Political and cultural barriers are perhaps most evident in LUCF abatement activities as multiple actors operate at different levels with diverse, often competing interests. Developing countries especially have low involvement in bio-sequestration activities (i.e. accounting for the capture and storage of carbon dioxide through biological processes) on the international level as they have no requirement or opportunity to account for emissions and sequestration activities in the LUCF sector. Competing demands for land use, as mentioned above, are an especially important barrier. For example, when Indonesia imposed a ban on forest and peatland conversion in accordance with its agreement with Norway, there was a rush to obtain licenses and amend spatial plans in favor of forest conversion just before the deadline. Conflicts are likely to arise and create different winners and losers in the short and medium term. Marginalized and indigenous communities who rely on forests for livelihood and survival - as is the case in much of the Amazon - are likely to lose when there are competing land-use conflicts. Policies that seek to promote forest ecosystem carbon management must do so while resolving conflicts between different land uses and making sure not to harm the poor.[62]

Political instability clearly has the ability to destroy forestry-related progress and threaten the REDD+ process, especially if there is no strong local base of technical knowledge or capacity (or if such capacities come primarily from abroad). This is clearly a factor in DRC and sub-Saharan Africa as well as in parts of the Amazon. Political instability and war has direct and indirect effects on forest preservation measures. Forests are cleared to expose hiding enemies and improve accessibility to resources. Organized forest management becomes impossible due to the destruction of governance structures and the absence of rule of law,[63] as was the case in DRC starting from the late 1990s. Even when war ends and political instability subsides, the bulk of state resources are focused on state building activities.

RECOMMENDATIONS TO OVERCOME POLITICAL AND CULTURAL BARRIERS

Successful forest protection strategies must have integrated approaches that combine national level policymaking with local level initiatives and opportunities. Bottom-up structures,

---

[61] Schonhardt, 2013.
[62] UNEP, 2013.
[63] Leal Filho, 2011.

such as sub-national REDD+ programs, could serve to inform national REDD+ program design and could help identify future participation barriers. Subnational REDD+ has to work nationally but also on the individual community and stakeholder levels. There is important knowledge at the local level that can inform decisions at the subnational or national levels. Political will, at the national level, can also drive change at the lower levels. Therefore, REDD+ must integrate both top-down and bottom-up approaches.[64]

In post-conflict developing countries, initiatives that accentuate participatory forest management can simultaneously build peace and protect vulnerable forests. Similarly, systems must be established that ensure long-term local capacity building. An example is the MRV/REDD+ certificate program developed in Peru's Madre de Dios region, which created continuity and constancy in the REDD+ process despite frequent political change and discord.[65]

DISCUSSION OF RECOMMENDATIONS

As the structure of the agricultural sector is fundamentally different from that of the forestry sector, large-scale international initiatives like REDD+ and FCPF are less likely to be effective. Success of interventions relies largely on influencing small farmer behaviors and incentivizing large industrial actors associated with the production and global supply chains of agricultural commodities. Governments can incentivize socially and environmentally responsible behavior through legislation and regulation as India has done. India's Corporate Responsibility law requires all large companies to pay 2% of annual net profits for socially responsible projects.[66] The international community can push for more transparent and sustainable sourcing practices. NGOs can target specific areas for improvement along the supply chain of global food and beverage companies, pinpointing policy weaknesses and celebrating improvements in social and environmental performance. One such effort is Oxfam's "Behind the Brands" campaign which examines the sourcing and supply chain policies of the ten largest food and beverage companies and pushes them to rethink their "business as usual."[67] The UN Global Compact, which also encourages environmental and social responsibility, could take up similar actions with respect to large actors in the international agricultural supply chain.

As noted earlier, small farmers have extremely short-term planning horizons that are susceptible to extreme environmental circumstances. As the benefits of sustainable land management practices culminate in the long-term, smallholder farmers can be incentivized to extend their planning and decision horizons through availability and access to credit, drought insurance, and increased information on weather and market volatility from the international community.

For improvement in forestry abatement continuing and increasing funding for technology transfers and MRV, including Landsat forest cover monitoring systems, at the local, regional, and national levels is critical. This can be done through existing REDD+ and FCPF protocols. This

[64] WWF, 2013.
[65] Ibid.
[66] Sustainable Business, n.d.
[67] Oxfam America, n.d.

could also increase the opportunities for private investment. As noted earlier, this strategy was employed and proved extremely successful in Brazil's Acre state. As another recommendation, expanding the CDM's mandate to apply to other LULUCF-related activities, apart from afforestation, would allow individual projects to be funded thus filling in the current gap in REDD+ (which does not currently fund individual projects).

CONCLUSION

The view that LULUCF and agriculture abatement strategies require low technology and are just a matter of behavioral changes misrepresents LULUCF as a "low hanging fruit". In truth, the issue is much more complex than simply educating farmers and rural communities to protect their forests and "grow crops properly." Market-driven forces that discourage sustainable, responsible use of land, the lack of financing and the lack of MRV practices are just a tip of the iceberg of why reductions in LULUCF greenhouse gas emissions are moving so slowly. However, no matter how you slice the pie, LULUCF and agriculture, as a contributor but also as a sink, is such an important element of reducing greenhouse gas emissions – it must be included in the national plan for many countries. The concentration of abatement potential to a select few countries and regions means that we can make great strides in these sectors, simply by focusing on a select few countries, mainly Brazil, Indonesia, the US, Russia and those in Africa (perhaps a reason for the international community to contribute to building political stability in the area) and the rest of Asia. By concentrating funding, research, governance building, technical assistance and capacity building in these countries, we might be able to achieve more than just 4.38 $GtCO_2e$.[68]

[68] per year by 2030.

APPENDIX

Abatement Potential for Agriculture

Abatement Potential for Agriculture																
	Abatement Potential (MtCO2e per year)								Cost (EUR per tCO2e)							
	2015	2020	2025	2030	2015%	2020%	2025%	2030%	2015	2020	2025	2030	2015 (Total)	2020 (Total)	2025 (Total)	2030 (Total)
South Africa	9.895	18.82	24.83	30.76	2%	2%	2%	2%	-10.53	-10.642	-10.523	-10.407	($33,989,850.00)	($33,754,700.00)	($17,812,700.00)	($1,574,900.00)
Rest of Africa	50.15	81.132	108.78	135.89	8%	8%	8%	8%	-5.7317	-6.0367	-6.0583	-6.08	$14,679,450.00	($2,214,306.00)	$75,539,475.00	$161,266,075.00
Middle East	49.41	0	0	0	8%	0%	0%	0%	0.03	0.11	0.33333	0.52833	$0.00	$0.00	$0.00	$0.00
India	16.16	34.31	38.565	42.77	3%	3%	3%	2%	-9.2533	-9.19	-8.9833	-8.785	($281,952,450.00)	($558,605,700.00)	($495,623,300.00)	($433,064,950.00)
Russia	51.905	93.155	119.15	144.98	8%	9%	8%	8%	-20.068	-20.032	-19.89	-19.763	($669,724,600.00)	($1,328,724,400.00)	($1,290,453,000.00)	($1,252,092,600.00)
China	106.83	175.1	225.82	275.88	17%	17%	16%	16%	-23.263	-23.51	-23.46	-23.41	($677,002,600.00)	($1,453,554,600.00)	($1,265,254,400.00)	($1,069,107,500.00)
United States	50.085	87.475	110.25	132.77	8%	8%	8%	7%	-39.593	-39.683	-39.357	-39.037	($1,283,341,600.00)	($2,513,296,500.00)	($2,483,467,700.00)	($2,452,502,600.00)
Rest of Eastern Europe	12.34	23.1	26.44	29.74	2%	2%	2%	2%	-16.477	-16.462	-16.318	-16.18	($256,525,600.00)	($525,789,200.00)	($516,329,400.00)	($506,811,200.00)
Rest of developing Asia	118.75	215.47	307.8	399.75	19%	21%	21%	23%	-13.81	-14.198	-14.28	-14.365	$219,193,350.00	$387,795,250.00	$702,891,600.00	$1,019,742,250.00
Brazil	15.315	38.985	64.09	77.155	2%	4%	4%	4%	-22.863	-23.257	-23.482	-23.713	($96,202,700.00)	($205,314,600.00)	($270,251,350.00)	($349,403,150.00)
Rest of Latin America	20.68	53.405	89.39	107.89	3%	5%	6%	6%	-25.655	-25.63	-25.492	-25.357	($93,246,900.00)	($218,585,450.00)	($276,535,250.00)	($345,818,300.00)
Canada	6.14	11.46	13.13	14.785	1%	1%	1%	1%	-19.358	-18.672	-18.105	-17.578	($149,847,300.00)	($292,950,400.00)	($272,275,800.00)	($253,910,500.00)
Rest of OECD Pacific	38.685	60.13	79.375	98.36	6%	6%	6%	6%	-6.6283	-6.1517	-5.8283	-5.5167	$35,956,300.00	$27,869,600.00	$100,412,300.00	$171,162,650.00
Mexico	6.11	19.56	31.515	39.42	1%	2%	2%	2%	-13.937	-14.327	-14.29	-14.253	($85,568,300.00)	($113,981,900.00)	($143,353,250.00)	($177,544,500.00)
Rest of EU27	38.145	72.995	103.1	133.12	6%	7%	7%	7%	-16.35	-16.34	-16.203	-16.072	$42,015,250.00	$86,180,450.00	$281,231,500.00	$477,373,100.00
Rest of OECD Europe	5.17	8.88	10.27	11.61	1%	1%	1%	1%	-18.423	-18.295	-18.273	-18.252	($103,177,000.00)	($206,823,400.00)	($201,159,200.00)	($194,341,400.00)
France	12.72	22.34	30.8	39.235	2%	2%	2%	2%	-31.853	-31.857	-31.867	-31.877	$25,004,800.00	$37,966,200.00	$88,983,400.00	$139,816,000.00
Germany	7.235	14.055	20.16	26.24	1%	1%	1%	1%	-31.79	-31.8	-31.817	-31.832	$14,130,600.00	$31,878,500.00	$71,847,300.00	$112,718,400.00
Italy	1.87	3.39	4.07	4.73	0%	0%	0%	0%	-32.74	-32.742	-32.752	-32.762	($21,116,800.00)	($41,292,700.00)	($34,996,500.00)	($28,759,700.00)
Japan	0.3	0.62	0.66	0.7	0%	0%	0%	0%	-41.683	-41.475	-41.132	-40.797	($30,945,000.00)	($65,253,000.00)	($62,754,800.00)	($61,811,600.00)
United Kingdom	8.57	16.15	23.45	30.75	1%	2%	2%	2%	-31.935	-31.938	-31.95	-31.96	$17,145,800.00	$41,519,700.00	$75,126,700.00	$108,703,300.00
Total MtCO2e)	626.46	1050.5	1431.6	1776.5									€ (3,414,515,150)	€ (6,946,931,156)	€ (5,934,234,375)	€ (4,935,961,125)

Forestry Abatement Potential

Forestry Abatement Potential																
	Abatement Potential (MtCO2e per year)								Cost (EUR per tCO2e)							
Region	2015	2020	2025	2030	2015%	2020%	2025%	2030%	2015	2020	2025	2030	2015 (Total)	2020 (Total)	2025 (Total)	2030 (Total)
South Africa	79.15	158.3	237.36	237.36	8%	8%	10%	9%	21.945	21.945	21.945	21.945	$1,465,990,600	$2,925,488,900	$4,382,564,700	$4,382,564,700
Rest of Africa	87.485	164.48	192.13	248.98	9%	9%	8%	10%	9.12	9.12	9.12	9.12	$1,270,819,325	$2,147,971,350	$2,405,786,300	$2,980,930,575
Middle East	96.773	0	0	0	10%	0%	0%	0%	29.5767	29.5767	29.5767	29.5767	$0	$0	$0	$0
India	**21.53**	**38.82**	**56.11**	**73.4**	2%	2%	2%	3%	**11.21**	**11.21**	**11.21**	**11.21**	**$206,768,800**	**$354,771,200**	**$502,773,600**	**$650,776,000**
Russia	8.01	16.023	19.813	19.915	1%	1%	1%	1%	25.16	25.16	25.16	25.16	$118,539,100	$237,150,625	$305,640,525	$330,439,450
China	**25.105**	**41.275**	**57.455**	**73.625**	2%	2%	2%	3%	**14.76**	**14.76**	**14.76**	**14.76**	**$338,410,150**	**$505,446,250**	**$672,585,650**	**$839,621,750**
United States	**9.39**	**18.77**	**28.16**	**34.17**	1%	1%	1%	1%	**7.7**	**7.7**	**7.7**	**7.7**	**$144,606,000**	**$289,058,000**	**$433,664,000**	**$526,218,000**
Rest of Eastern Europe	8.85	17.685	25.96	34.14	1%	1%	1%	1%	20.43	20.43	20.43	20.43	$211,076,100	$421,825,650	$623,466,000	$823,467,000
Rest of developing Asia	344.46	748.35	876.47	938.22	34%	39%	37%	36%	9.60375	9.60375	9.60375	9.60375	$4,142,672,900	$9,087,966,525	$10,483,745,825	$11,015,007,625
Brazil	**199.81**	**448.12**	**502.01**	**507.3**	20%	23%	21%	19%	**6.52375**	**6.52375**	**6.52375**	**6.52375**	**$453,749,475**	**$1,306,640,475**	**$1,492,411,950**	**$1,544,752,325**
Rest of Latin America	53.238	118.11	175.2	182.03	5%	6%	7%	7%	9.35125	9.35125	9.35125	9.35125	$207,328,050	$439,688,150	$655,198,950	$763,596,425
Canada	1.0925	2.1975	3.29	4.395	0%	0%	0%	0%	20.1933	20.1933	20.1933	20.1933	$32,685,650	$65,639,150	$98,324,800	$131,278,300
Rest of OECD Pacific	17.163	34.315	51.478	68.64	2%	2%	2%	3%	21.3667	21.3667	21.3667	21.3667	$253,762,350	$507,376,800	$761,139,150	$1,014,901,500
Mexico	6.3975	13.665	17.483	19.565	1%	1%	1%	1%	15.3375	15.3375	15.3375	15.3375	$85,257,700	$172,962,080	$250,449,570	$303,428,545
Rest of EU27	10.91	18.75	24.38	24.38	1%	1%	1%	1%	10.54	10.54	10.54	10.54	$115,455,500	$199,197,900	$259,720,400	$259,720,400
Rest of OECD Europe	8.97	16.3	22.77	29.25	1%	1%	1%	1%	10.54	10.54	10.54	10.54	$93,710,100	$169,790,200	$236,625,300	$303,563,700
France	5.16	9.31	12.71	16.11	1%	0%	1%	1%	13.26	13.26	13.26	13.26	$72,538,000	$134,218,500	$187,836,500	$241,454,500
Germany	5.43	9.06	12.7	16.33	1%	0%	1%	1%	17.6	17.6	17.6	17.6	$108,240,500	$196,994,000	$285,992,000	$374,745,500
Italy	5.51	9.42	10.8	10.8	1%	0%	0%	0%	10.54	10.54	10.54	10.54	$57,594,500	$97,984,800	$112,240,200	$112,240,200
Japan	15.38	27.93	40.14	52.36	2%	1%	2%	2%	10.455	10.455	10.455	10.455	$143,667,100	$252,345,800	$356,863,400	$461,466,600
United Kingdom	4.54	8.62	12.7	16.78	0%	0%	1%	1%	11.305	11.305	11.305	11.305	$53,333,800	$101,722,600	$150,111,400	$198,500,200
Total MtCO2e)	**1014.4**	**1919.5**	**2379.1**	**2607.7**									**€ 9,576,205,700**	**€ 19,614,238,955**	**€ 24,657,140,220**	**€ 27,258,673,295**
Indonesia*	**141.87**	**309.04**	**360.44**	**383.86**	**14%**	**16%**	**15%**	**15%**	**9.60375**	**9.60375**	**9.60375**	**9.60375**	**€ 1,584,528,630**	**€ 3,475,970,510**	**€ 4,010,009,954**	**€ 4,213,412,817**

REFERENCES

Agricultural Economy and Policy Report - BRAZIL." *United States Department of Agriculture Foreign Services*. N.p., Feb. 2009. Web. http://www.fas.usda.gov/country/Brazil/Brazil%20Agricultural%20Economy%20and%20Policy.pdf

Brazil Low Carbon Case Study - Mitigating Climate Change through Development." *The World Bank Energy Sector Management Assistance Program*. N.p., n.d. Web. <http://sdwebx.worldbank.org/climateportalb/doc/ESMAP/FINAL_LCCGP_Brazil.pdf>.

"Building REDD+ for People and Nature: From Lessons Learned across Indonesia, Peru and the Democratic Republic of Congo to a New Vision for REDD+." *WWF Forest and Climate Programme*. WWF International Report 2013, 2013. Web.

Clay, Jason. "Are Agricultural Subsidies Causing More Harm than Good?" *Theguardian.com*. Guardian News and Media, 08 Aug. 2013. Web. 17 Dec. 2013. <http://www.theguardian.com/sustainable-business/agricultural-subsidies-reform-government-support>.

Ellison, David et al. "The Incentive Gap: LULUCF and the Kyoto Mechanism Before and After Durban." *Global Change Biology Bioenergy*. Vol. 5. Pg. 599-622., Oct. 16, 2012.

Ellison, David. "On the Future of REDD and the Carbon Market, by David Ellison | ERC Blogs." *ERC Blogs*. N.p., 7 Nov. 2012. Web. 17 Dec. 2013. http://www.ercblogs.co.za/2012/future-of-redd-carbon-market/

Erda, Linda."Opportunities for GHG Mitigation in Agricultural Systems and the Technology Transfer," Agro-Environment & Sustainable Development Institute

"Environmental Services Incentives System in State of Acre, Brazil." *WWF : Brazil Report 2013*. N.p., n.d. Web. http://awsassets.panda.org/downloads/acre_brazil_sisa_report___english_10_13.pdf

Food and Agriculture Organization of the United Nations, FAOSTAT database (FAOSTAT, 2008), available at http://faostat.fao.org/site/362/DesktopDefault.aspx?PageID=362

Gartlan, Kieran. "The Global Power of Brazilian Agribusiness." The Economist Intelligence Unit. N.p., Nov. 2010. Web. 04 Feb. 2014. <http://www.redd-monitor.org/2013/05/15/indonesias-president-extends-forest-moratorium-for-two-more-years/>.

Grieg-Gran, M., 2004: Making environmental service payments work for the poor: some experiences from Latin America. International Fund for Agricultural Development Governing Council Side Event. <www.ifad.org/events/gc/27/side/presentation/ieed.ppt> accessed 1 September 2005.

Indonesia Second National Communication Under the UNFCCC," January 2011. http://unfccc.int/resource/docs/natc/indonc2.pdf

Indonesia's President Extends Forest Moratorium for Two More Years." Redd Monitor. N.p., 15 May 2013. Web. 04 Feb. 2014.

IPCC Fourth Assessment Report: Climate Change 2007 - Working Group III: Mitigation of Climate Change

Lang, Chris. "Norway and Indonesia Sign US$1 Billion Forest Deal." REDDmonitor. N.p., 27 May 2010. Web. 17 Dec. 2013. <http://www.redd-monitor.org/2010/05/27/norway-and-indonesia-sign-us1-billion-forest-deal/>.

Leal Filho, Walter, ed. *Experiences of Climate Change Adaptation in Africa*. Springer, 2011.

"OECD Calls on Indonesia to Reform Agricultural Policy." *The Jakarta Post*. N.p., 11 Oct. 2012. Web. 17 Dec. 2013. <http://www.thejakartapost.com/news/2012/10/11/oecd-calls-indonesia-reform-agricultural-policy.html>.

"Rapid Growth of Selected Asian Economies - Lessons and Implications for Agriculture and Food Security." *FAO Regional Office for Asia and the Pacific*. Policy Assistance Series 1/1, n.d. Web. <ftp://ftp.fao.org/docrep/fao/009/ag087e/ag087e00.pdf>.

Renkow, M. and Byerlee, D. 2010. The impacts of CGIAR research: A review of recent evidence. Food Policy, 35 (5):391-402

Schlamadinger, Bernhard, et al. "A synopsis of land use, land-use change and forestry (LULUCF) under the Kyoto Protocol and Marrakech Accords." Environmental Science & Policy 10.4 (2007): 271-282.

Shah, Tushaar. "Water Energy and Agriculture Nexus in India." International Water Management Institute. 2012.

Tacconi, L., M. Boscolo, and D. Brack, 2003: National and international policies to control illegal forest activities. Center for International Forest Research, Jakarta.

Wunder, S., 2004: Policy options for stabilising the forest frontier: A global perspective. In *Land Use, Nature Conservation and the Stability of Rainforest Margins in Southeast Asia,*M. Gerold, M. Fremerey, and E. Guhardja (eds). Springer-Verlag Berlin, pp. 3-25.

Rapid Response Assessments." *Opportunities and Challenges*. GRID Ardenal - A Centre Collaborating with UNEP, n.d. Web. 17 Dec. 2013. <http://www.grida.no/publications/rr/natural-fix/page/3728.aspx>.