



How Agroforestry Propels Achievement of Nationally Determined Contributions

Summary

Nationally Determined Contributions (NDCs) have emerged as the main tool for defining, communicating and potentially reporting party contributions to the Paris Agreement on climate change. Agroforestry has been identified as a key part of most developing country NDCs, hence it is a potentially important contributor to global climate objectives. This policy brief seeks to explore the degree to which agroforestry is represented in current NDCs ambitions, how its application is envisaged and how its contribution could be enhanced.

Key Messages

- Agroforestry is one of the land uses with most potential to fulfill commitments set out in NDCs and reduce emissions from agriculture; estimates of its potential to sequester vary widely, between 1.1–34.2 Pg C¹ globally.
- Over 85% of the 22 NDCs assessed mentioned agroforestry as a strategy for achieving unconditional NDCs commitments.
- By converting 25% of deforested areas to agroforestry, about 80% of the non-annex I countries could achieve their unconditional commitments.
- The widespread use of agroforestry (about one billion hectares) and the familiarity of smallholder farmers and local practitioners makes it a potential low-hanging fruit for achieving NDCs commitments, emission reduction in agriculture and resilience.
- However, there are financial, policy and technology challenges that should be addressed including land and tree tenure and carbon rights in some countries, potential impacts of climate change on the growing niches of tree species, and limited sources of quality germplasm.

Policy Implications

- Increased investments in tree planting material infrastructure and agroforestry knowledge systems are necessary to overcome current market deficiencies and technical knowledge shortfalls;
- Innovative blended financing mechanisms – including blending mitigation and adaptation finance, and impact investments, could facilitate rapid transformation through the effective implementation of agroforestry practices;
- Devising policy instruments that clarify tree tenure and carbon rights are fundamental to motivate local actors to implement agroforestry;
- Research should continue to provide technical and policy guidance on a number of issues needed for the advancement of agroforestry in NDCs, including, among others, domestication of potential tree species, improved germplasm, potential impacts of climate change on the growing niches of tree species and more;
- Capacity building and dynamic partnerships would be needed to overcome technological and investment challenges.

¹ Pg C = 10¹⁵ gm; 1 gm C = 3.67 gm CO₂eq

Introduction

Since the Paris Agreement of 2015, Nationally Determined Contributions (NDCs) represent the main instrument for defining, communicating and potentially reporting contributions of countries to long-term climate goals of the UNFCCC. The NDCs represent a process of prioritization in which countries consider options and possible scope for contributing to global climate mitigation objectives and increasingly, adaptation objectives beyond 2020. NDCs cover most of the possible emission reduction pathways and sectors from energy, transport, industry, through land use and land use changes including agriculture and forestry among others. Depending on the circumstances, mainly the sources of emissions and opportunities for emission reduction and resources, countries choose and prioritize different sectors. Most parties to the UNFCCC have already submitted NDCs.

Agricultural emissions in 2011 were estimated to be over five million tons of GHG, accounting for almost 13% of global emissions (Tubiello et al 2014). Agricultural emissions are growing rapidly in developing countries and a large portion of this emission comes from use of chemical fertilizers and unsustainable land use practices. Therefore, developing countries NDCs tend to prioritize agriculture and forestry or land use and land use change in general.

Agroforestry has been identified as a key strategic dimension of many developing countries NDCs, hence a potentially significant contributor to global climate change objectives. Agroforestry, defined as the integration of trees into farms and their management in agricultural landscapes, can help in emission reduction and carbon neutrality in agriculture in several ways. First, through carbon sequestration as trees grow; second, by substituting conventional fertilizer (a source of N_2O) through nitrogen fixation and soil fertility enhancement. Indirectly, agroforestry could help reduce emissions from adjacent forests as a sustainable intensification option – avoided deforestation; and by providing on-farm timber and tree products – avoided degradation (Minang et al 2014, Mbow et al 2014).

This policy brief explores the degree to which agroforestry is represented in current NDCs ambitions, how its application is envisaged and how its contribution could be enhanced. Twenty-two (22) developing countries NDCs were reviewed. Key findings are presented in the ensuing sections, closing with policy recommendations for enhancing the potential of agroforestry to contribute to long-term climate change goals.

Methods

The analysis focused on developing countries, classified in the UNFCCC as non-annex I countries. Twenty-two (22) non-annex I countries, who submitted their commitments

in the form of NDCs were selected based on how clearly the NDCs presented the emission targets, business as usual (BAU) projected emission amount at target year, and the commitments to emission reduction based on the BAU emission scenario. The following countries were used in this analysis: Indonesia, Peru, Botswana, Brazil, Costa Rica, Jamaica, Vietnam, Central African Republic (CAR), Namibia, Argentina, Ghana, Kenya, Ethiopia, Togo, Tunisia, Djibouti, Uganda, Malawi, Burkina Faso, Chad, Zambia and Niger. The NDCs were downloaded from the UNFCCC site where the commitments are hosted – <http://www4.unfccc.int/ndcregistry/Pages/All.aspx>. It is important to note that this analysis does not take into account progress made since submission. Data on the extent of deforestation was obtained from FAO (2015) specifically from Forest Resources Assessment 2015.

The computation of agroforestry's contribution to NDCs was done by adopting the following assumptions. First, most agroforestry land uses are traditional practices familiar to the local actors and were often mentioned in the unconditional commitment as practices where no external support is critically needed. Second, unconditional commitments were considered more realistic and achievable and less dependent on often unpredictable external resources. Hence, our analysis focused on unconditional commitments only.

Equation 1 was used to compute the NDCs contribution of agroforestry.

Equ. 1: Agroforestry carbon stock = Carbon density * Conversion rate * Deforested area (2000-2015) * NDCs commitment period

Annual carbon increments of agroforestry = $3.3 \text{ t ha}^{-1} \text{ yr}^{-1}$
(Palm et al 2000)

Conversion rate = 25%, 50% or 100% of the deforested area
NDCs commitment period = Target year - base year

Agroforestry for Achieving Emission Reduction at Global Level

Despite varying estimates of the area under agroforestry, there seems to be consensus among the different sources that there is close to a billion ha of land covered by agroforestry practices (Table 1). The estimate of carbon stock from this practice is in the range of 1.1–3.3 Pg C. A recent analysis by Zomer et al (2016), however, put the estimate higher. The authors estimated biomass carbon of 45.3 Pg C on agricultural land in 2010, of which approximately 34.2 Pg C (75%) was contributed by tree components in

the agricultural systems. Table 1 summarizes the different estimates of carbon sequestration potential in agroforestry.

Table 1: Area estimates of agroforestry and its carbon sequestration potential

Source	Estimated area of agroforestry	Estimated carbon stock
Zomer et al (2016)*; Zomer et al (2014)*; Nair et al (2010)	Over 1 billion ha	3.3 Pg C**
IPCC (Watson et al 2000)	400 million ha	2.78 Pg C
	630 million ha (potentially suitable area)	0.012 Pg C***
Albrecht and Kandji (2003)	585-1215 million ha	1.1-2.2 Pg C

Note: * These sources refer to agroforestry as agricultural lands with at least 10% tree cover. ** We used $3.3 \text{ t ha}^{-1} \text{ yr}^{-1}$ average carbon stock value for agroforestry (Palm et al 2000). *** The value is estimated assuming a third of the 630Mha could be converted to agroforestry especially in developing countries.

Gibbs et al (2010) found that more than 80% of the new croplands created in the tropics between 1980– 2000 came at the expense of clearing intact and disturbed forests. West et al (2010) estimated that with every ton of crop yield produced annually per ha in the tropics, close to 77 t C ha^{-1} is lost. With an average crop yield of 1.7 t ha^{-1} , the associated carbon loss is $120.3 \text{ t C ha}^{-1}$. Hence, it is imperative to find means of reducing the emissions or creating offsetting mechanisms to reduce the system level GHG emissions. Agroforestry plays a crucial role in achieving this. [Smith et al \(2008\)](#) listed agroforestry as one of the key strategies to mitigate emissions from agriculture. Trees in the form of agroforestry practices could offset such emissions from within the landscape.

Combining results from Sanchez (2000) of 57 t C ha^{-1} sequestration from agroforestry when it is established in deforested areas and the $120.3 \text{ t C ha}^{-1}$ loss described in [West et al \(2010\)](#), agroforestry cuts emission from agriculture by almost half (47%). On the other hand, Watson et al (2000) estimated that by improving tree management on croplands, it is possible to gain $0.08\text{--}0.33 \text{ t C ha}^{-1} \text{ yr}^{-1}$ with an average value of $0.22 \text{ t C ha}^{-1} \text{ yr}^{-1}$ for non-annex I countries considering the policy and institutional challenges. Figure 1 presents results of the emission reduction potential using a scenario where improved tree management is practiced on croplands.

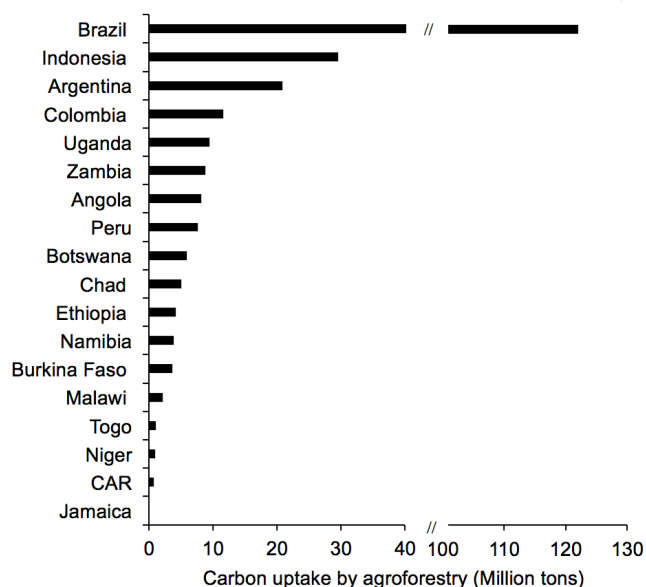


Figure 1: Potential amount of carbon sequestered by agroforestry if implemented as an improvement in cropland systems in 80% of the deforested area during the NDCs commitment period



A shaded cocoa agroforestry system established after selective cutting of forests

Agroforestry's Contribution to Achieving NDCs Targets

An in-depth look at the NDCs of selected countries revealed that agroforestry is included among key strategies towards achieving NDCs unconditional targets. Except for two countries, the remaining 20 prioritized agroforestry as an

intervention in NDCs. The dominance of agroforestry in NDCs is very high in sub-Saharan Africa (Figure 2), which may not necessarily mean they implement more agroforestry practices compared to other countries.

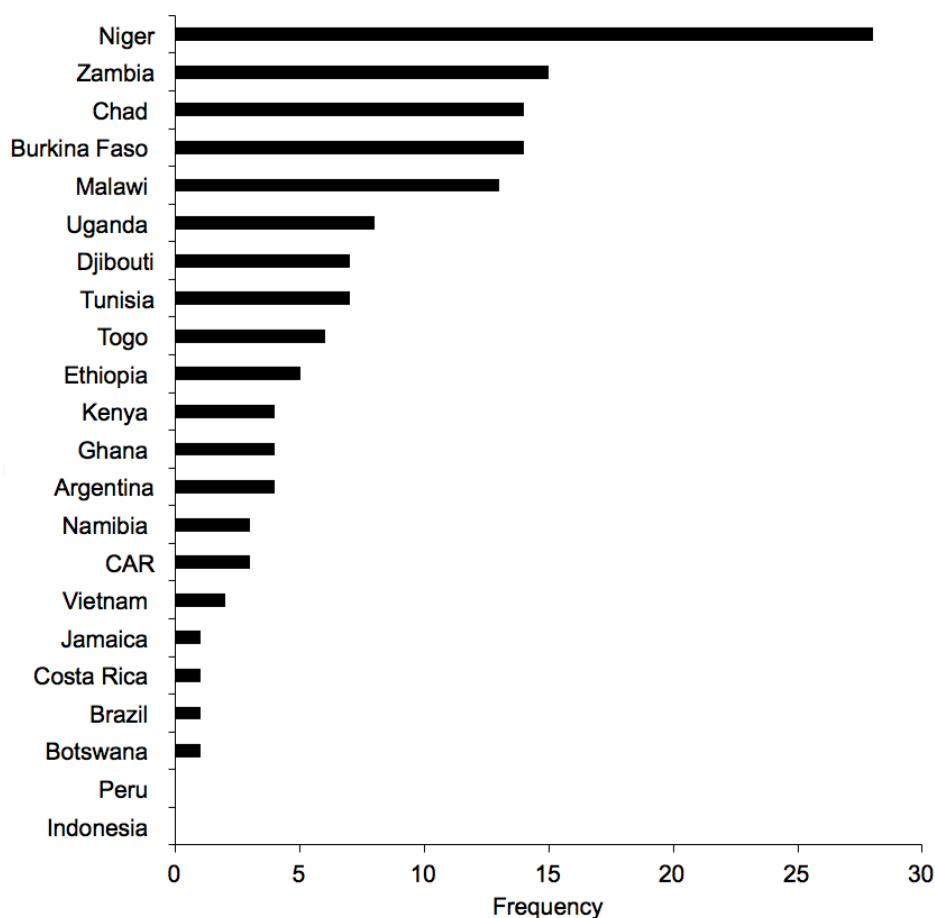


Figure 2: Frequency of the word 'agroforestry' and its synonyms in NDCs of selected countries

Table 2 presents the contribution of agroforestry to NDCs targets under different conversion scenarios of deforested areas. More than 80% (12 out of 15) of the countries that experienced deforestation between 2000-2015 could meet their unconditional NDCs targets by converting 25% of the deforested lands to agroforestry. Such action enables countries to meet multiple policy objectives at global, national and local level such as the Bonn Challenge commitments, the REDD+ objectives and other SDG targets.



A shaded coffee agroforestry in Cameroon

Table 2: Agroforestry potentials to achieve NDCs targets under different scenarios

Country	Amount of emissions to be reduced at target year (Gt CO ₂ eq)	Forest cover loss 2000-2015 (1000 ha)	Sequestration potential (Gt CO ₂ eq) achievable by agroforestry establishment		
			Scenario 1: using 25% of the 2000-2015 deforested areas	Scenario 2: Using 50% of the 2000-2015 deforested areas	Scenario 3: Using 100% of the 2000-2015 deforested areas
Argentina	0.1090	4,748	0.359	0.719	1.438
Brazil	0.9030	27,736	2.099	4.199	8.398
Burkina Faso	0.0078	898	0.063	0.125	0.250
Central African Republic	0.0055	234	0.014	0.028	0.057
Chad	0.0417	1,451	0.088	0.176	0.351
Ethiopia	0.2550	1,206	0.073*	0.146*	0.292
Indonesia	0.8340	8,399	0.509*	1.017	2.034
Jamaica	0.0011	6	0.000*	0.001*	0.002
Malawi	0.0048	420	0.038	0.076	0.153
Namibia	0.0020	1,113	0.067	0.135	0.270
Niger	0.0034	186	0.017	0.034	0.068
Peru	0.0597	2,174	0.132	0.263	0.527
Togo	0.0043	298	0.018	0.036	0.072
Uganda	0.0170	1,792	0.163	0.326	0.651
Zambia	0.0200	2,499	0.151	0.303	0.605

Note: * denotes cases where conversion of deforested areas may not be sufficient to meet the NDCs commitment.

Adaptation/Resilience and Livelihood Benefits of Agroforestry

Besides the enormous emission reduction potentials of the scheme described above, agroforestry practices are directly linked to the livelihood of 12–16% of the global population. Leakey and Sanchez (1997) estimated that close to 1.2 billion people (16% of the current global population) directly depend on the products and services of agroforestry. Zomer et al (2014) estimated that the area under agroforestry systems between 2008–2010 is directly linked to livelihoods of about 900 million people (12% of the global population). There are very few interventions that support such proportions of global population while also mitigating emissions emanating from human activities.

Implementation of agroforestry can help systems adapt to greater climate variability by increasing structural and temporal diversity of the production system and therefore increasing capacity for supporting various ecological and production services that impart resilience to climate change impacts (Verchot et al 2007). By altering the microclimate, agroforestry practices can promote resilience to shifting temperature, precipitation variation as well as strong winds associated with storms and therefore produce more favourable conditions for crops, forage and livestock production (Schoeneberger 2009). For instance, in coffee

agroforestry systems, it was proven that crops grown under heavy shade (60–80%) were kept 2–3°C cooler during the hottest times of the day than crops under light shading (10–30%) (Lin 2007) and lost 41% less water through soil evaporation and 32% less water through plant transpiration (Lin 2010).

Agroforestry also provides greater habitat diversity to support organisms (e.g., native pollinators, beneficial insects) (Schoeneberger et al 2012) as well as naturally occurring co-benefits such as enhanced nutrient cycling, integrated pest management, and increased resistance to diseases, which will additionally protect farm production (Jose 2009). It also offers greater economic stability and reduced risk to smallholder farmers vulnerable to the effects of climate change by improving production and creating more diversified enterprises with greater income distribution over time (e.g. short-term (forage and/or livestock) versus long-term (timber) income sources in a silvopastoral system). Kristjanson et al (2012), in a study that involved about 700 households in East Africa, found that at least 50% of those households had begun planting trees on their farms to adapt to the impacts of climate change.

Recommendations for Realizing Agroforestry Contributions in NDCs

Despite tremendous potential of agroforestry described, quantified and qualified above, several challenges remain. We present options for mitigating these challenges as espoused in the literature.

Increased investments in tree germplasm supply systems and knowledge systems for agroforestry are crucial

Smallholders experience difficulties in accessing – at the right time, in the right quantities and of high quality – the trees that they want to plant. Therefore, increased investments in planting material infrastructure are necessary to meet demand for planting materials now and in the future. Training on seedling and germplasm management as well as supply of the planting materials are key to promote adoption of agroforestry. Knowing the right tree for the right place and for the right purpose as well as recognizing good quality planting material represent a set of examples of the knowledge demands of agroforestry. The World Agroforestry Centre (ICRAF) has tools that can help determine the right trees for the right place in terms of agro-ecology (www.vegetationmap4africa.org).

Innovative blended financing mechanisms – including blending mitigation and adaptation finance, and impact investments, could facilitate rapid transformation through the effective implementation of agroforestry practices

Agroforestry takes on average 3–5 years before production and delivering benefits, therefore farmers need financing and technical support during the early phases. Blended finance or a co-investment approach is needed in order to achieve results at scale. This involves looking at multiple sources (government, multi- and bilateral donors, private sector, philanthropic capital, communities, etc.), multiple streams (both mitigation and adaptation) and different finance instruments (e.g. grants, government investment, philanthropic capital, money from Corporate Social Responsibility and other emerging innovations for financing green initiatives (e.g. Green Bonds)). Innovative blended financing also comes with the growing need for a robust accounting and accountability system with reliable data and good transparency.

Devising policy instruments that clarify land and tree tenure and carbon rights is fundamental to motivate local actors to implement agroforestry within their routine agricultural activities, which then contributes to achievements of the NDCs

There is evidence that non-financial incentives emerge as better stimuli of change in landscapes with sustainable benefits. When local actors are recognized as resource right owners, they are better incentivized to sustainably manage the forest areas. For instance, in Ba Be and Na Ri Districts, Bac Kan Province, Viet Nam, the establishment of long-term Land Use Right Certificates (LURC) and community forest management on previously “unmanaged” forest was a key successful incentive for people to adopt agroforestry on sloping land, replace maize mono-cropping and restore encroached forests. In TanJaBar Province, Indonesia, the development of a community forestry license providing conditional land rights to the communities that managed and cultivated in those peatlands areas, had significant impact as local actors took it as a solution to address land conflicts and mitigate further land degradation in the peatland area.

Research should continue to provide technical and policy guidance on several issues needed for the advancement of agroforestry in NDCs, including among others – domestication of potential tree species, improved germplasm, potential impacts of climate change on the growing niches of tree species and more

Agroforestry provides positive climate change adaptation services. However, this could also be affected by weather variability and climate change conditions. Since agroforestry systems require a few years to become established and fully functional, this is of concern. More research is therefore needed on climate change-adapted planting materials and understanding which agroforestry species may be more suited to future conditions in various field conditions that agroforestry could be implemented in.

Capacity building and dynamic partnerships would be needed to overcome technological and investment challenges

The investments required in early phases of agroforestry and in developing the necessary infrastructure for measurement, reporting and verification of the contributions of agroforestry

to NDCs necessitates a different way of working in order to succeed. One that is inherently cross-sectoral given that agroforestry is neither forestry nor agriculture. It also calls for co-investments from public, private and civil society to enable it work. Stakeholders need to work towards these innovative approaches for agroforestry to fulfil its major potential contribution to NDCs’.



A private nursery for cocoa seedling production in Cameroon

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² Some in-text references are hyperlinked and not shown here.

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Authors: Lalisa A Duguma, Judith Nzyoka, Peter A Minang and Florence Bernard

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World Agroforestry Centre,
United Nations Avenue, Gigiri
PO Box 30677-00100, Nairobi, Kenya.
Phone: + (254) 20 7224000,
Fax: +(254) 20 722 4001.
Via USA phone (1-650) 833-6645,
Via USA fax (1-650) 833-6646



Email: worldagroforestry@cgiar.org
Website: www.worldagroforestry.org



Email: asb@cgiar.org
Website: www.asb.cgiar.org



Website: foreststreesagroforestry.org