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Forestry-based carbon sequestration projects in Africa: Potential benefits and challenges

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Abstract

Carbon sequestration through forestry and agroforestry can help mitigate global warming. For Africa, carbon sequestration also represents an opportunity to fund sustainable development through financial inflows. However, with a low share of global carbon trade, there are strong concerns that African countries are losing out on this valuable opportunity. Through a comprehensive review of 23 carbon sequestration projects across 14 countries, this paper discusses ways to overcome critical challenges to scale up carbon investments in Africa. These projects are expected to sequester 26.85 million tCO_2 beyond the baseline situation. Within the continent, East Africa is the preferred destination for carbon investors. Most projects are non-Kyoto compliant and represent voluntary emission reductions. While project benefits such as increased local incomes and improved natural resources are promising, there are concerns that conversion of grasslands into tree plantations can harm local ecosystems. Insecure land tenure constrains new investments and increases the risk that local communities will lose access to forests. Another challenge is that projects with smallholders have high transaction costs. These costs can be overcome by building strong community institutions and simplifying project guidelines. To attract more projects, African governments will need to build their capacity to identify relevant opportunities.

Keywords: Africa; Carbon sequestration; CDM; Forestry; Carbon markets; Sustainable development.

1. Introduction

This paper reviews forestry-based carbon sequestration projects in Africa and identifies ways to scale up these initiatives in the region to enhance local people's livelihoods. Recent attempts to mitigate global warming have brought this non-geological form of carbon storage into sharp focus as many land use practices such as forestry have the potential to absorb (or sequester) carbon dioxide (CO_2) from the atmosphere. The Ecosystem Marketplace estimates that over the last decade, more than 880,000 hectares of forest and agricultural land have been brought under carbon sequestration, yielding carbon offsets or credits[1] worth US$92 million.[2] Many of these offsets are being traded in voluntary emission reduction markets while a small number are financed through the Clean Development Mechanism (CDM). The Kyoto Protocol introduced the CDM as one of three market mechanisms (the other two being Joint Implementation and Emissions Trading) to make climate change mitigation more cost-effective. The CDM opens up ways for industrialized countries to cut emissions or enhance carbon storage more cheaply abroad than at home. For instance, it allows them to offset a small portion of their carbon emissions through forestry projects in developing countries. Eligible activities include afforestation (establishment of forests on lands previously unforested) and reforestation (establishment of forests on lands previously forested, but deforested as of December 1989). Under the CDM, industrialized countries can invest in these carbon sequestering activities in developing countries in return for carbon offsets that count against emission reduction targets specified by the Kyoto Protocol (UNEP, 2002). Investments in the form of carbon sequestration projects thus represent valuable financial inflows for developing countries. Experience also suggests that, if undertaken with small land holders, carbon sequestration projects can help alleviate rural poverty and improve local livelihoods in developing countries (Tipper, 2002). Carbon sequestration projects may thus provide a win–win situation between environmental conservation and

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[1] Each offset or carbon credit is equal to one ton of CO_2 (tCO_2) that forests absorb from the atmosphere.

[2] www.ecosystemmarketplace.com accessed on 21 March 2008.

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increased opportunities for economic development in poor countries (UNEP, 2002).

Amidst this growing interest in forest-based carbon sequestration, there are concerns that carbon investments are unequally distributed (Capoor and Ambrosi, 2006). For instance, out of the 13 afforestation and reforestation CDM projects[3] that have either been registered or are in the pipeline, only two are based in Africa while all others are located in Asia or Latin America (UNEP, 2008). Similarly, many of the voluntary carbon sequestration initiatives are based in Latin America and Asia. In general, fewer forestry-based carbon projects have been located in Africa than in other developing regions of the world (Nanasta, 2007). During the 2007 climate change negotiations in Bali, the United Nations Framework Convention on Climate Change (UNFCCC) Secretariat expressed serious concern about the relatively low levels of carbon offset investments in Africa and the need to initiate more projects in the region.[4] As the international community moves towards a post-Kyoto agreement on carbon emissions, the UNFCCC has asked policy makers and researchers to explore ways in which African countries can enhance their role in climate change mitigation by receiving a larger share of carbon projects. Given that many African countries are among the poorest in the world, financial inflows through such projects could also have greater economic significance for them than for many of the better-off countries in Asia or Latin America.

There is a lack of relevant literature that reviews the experience with forestry-based carbon sequestration in Africa. While there has been some case study research on specific projects, a more comprehensive discussion is usually absent. This paper attempts to fill this gap through a regional synthesis of carbon sequestration projects in Africa. It considers the potential benefits from carbon sequestration projects and examines challenges that the region must address to scale up carbon investments and ensure that those projects have favourable local impacts. The paper considers both demand and supply side factors that can help in locating more carbon sequestration projects in the region. It also explores the potential for linking forestry projects in the region with alternative carbon markets such as the Chicago Climate Exchange. The paper is therefore targeted at policy makers both within and outside Africa as well as researchers who work on climate change issues.

2. Status of carbon sequestration projects in Africa

This paper reviews 23 carbon sequestration projects in 14 countries across Africa (Table 1). It includes most existing projects or projects that have already been approved by respective donors. It excludes projects still in the planning stage.

2.1. Data on carbon projects

Details of carbon projects in Africa were collected from a wide range of sources — the authors' own field research with local communities in Kenya and Mozambique, secondary sources such as case studies, and international policy updates (Capoor and Ambrosi, 2006; FAO, 2004). In the absence of published literature, websites of international donors such as the World Bank, Global Environment Facility (GEF), and FACE Foundation were useful in collecting data on their carbon sequestration investments in Africa. Wherever possible, data were verified by accessing information from multiple sources. CDM-specific information was obtained from the United Nations Environment Programme's (UNEP) Risoe Centre, which maintains an online database of projects at different stages of approval by the CDM's Executive Board (http://cdmpipeline.org/). The carbon market is growing so rapidly that there are significant developments each month. Therefore, research institutes that keep a tab on these markets, such as the Ecosystem Marketplace (www.ecosystemmarketplace.com), are an important source of updated information. Finally, recent publications of Forest Trends and the International Institute for Environment and Development provided useful insights into experience with payments for environmental services, forest-based carbon sequestration projects being a specific case of such payment schemes.

2.2. An overview of projects

Nine out of 23 carbon sequestration projects are located in three East African countries — Kenya, Tanzania, and Uganda. This indicates that even within Africa, the distribution of carbon sequestration projects is skewed with East Africa receiving the most carbon investments. In fact, the International Small Group and Tree Planting Program (TIST) operates in all three of these countries, while commercial plantation projects have been carried out in Tanzania and Uganda. One project, Participatory Rehabilitation of Degraded Lands, is being implemented in the two West African countries of Mauritania and Senegal.

The location of projects in Africa needs to be viewed in the context of wide variation in rainfall and water availability across the region. Many parts of Africa lack adequate rainfall to support large-scale tree-planting for carbon, including much of South Africa and the Sahelian region (Zomer *et al*., 2006).

Projects also need to be categorized by whether they are purely commercial enterprises aiming to bring profits to investors, or if they aim to raise the incomes of local landowners by using carbon sequestration as part of a rural

[3] Afforestation and reforestation projects are examples of a category of projects generally known as LULUCF — Land use, land use change and forestry. This category has now been re-labeled as AFOLU — agriculture, forestry and land use.

[4] http://cdm.unfccc.int/index.html accessed on 12 January, 2008.

Table 1. Details of carbon sequestration projects in Africa

Project Title	Host Country	Investor	Fund Invested	Year	Implement. Agency	Carbon offsets	Nature of Benefit Sharing	Other details	Sources of Information
1. The International Small Group and Tree Planting Program (TIST)	Tanzania, Uganda, Kenya	Dow Chemical Company, World Bank BioCarbon	Dow — US$1.2 million, WB — US$45,000	Since 1999	CAAC, I4EI	4.47 $MtCO_2$# by 2030	Carbon rights transferred to CAAC. All others, viz. timber, NTFPs with community.	No. of farmers' groups = 4,309. Live trees > 5 million Seedlings in millions.	TIST (www.tist.org) Scurrah-Ehrhart (2006)
2. Participatory Rehabilitation of Degraded Lands	Mauritania and Senegal	GEF, African Dev. Bank, UNDP, National Government	GEF — US$7.996 M*Co-fin. — US$4.370 M	Since 2000	National Government, UNDP, UNEP	n.a. +	All benefits belong to community. Carbon credits not claimed.	Aims to reach 80,000 people in 100 villages. Target area is 600 km along Senegal River Valley.	GEF http://www.gefonline.org/projectDetails.cfm?projID=457
3. Community based Rangeland Rehabilitation for Carbon Sequestration	Sudan	GEF	GEF — US$1.5 million, Co-finance — US$0.085 million	1995–2000	National Government (Environment Ministry)	0.18 $MtCO_2$	All benefits including timber and NTFPs belong to local community.	Trees planted as windbreaks over several kilometers. 700 hectares of rangeland rehabilitated.	Dougherty *et al.* (2001)
4. Village-Based Management of Woody Savanna & Establishment of Woodlots for Carbon Sequest	Benin	GEF	US$2.5 million	1992	National Government (Environment Ministry), UNDP	0.5 $MtCO_2$	Woodlots with all products belong to community. Information on carbon offsets n.a.	609,098 trees planted on 126,700 ha of land.	GEF (http://www.gefonline.org/projectDetails.cfm?projID=389) FAO, 2004
5. Sustainable Energy Management Project	Burkina Faso	World Bank, Government of Norway, DANIDA	n.a.	1997–2003	National Government (Energy Ministry)	1.5 $MtCO_2$	Carbon offsets with World Bank. All other benefits with community.	Project registered as AIJ (Activity Implemented Jointly).	UNFCCC** (http://unfccc.int/kyoto_mechanisms/aij/activities_implemented_jointly/items/2005.php)
6. Forest Rehabilitation in Mt. Elgon & Kibale National Parks	Uganda	FACE Foundation	n.a.	Since 1994	Uganda Wildlife Authority	7.1 $MtCO_2$ over 99 years	Carbon offsets with FACE. All other rights with Uganda Wildlife Authority.	Project registered as AIJ, and has FSC Certification.	Face Foundation (www.stichingface.nl)

Table 1. *Continued*

Project Title	Host Country	Investor	Fund Invested	Year	Implement. Agency	Carbon offsets	Nature of Benefit Sharing	Other details	Sources of Information
7. Nhambita Community Carbon Project	Mozambique	European Union, MAN group, IIED etc.	n.a.	Since 2003	Envirotrade, ECCM, Univ. of Edinburgh	> 0.5 $MtCO_2$	Envirotrade buys carbon offsets from farmers by paying them in cash.	> 500,000 trees planted on about 1,000 hectares.	University of Edinburgh http://www.miombo.org.uk (Jindal, 2004)
8. Plan Vivo Project	Uganda	UK DfID, USAID, START, Tetra Pak UK	€1 million (expected)	2003–2012	Ecotrust Uganda, ECCM	0.9 $MtCO_2$ by 2012	Timber and other biomass benefits with farmers. Tetra Pak buys carbon credits. 60% of the sale money goes to farmers.	Carbon sequestration through small-scale tree planting on 5,000 ha. Project expanding to other areas.	Plan Vivo (www.planvivo.org) Carbon Neutral Company (http://www.carbonneutral.com/projects/projects.asp?id=13)
9. Western Kenya Integrated Ecosystem Management Project	Kenya	GEF, Co-financed by National Government, Japan PHRD	GEF — US$4.1 million. Co-fin. — US$2.7 million	2005	KARI, ICRAF, KEFRI	n.a.	Local community to get all timber, NTFP benefits. Carbon rights yet to be worked out.	The project will promote conservation activities to control sediment and nutrient flow into Lake Victoria.	GEF (http://www.gefonline.org/projectDetails.cfm?projID=1362) (Mutunga and Mwangi, 2006)
10. Sequestration of Carbon in Soil Organic Matter (SOCSOM)	Senegal	USAID, International Fund for Agriculture, FAO	n.a.	1999–2003	USGS, Many research universities	n.a.	All benefits with local community. Carbon rights not traded.	Pilot project to assess the potential for carbon sequestration in soils.	US Geological Survey (http://edcintl.cr.usgs.gov/carboninfosheet.html) (Tieszen *et al.*, 2004)
11. Commercial Plantation Projects	Tanzania and Uganda	Tree Farms AS of Norway (local subsidiaries)	At least US$600,000 in Uganda. Tanzania n.a.	Since 1997	Green Resources, Busoga Forestry Company	2.3 $MtCO_2$ expected in Uganda	Commercial plantation, all rights including carbon credits with the company.	SGS Products Certification in Tanzania. 6,500 ha already planted.	Norwatch newsletter no. 5, 2000. (FAO, 2004)
12. Carbon from Communities	Mali	NASA	US$143,236	2002–2005	SANREM-CRSP (USAID), Univof Georgia, Local Univs.	n.a.	All benefits with local communities.	Mainly a research project.	Virginia Tech University (http://www.oired.vt.edu/resanddev/projects/carbon.htm)
13. The Participatory Environmental Management Programme (PEMA)	Tanzania	Int. Donors, Govt. of Tanzania will make non-cash investments	n.a.	2008	CARE, ICRAF	0.05 $MtCO_2$	Participating communities will receive cash and non-cash benefits for carbon sequestration.	Joint Forest Management in 19 villages. Project follows Climate Community Biodiv. Standards.	Scurrah-Ehrhart (2006)

Table 1. *Continued*

Project Title	Host Country	Investor	Fund Invested	Year	Implement. Agency	Carbon offsets	Nature of Benefit Sharing	Other details	Sources of Information
14. Nile Basin Reforestation	Uganda	World Bank BioCarbon Fund	n.a.	2006	National Forest Agency	0.29 $MtCO_2$ by 2017	Timber benefits shared with locals. Carbon credits with World Bank.	Planting of pine and mixed native species on 2,000 ha. New jobs will be created.	WB BioCarbon Fund (http://carbonfinance.org/Router.cfm?Page=Projport&ProjID=9644)
15. Acacia Community Plantations	Niger	World Bank BioCarbon Fund	n.a.	2006	Achats Services Int. (ACI) ICRISAT	0.69 $MtCO_2$ by 2017	Gum, firewood and timber to be shared with locals. ASI will sell carbon credits.	Acacia plantations on 22,800 ha. Project will benefit 15,000 farming families in the area.	WB BioCarbon Fund (http://carbonfinance.org/Router.cfm?Page=Projport&ProjID=9634)
16. Senegal Plantation Project	Mali	World Bank BioCarbon Fund	n.a.	2006	Deguessi Vert, Malian Rural Economic Institute (IER)	1.4 $MtCO_2$ by 2035	Gum, firewood etc. to be shared with locals. Deguessi-IER to sell carbon credits.	The project will reforest about 10,000 ha of Acacia Senegal, a species endemic to the whole African Sahel.	WB BioCarbon Fund (http://carbonfinance.org/Router.cfm?Page=Projport&ProjID=24878)
17. Andasibe-Mantadia Biodiversity Corridor	Madagascar	World Bank BioCarbon Fund, GEF	Part of US$150 million grant for biodivrst. Conserv.	2006	ANGAP, CI, Ministry of Environment, Water and Forests	0.31 $MtCO_2$ (Kyoto) 4.0 $MtCO_2$ (Non-Kyoto) by 2017	Mainly a biodiversity conservation project. Some benefits including carbon payments will be shared with locals.	Afforestation on 5,000 ha and protection of 80,000 ha to conserve biodiversity.	WB BioCarbon Fund (http://carbonfinance.org/Router.cfm?Page=Projport&ProjID=9638) Capoor and Ambrosi, 2006
18. Green Belt Movement	Kenya	Green Belt Movement, World Bank BioCarbon Fund	n.a.	2006	Green Belt Movement, Community Forest Associations	0.38 $MtCO_2$ by 2017	Farmers will receive payments for carbon sequestration to carry out conservation activities.	Project builds on the thirty year old Green Belt Movement in Kenya. It will reforest 1,876 ha of degraded land.	WB BioCarbon Fund (http://carbonfinance.org/Router.cfm?Page=Projport&ProjID=9635)
19. Humbo Assisted Regeneration	Ethiopia	World Vision Australia, World Bank BioCarbon Fund	n.a.	2006	World Vision, Ethiopian Agr., Rural Devl., & Forestry Coord. Office	0.16 $MtCO_2$ by 2017	Biomass benefits will be shared with local communities. Carbon payments to improve local infrastructure and food security.	The project proposes to restore 2,428 ha of biodiverse natural forest in the vicinity of the town of Humbo, in Southwestern Ethiopia	WB BioCarbon Fund (http://carbonfinance.org/Router.cfm?Page=Projport&ProjID=9625)

Table 1. ***Continued***

Project Title	Host Country	Investor	Fund Invested	Year	Implement. Agency	Carbon offsets	Nature of Benefit Sharing	Other details	Sources of Information
20. Reforestation on degraded land for sustainable wood production of woodchips	Madagascar	Japan	n.a.	2006	Oji Paper Company Ltd.	1.86 $MtCO_2$ by 2035 (I-CERs)	Carbon offsets belong to the Japanese investor. Local farmers will get free seedlings and all benefits from plantations on community lands.	Eucalyptus and Acacia plantations on 15,000 ha. Project in the Clean Development Mechanism pipeline.	CDM pipeline updated by UNEP Riso Centre http://cdmpipeline.org/
21. The Namwasa Forestation Project	Uganda	European Banks (EBRD, EIB, EMI)	US$12.85 million (total)	2007	New Forests Company Ltd.	0.26 $MtCO_2$ over 20 years (t-CERs)	Carbon offsets belong to the international investors.	Eucalyptus and pine plantation on 9,000 ha of degraded forest land. Project in the CDM pipeline.	CDM pipeline updated by UNEP Riso Centre http://cdmpipeline.org/
22. Rehabilitation of coastal dunes and riparian areas: Port St John	South Africa	Dept. of Environment Affairs and Tourism (DEAT)	n.a.	2004	Environment Offset Investments	n.a.	Carbon offsets belong to the investor. Collectives of land owners in Port St. John receive direct payments for labour.	The two major activities are: — Rehabilitation of riparian vegetation — Rehabilitation of coastal dunes.	King *et al.* (2005)
23. Rehabilitation of riparian areas: Letaba river	South Africa	Dept. of Environment Affairs and Tourism (DEAT)	n.a.	2005	Environment Offset Investments	n.a.	Carbon offsets belong to the investor. Collectives of local land owners receive direct payments for labour.	The main activity under the project is rehabilitation of riparian vegetation.	King *et al.* (2005)

Notes: # MtCO2: million tons of carbon dioxide. * M: million; + n.a.: not available; ** UNFCCC: United Nations Framework Convention on Climate Change.

development strategy. Projects reviewed in the paper include a range of approaches in this regard, with most offering at least some level of benefit to local communities but others largely excluding local people. For instance, the commercial plantations in Tanzania and Uganda aim to raise additional revenue for the timber company without much benefit for the local people.

Project size ranges from a small area of about 700 hectares (Community-Based Rangeland Rehabilitation for Carbon Sequestration, Sudan) to several thousand hectares (ha) under the Forest Rehabilitation Project in Mt. Elgon and Kibale National Parks, Uganda. Project activities include rangeland conservation (Sudan), farm forestry (Tanzania), rehabilitation of dense forests (Uganda), conservation of biodiversity corridors (Madagascar), restoration of Lake Victoria basin (Kenya), and rehabilitation of riparian vegetation (South Africa). Many projects follow a multi-sector approach; for example, apart from carbon sequestration, Burkina Faso's Sustainable Energy Management Project aims to improve the energy situation through a shift from wood fuel and charcoal to solar photovoltaics. Some projects are mainly research initiatives; the Sequestration of Carbon in Soil Organic Matter (SOCSOM) project in Senegal assessed the feasibility of storing carbon in the soil through change in land use practices. It was jointly implemented by several research universities — Centre Suivi Ecologique (CSE), Senegal, University of Arizona, USA, and the Lund University, Sweden (Tieszen *et al*., 2004).

2.3. Kyoto-compliant versus voluntary projects

Carbon sequestration projects approved under the Kyoto Protocol's Clean Development Mechanism are here called Kyoto-compliant, with carbon offsets generated by such projects termed as Certified Emission Reductions or CERs (UNEP, 2002). Until recently, none of the carbon sequestration projects in Africa were Kyoto-compliant. During the last few months, however, two projects, Reforestation on Degraded Land for Sustainable Production of Woodchips in Madagascar and the Namwasa Forestation Project in Uganda, have been added to the list of projects awaiting approval by the CDM's Executive Board and can be broadly considered as Kyoto-compliant (UNEP, 2008). Furthermore, the six carbon sequestration projects funded by the World Bank BioCarbon Fund (projects 14 to 19 in Table 1) follow broad CDM guidelines and are potentially Kyoto-compliant. Similarly, two projects, i.e., Forest Rehabilitation in Mount Elgon and Kibale National Parks in Uganda and Sustainable Energy Management Project in Burkina Faso, were first approved as Activities Implemented Jointly (AIJ).[5] Therefore, strictly speaking only two out of 23 carbon sequestration projects in Africa are Kyoto-compliant, but eight more projects are potentially Kyoto-compliant.

The other 13 projects in Africa are voluntary carbon sequestration projects (or non-Kyoto compliant). Firms and organizations invest in such projects for several reasons, e.g., as part of their corporate social responsibility initiatives, to experiment with voluntary markets before joining formal markets, to influence policy, to improve goodwill, or for philanthropic reasons (Gutman, 2003).

Apart from raising new plantations, some projects, such as the Andasibe-Mantadia Biodiversity Corridor Project in Madagascar, also aim to conserve existing forests through avoided deforestation. It is important to note that avoided deforestation or Reduced Emissions from Deforestation in Developing Countries (REDD) is presently excluded from the Kyoto Protocol. However, the UNFCCC has now initiated discussions on possible inclusion of avoided deforestation in a future climate change agreement. As per a decision reached at COP 13 in December 2007, it invites voluntary action on avoided deforestation, and encourages the development of appropriate methodologies and demonstration activities.

2.4. Carbon sequestration potential

Carbon sequestration potential is the amount of carbon dioxide (in tons) that a project can realistically sequester over its lifetime. Out of the 23 projects reviewed, carbon sequestration details were only available for 15 projects. Relative to baseline conditions, the total carbon sequestration potential of these 15 projects is estimated to be 26.85 million tons of carbon dioxide ($MtCO_2$), with an average of 1.79 $MtCO_2$ per project.[6] The highest potential is from Forest Rehabilitation in Mount Elgon and Kibale National Parks, Uganda, which is expected to sequester 7.1 $MtCO_2$ over its lifetime. The Participatory Environmental Management Programme (PEMA) has the lowest sequestration potential of 0.05 $MtCO_2$. There are however, some important caveats with these estimates. Projects use different time lines to compute their respective carbon sequestration potential. For instance, the sequestration potential of the Forest Rehabilitation Project in Uganda is calculated over 99 years while TIST estimates its sequestration potential over 30 years. Furthermore, most carbon projects in Africa (and elsewhere) are in initial stages of implementation, with sequestration potential being an estimate rather than an actual figure.

A related concern about carbon sequestration potential is the threat of impermanence: a forest can be burned or cut at any stage, potentially releasing most of the sequestered carbon back into the atmosphere (Sedjo *et al*., 2001). Several carbon projects in Africa address the need to ensure permanence of sequestered carbon. For instance, TIST has set up long-term contracts with participating farmers and

[5] These were pilot CDM projects that were initiated before the Kyoto Protocol officially came into force in 2005.

[6] These figures include the estimated emission reduction of 4 $MtCO_2$ from avoided deforestation for the Andasibe-Mantadia Biodiversity Corridor Project in Madagascar.

the carbon payments they receive are directly proportional to the number of live trees they maintain. If a farmer cuts down trees on her farm the corresponding payment also declines. Of course, the actual impact of tree harvesting on the global carbon balance depends upon the harvesting technique used, the land use after harvesting, and the fate of the wood that is produced. Wood used for furniture or house construction, for example, may sequester carbon for decades or longer.

CDM deals with the threat of impermanence by categorizing carbon offsets as either temporary Certified Emission Reductions (t-CERs) or long-term Certified Emission Reductions (l-CERs). Projects receive t-CERs if they ensure permanence of carbon stocks only until the end of the Kyoto Protocol's current commitment in 2012, while projects that ensure long-term sustainability of carbon stock for the next 30 years can claim l-CERs (Haites, 2004). Regarding Kyoto-compliant projects in Africa, the Namwasa Forestation Project in Uganda generates t-CERs (13,000 tCO_2 per annum), and Reforestation on Degraded Land for Sustainable Production of Woodchips in Madagascar produces l-CERs (37,000 tCO_2 per annum).

2.5. Prominent investors, service providers and intermediaries

The World Bank (WB) is the biggest carbon investor in Africa. It is funding 12 carbon sequestration projects, including seven through its BioCarbon Fund and four under the Global Environmental Facility (GEF) (Table 1). Two projects are supported by the United States Agency for International Development (USAID), and one each by the FACE Foundation and the European Union. One project was sponsored under a research grant from NASA and one was paid for by a commercial plantation company — Tree Farms AS of Norway. Some projects are co-financed by UN organizations such as UNDP and UNEP. Moreover, national governments of industrialized countries such as Norway and the United Kingdom are also funding carbon projects in Africa. Three projects — TIST, the Nhambita Community Carbon Project in Mozambique, and the Plan Vivo Project in Uganda, have partially financed their activities by selling carbon offsets to international buyers. For instance, TIST sells carbon offsets to individuals through eBay as well as through its own web portal at the price of US$8.50 per tCO_2. Similarly, the Nhambita Project has sold carbon offsets to MAN group and to the International Institute for Environment and Development, UK. A portion of these sale revenues are then shared with participating farmers as carbon payments.

Most projects are covered under bilateral agreements and managed by host country national governments (respective Ministries of Environment) or other national agencies (National Forest Agencies). Other implementing organizations include private companies or their local subsidiaries (six projects), non-government organizations (NGOs — four projects), and research institutes or universities (four projects).

In projects that focus on rural development, local communities act as service providers. In most such cases they get a share of carbon revenue whereas in others, the project retains the carbon rights while community members have rights to only non-timber forest products (NTFPs). Intermediaries such as NGOs and local governments take up additional responsibilities for organizing communities, building the capacity of community representatives, monitoring and supervision, and obtaining funds from investors.

3. Potential benefits and related issues

Most carbon sequestration projects in Africa are fairly new, with many initiated very recently. As a result, there are few studies on the impacts of these projects on host countries or project participants. This section therefore explores potential benefits and cites field evidence where available. It also points out some key concerns about carbon plantations.

3.1. Economic benefits and costs for local communities

Community development-oriented carbon sequestration projects can provide significant economic benefits to local communities in the form of cash incomes as well as through access to NTFPs generated through forestry activities. For instance, in the Nhambita Community Carbon Project in Mozambique, local households receive a cash payment of US$242.60 per ha over seven years for carbon sequestered on their farms. Although the percentage of money paid to each household varies from 30% of the total in the first year to 10% of the total in the seventh year, a simple average works out to US$34.70 per household per annum (taking an average of one hectare of land per household). This represents a significant increase in cash incomes for most households and addresses their felt need of a regular cash source (Jindal, 2004). Similarly, under the contract with TIST, local farmers in Tanzania receive Tsh 20 (US$0.02) per tree per year for a period of 20 years (Scurrah-Ehrhart, 2006). Other benefits to farmers include access to fruits, minor timber, firewood and any other NTFPs.

Not all sequestration projects provide the same benefits. First, not all projects aim to provide benefits to local communities. Second, economic returns from a specific project depend on the quality of land and the actual land use practice that is followed. Dry lands, for example, sequester only 0.05–0.7 tons of carbon (tC)/ha/year[7] compared to 0.43 tC/ha/year for Miombo woodlands[8] and 5.9 tC/ha/year for *Alnus* woodlots (Perez *et al*., 2007; Aune *et al*., 2005).

[7] 1 ton of carbon (1 t C) = 3.67 t CO_2.

[8] Characterized by Miombo species (*Brachystegia*, *Julbernardia*, and *Isoberlinia*), these woodlands form a broad belt across south-central Africa.

Therefore, economic benefits need to be clearly evaluated before a carbon sequestration project can be deemed profitable. A related issue is the difficulty that poor households face investing in new, project-recommended land use practices for carbon sequestration. A possible solution is to offer a higher proportion of overall payment during the first year as a way to help the poor overcome their investment constraints, as is done by the Nhambita Community Carbon Project.[9]

While carbon projects can potentially benefit poor households, they can also have adverse impacts. This can be especially pertinent when plantation companies take up sequestration activities in forest areas. For instance, the commercial plantations project in Uganda has barred local households from harvesting any timber or other NTFPs, resulting in loss of income for the entire community (Eraker, 2000). Similarly, local communities do not get a share of carbon revenue from the Forest Rehabilitation Project in Mt. Elgon and Kibale National Parks in Uganda. In fact, critics have charged that the project harms the poor by excluding them from the park lands (Lang and Byakola, 2006).[10] Local people also can be harmed if intensive plantations of fast-growing trees like *Eucalyptus* interfere with the water available to downstream areas, as discussed in section 3.4. Additional studies are needed to objectively assess whether or not harm of local people by commercial carbon sequestration projects is a general phenomenon and how such projects can be made more inclusive.

In community development-oriented projects, farmers' understanding of the nature of carbon sequestration, carbon trading and their contractual obligations also needs to be better understood. It is unclear whether local communities understand this process and the fact that carbon payments are quite different from financial support from other development programs. A contract that offers a farmer payment in exchange for planting trees may initially look attractive, but problems may arise if the farmer does not understand that the contract is binding even in later years, when harvesting the trees may become an attractive option.

3.2. Benefits from avoided deforestation

Many forest management projects are not viable either because their benefits are uncompensated environmental services or because national governments and other local agencies do not have adequate funds to undertake conservation activities. Carbon projects could address these concerns by providing financial assistance to government agencies to invest in forest conservation (Gutman, 2003). As mentioned above, the Kyoto Protocol does not support avoided deforestation, nor do the projects covered in this review. But earning carbon credits through avoided deforestation could be particularly relevant for Africa, where many countries have very high deforestation rates. For instance, between 2000 and 2005, Sudan lost an average of 117,807 ha of forest per year, while Nigeria lost 82,000 ha of forest per year (FAO, 2005). In fact, Nigeria lost 55.7% of its primary forests between 2000 and 2005, the highest proportion of forest loss in the world, due to logging and subsistence agriculture. These high deforestation rates are often accompanied by rapid loss of species, reduction in land productivity and other adverse environmental impacts. Many African countries, however, lack adequate financial or technical means to conserve their forests. Carbon investments for emission reduction through avoided deforestation could therefore provide direct economic incentives for these countries to take up conservation. FAO (2007) estimates that the total carbon mitigation from avoided deforestation in Africa from 2003–2012 could be 615.8 million tCO_2. A sale of even a small proportion of these carbon offsets to international investors will provide significant economic returns to local communities and to host governments in Africa to invest in forest conservation.[11]

3.3. Biodiversity conservation

Similar to avoided deforestation, carbon payments can also generate revenues for biodiversity conservation where carbon and biodiversity are jointly produced. A case in point is the World Bank BioCarbon Fund's Andasibe-Mantadia Biodiversity Corridor Project, which will protect several endemic species by linking fragmented parts of the Malagasy rainforest in Madagascar. Similarly, the Forest Rehabilitation Project promotes reforestation on 24,000 ha in Mount Elgon and Kibale National Parks, Uganda. These parks were widely deforested during the political strife of the 1970s and 1980s when various ethnic groups sought refuge in them. The project has been trying to reverse this degradation by planting indigenous tree species and training the forest officials. In addition to carbon sequestration, these activities are helping to conserve the local biodiversity and protect endangered wildlife such as chimpanzees.[12]

In general, however, biodiversity conservation benefits are more likely to be associated with avoided deforestation than with carbon sequestration from new plantations. This is because natural forests conserved through avoided deforestation will provide habitat to more endemic species than plantations that tend to focus on fast growing exotics.

[9] However, if payments are lower when trees are larger, some farmers might be tempted to harvest the trees in violation of the contract.

[10] However, it is important to note that this project operates in national parks where Ugandan law prohibits land use by local people. Carbon sequestration *per se* is not necessarily to blame for excluding local people.

[11] Whether or not local communities would gain under a contract for avoided deforestation depends on the project design. Most likely, efforts to avoid deforestation would be more successful if local communities share in the revenue.

[12] Project details are available at http://www.facefoundation.nl/Eng/projectAfrica.html.

For instance, the Namwasa Forestation Project in Uganda will undertake only *Eucalyptus* and pine plantations over an area of 9,000 ha. Even when a project includes native species, such as the Senegal Plantation Project in Mali, the focus is still on a small list of tree species, in this case *Acacia Senegal*.

3.4. Impact on local ecology

Carbon sequestration through afforestation and reforestation can often generate other locally valued ecosystem services such as more regular and higher quality water supplies and control of soil erosion and sedimentation (Scherr *et al.*, 2004). In Western Sudan, for example, the Community-Based Rangeland Rehabilitation for Carbon Sequestration Project has helped improve local rangelands. Rangelands are a mainstay of Sudan's economy, covering about 60% of the country and providing fodder for one of Africa's largest concentrations of livestock. However, many rangelands are badly degraded due to recurrent droughts and overgrazing. The project has restored 700 ha of community rangeland by planting grasses and leguminous crops. It has also helped to protect more than 300 local farms from wind erosion by planting *Acacia Senegal* and *ZiZiphus* trees as windbreaks over a stretch of 108 km. Furthermore, several sand dunes near the Bara town were stabilized through *Acacia* and *Panicum* plantations, and by formulating long-term management plans with the local village councils (Dougherty *et al.*, 2001). Similarly, the Western Kenya Integrated Ecosystem Management Project will improve the ecology of Lake Victoria Basin by taking up erosion control and watershed management activities on 900 square km. A key project component will be to encourage adoption of agroforestry by paying local communities for generating carbon sequestration offsets (Mutunga and Mwangi, 2006). Agroforestry also has high potential to enhance soil fertility (Albrecht and Kandji, 2006).

While projects like these are beneficial for the local ecology, some sequestration projects may actually be harmful, particularly if they focus on single species plantations or fast growing exotics that are effective in storing carbon but create other adverse effects (IUCN and UNEP, 2002). Such plantations can often result in substantial losses in stream flow, and increased salinization and acidification (Jackson *et al.*, 2005). A global study on hydrologic effects of forest plantations found that annual runoff reduced by as much as 75% when grasslands were converted into *Eucalyptus* plantations (Farley *et al.*, 2005).

Exotics can also threaten local biodiversity and destroy native species. *Eucalyptus* and pine, for example, do not support undergrowth, so other plants cannot coexist with them. In order to avoid harmful effects, there is a need to plan carbon sequestration projects carefully and encourage native plant species over exotics. Deciduous indigenous trees that shed their leaves in the dry season are particularly appropriate for use in water scarce catchments.

4. Carbon sequestration projects in Africa: Challenges to scaling up

Scaling up carbon investments in Africa will require a mix of 'push' and 'pull' factors. This section looks at important push factors as well as other challenges that African countries must address to attract or 'pull' more carbon investments to the continent.

4.1. Push by multilateral donors

The CDM was introduced for industrialized countries to achieve their emission reduction targets in a cost effective manner while contributing to sustainable development in developing countries (UNEP, 2002). However, CDM investments have been rather skewed with hardly any investments in the least developed countries, particularly in Africa (Capoor and Ambrosi, 2006). The World Bank has attempted to improve the distribution of carbon investments in Africa through its Community Development Carbon Fund and BioCarbon Fund. However, all these investments in Africa still comprise less than 10% of the US$629 million worth of global carbon portfolio managed by the World Bank's carbon finance unit. There is thus a need for other multilateral donors to push for more carbon investments in African countries.

An encouraging start in this regard is the creation of international funds that focus on carbon projects in poor countries. Examples include the International Union for Conservation of Nature (IUCN) Climate Fund and the Finnish CDM Program that are mandated to support carbon projects in Africa (UNEP and IETA, 2005). The UNDP's Millennium Development Goals Carbon initiative also seeks to redress this imbalance. Similarly, France, Italy and Germany have signed bilateral agreements with Morocco, Algeria, Egypt and Mali respectively to support carbon projects (Point Carbon, 2003).

4.2. Selling offsets on the Chicago Climate Exchange

The Chicago Climate Exchange (CCX) is a voluntary cap-and-trade program that requires its members (mostly large companies like Ford, DuPont, and IBM) to voluntarily reduce their carbon emissions every year. If members are unable to meet their annual reduction targets, they can purchase carbon offsets from others, including carbon sequestration offsets from forestry projects. CCX transacted volumes of 22.9 million tCO_2 in 2007 (twice the previous year and 15 times higher than in 2005), making it one of the largest carbon markets in the world.[13] Recent research in India found that TIST, India, is eligible to sell carbon offsets worth US$43,000 per annum through CCX (Jindal *et al.*, forthcoming). While more research needs to be carried

[13] As on March 23, 2008, carbon was being traded on the CCX at a price of US$5.50 per tCO_2.

out on specific modalities, there appears ample scope for TIST and other voluntary carbon sequestration projects in Africa to link with CCX and sell carbon sequestration offsets to its members.

4.3. Reducing transaction costs

Transaction costs include costs of negotiating, contracting, implementing, and monitoring a project. For CDM projects, transaction costs also include costs of registering, verifying, and certifying a project, which are usually independent of the project size. As a result, transaction costs can vary from US$1.48 per tCO_2 for large projects to as high as US$14.78 per tCO_2 for small projects (Michaelowa and Jotzo, 2005). Similarly, transaction costs are much higher in absolute terms when dealing with multiple parties (each with separate contracts) rather than a single party. Gaining information about landowners, contacting them, and certifying changes in land use, all increase the cost per hectare and per unit of carbon sequestration when working with many small holders (Smith and Scherr, 2003). As a result, community development-oriented projects targeting small holders will have the highest transaction costs, making them less attractive to investors.

Regarding Kyoto-compliant projects, the CDM has a set of simplified guidelines to reduce transaction costs for small-scale carbon sequestration projects (with sequestration potential of less than 8,000 tCO_2 per year) that focus on sustainable development of local communities. While these developments are encouraging, the overall approval process of sequestration projects is so slow that these guidelines have not had much impact on growth of carbon projects in Africa.

Transaction costs can also be lowered by involving intermediary organizations as project partners. At present, most carbon projects in Africa are directly implemented by national governments. One major limitation of this approach is that centralized agencies are unfamiliar with local conditions and cannot identify and target small holders effectively. Further, these agencies can take up only a certain number of projects, thereby constraining their expansion. Therefore, African countries need to promote organizations that can act as intermediaries for carbon sequestration projects. Additionally, community-oriented carbon sequestration projects can be developed in communities where local organizations are already active and participatory development processes are in place (Landell-Mills and Porras, 2002). For instance, TIST (Tanzania) has reduced transaction costs by organizing local farmers into small groups of 10–12 people. The two project partners — Institute for Environmental Innovation (I4EI) and Clean Air Action Corporation (CAAC) — have registered a local subsidiary called UMET Ltd. (Ukuzaji Maendeleo Endelevu Tanzania), which manages the project. Farmer groups transfer all carbon offsets to UMET Ltd. in return for quarterly payments. Finally, all activities including monitoring and supervision are performed by UMET's staff drawn from the local population, which further helps to reduce costs.

4.4. Securing property rights and land tenure

Tenure security is crucial for implementing carbon sequestration projects. Without clear and defendable rights to land, forest or the sequestration service itself, suppliers cannot make a credible commitment to supply carbon offsets (Gutman, 2003). For projects where local communities act as service providers, it means that unless they have secure rights to the land on which forestry activities are taken up, the investor may have little confidence in financing the project.

Most African countries have multiple tenure systems whereby several land users may have access to different resources on the same piece of land (Lund, 2000). For instance, in the Nyando basin in Kenya, land may be held under individual title but used communally for grazing and wood collection (Swallow *et al.*, 2001). This can often cause confusion as to whether the land belongs to the group or to specific individuals, and it may be difficult for the investor to identify actual service providers. In general, there exists a duality between customary and statutory land rights in many African countries (Woodhouse, 2003). In Ethiopia, for example, even though all land was officially nationalized in 1974, there continues a system of inheritance and hereditary rights in several parts of the country.

If carbon sequestration projects are taken up where property rights are unclear, it is also possible that more powerful people may take control over the land. Consequently, poor people who may have been occupying it will not receive any benefits from carbon sales and could even end up losing their access to the land. For instance, a 50-year concession owned by Tree Farms AS of Norway to raise commercial plantations and generate carbon offsets from 5,160 hectares of land in Bualeba Reserve (Uganda), threatens the livelihoods of the local poor by barring them from using the forest for farming, collection of timber and NTFPs, cattle grazing and fishing. As local people do not possess formal land titles, they may be completely evicted from the area (Eraker, 2000).

Solving this problem is not as easy as simply establishing formalized land rights, since many land titling projects in Africa have failed because they were inconsistent with customary practices (e.g., Ensminger, 1996). Where local economic systems are more amenable to titling, this can be facilitated through coordination of government departments involved in allocating rights and strengthening dispute resolution mechanisms (Gutman, 2003). Regardless of the land rights system, countries need to improve their monitoring and enforcement procedures so that rights can be effectively defended when challenged.

One possible way for carbon projects to operate in areas under customary tenure is by working on land held as common property by an entire community, rather than

growing trees only on privately held land. Project benefits can be shared amongst the entire community. For example, the Nhambita Community Carbon Project (Mozambique) deposits US$40.50 per hectare in a community fund as per the number of hectares that are brought under carbon sequestration. Since all land is registered in the name of the village chief and no household has individual titles, the entire community gains from these group payments (Jindal, 2004). It is worth noting that where contracts are paid to a group, care may be needed to help ensure that payments are distributed in a way that local people deem fair, as opposed to being captured by those who handle the contract.[14]

4.5. Improving governance

Considering that most carbon sequestration projects have a long gestation period, any investment is liable to be risky unless backed by long-term economic and political stability. Moreover, governments are important buyers and sellers of environmental services and often also act as intermediaries (as seen in several projects in Africa). Therefore, in order to attract and sustain international carbon projects, it is essential to have good governance practices at national and local levels.

However, many African countries face political volatility and unpredictable governance systems thus making carbon sequestration investments a risky proposition. Several sub-Saharan countries are under the grip of long-term civil strife, making it most difficult for them to attract international carbon sequestration investments. On the brighter side, in many other African countries the political leadership is taking ownership of conflict resolution, good governance and poverty reduction (World Bank, 2005).

4.6. Building institutional capacity

Facilitating successful implementation of carbon sequestration projects requires having adequate national institutional capacity. The Kyoto Protocol requires each developing country to establish a Designated National Authority (DNA) that serves as the point of contact between international investors and local service providers. One important factor in establishing a DNA is its institutional sustainability, reflected in its capacity to ensure a coherent, justifiable and transparent assessment of carbon projects and to generate enough revenue through these assessments to finance itself.

There are, however, few operational DNAs in Africa, with most countries lacking institutional capacity to promote viable carbon projects (Nanasta, 2007). Not only is there an absence of supporting policy and legal frameworks, but some countries even lack a general awareness about carbon payment processes (Kituyi, 2002). In order to build institutional capacity in Africa to improve its share of global carbon trading, the United Nations has launched the Nairobi Framework under which international organizations such as the World Bank and the African Development Bank will support capacity building initiatives in the region. As part of this framework, UNDP and UNEP initiated a comprehensive capacity building project in sub-Saharan Africa that targets Ethiopia, Kenya, Mauritius, Mozambique, Tanzania and Zambia. The Governments of Spain, Sweden and Finland have already contributed a total of US$1.5 million to this project.[15]

While initiatives like these are helpful, much more needs to be done. One alternative is to include capacity building as an integral component of each carbon project. For example, the Western Kenya Integrated Ecosystem Management Project includes a comprehensive capacity building phase, supported by Japan Policy and Human Resources Development Fund (PHRD). The aim is to establish a national carbon assessment and certification capacity within Kenya's national research system. A downside of this strategy is a possible escalation in project overheads, which may be unacceptable to international investors. Therefore, apart from donor led efforts, host countries should also be willing to invest in capacity building. A step in this direction can be made through developing national level CDM/carbon programs in line with National Development Plans and Poverty Reduction Strategy Papers. This would ensure that carbon projects meet the goal of sustainable development for host countries while conveying a transparent set of project assessment criteria to investors.

5. Conclusion

Forestry-based carbon sequestration has the potential to offer win–win opportunities for economic development and environmental protection and restoration. Payment for carbon sequestration is part of a larger class of payment for environmental service systems that pays local land users for protecting the environment. Many advocates of the rural poor in developing countries are very hopeful that such programs can offer a boon to rural people who otherwise have little to offer to global and regional markets (Rosander, 2007). Carbon payments could provide an important boost to their incomes. From this perspective, tree-based carbon sequestration seems highly fitting for sub-Saharan Africa.

Despite this potential, forestry-based carbon sequestration projects are currently scarce on the continent, and even among the small number of projects, some of them offer

[14] Non-cash payments that are indivisible and benefit the entire community can help avoid this problem. A project in Sumberjaya, Indonesia utilizes this approach, by giving secure tenure to group members who occupy government forest land for providing environmental services (Kerr *et al.*, 2006).

[15] UNFCCC has issued several important press releases on this issue, which are available at http://cdm.unfccc.int/index.html. This website was accessed on 12 January, 2008.

nothing in the way of benefits to local communities and may even harm them by restricting access to natural resources or competing for scarce groundwater. Carbon sequestration can benefit the poor if it helps small farmers sell carbon credits either individually or in groups from trees that provide multiple benefits beyond carbon income and do not pose a threat to local livelihood systems.

This paper has illustrated the challenges involved in promoting forestry-based carbon sequestration in Africa and suggested some ways to address them. To promote successful tree-based carbon sequestration projects that can provide economic benefits to local communities, several steps must be taken. These steps relate to operating in appropriate places; using suitable trees; ensuring that farmers understand the nature of carbon sequestration contracts; accommodating the characteristics of African land tenure systems; keeping transaction costs manageable, and building the capacity of African governments. For community-oriented projects, key points that arise are as follows:

Project locations, trees and participants

Not every place is suitable for carbon sequestration projects, whether because trees grow too slowly or they use too much water. It is worth keeping in mind that South Africa's Working for Water program actually pays people to remove exotic trees in order to restore stream flows (http://www.dwaf.gov.za/wfw/). Project locations must be appropriate for tree planting, with trees that can grow in harmony with the local ecology. Carbon payments alone may not provide farmers with sufficient income and are most attractive if they are part of a broader income stream.

Carbon projects also must choose the right participants. Farmers engaged in carbon sequestration must understand and accept the long-term nature of carbon contracts with their benefits and obligations.

Given these concerns, carbon sequestration is perhaps most attractive in places where agroforestry systems are a viable economic opportunity even without potential carbon sequestration income. This is likely to be the case in humid or sub-humid environments, where multi-storey agroforestry systems produce numerous marketable products, can co-exist with food crop systems, and are well-suited to the local water regime. Even in less humid areas where multi-storey agroforestry systems are less viable, farmers are well-known to incorporate trees into their farming systems (Dewees, 1993), for example on plot boundaries or in woodlots. Even relatively small payments for carbon sequestration may help tip these systems into profitability in some cases.

Land tenure

As discussed, African land tenure systems are complex and sometimes a given land user cannot realistically commit a plot of land to trees over a several year period. It is critically important to understand local land tenure systems before introducing a carbon sequestration project. In some locations the local tenure system may be such that no adaptations are needed, whereas in others, carbon sequestration contracts with individual farmers may be untenable. In the latter case, group-based contracts, possibly on communal land that is not used for crops, may be a viable option for carbon sequestration.

Transaction costs

Entering into carbon sequestration contracts with small farmers requires identifying them, agreeing to a contract, monitoring compliance, and paying them. As mentioned in section 4.3, transaction costs in small scale carbon projects can reach as high as US\$14.78/tCO_2. This is about three times the market price of carbon credits on the Chicago Climate Exchange in early 2008. Clearly, making carbon sequestration viable for small farmers would require innovations that reduce such costs to well below the market price.[16]

Some ways to reduce transaction costs include contracting with groups rather than individuals (although group-based contracts bring their own challenges as discussed in section 4.4), working with local intermediary groups who can facilitate engagement with local people, and devising low cost monitoring systems. Some organizations have already developed approaches along these lines. Regarding working in groups, in a project in Indonesia 10,000 farmers have organized into about 20 groups to jointly provide environmental services. Groups take the responsibility of organizing their members and monitoring compliance, effectively incorporating many of the transaction costs within the group, which can manage them less expensively (Kerr *et al*., 2006). Regarding low cost monitoring, TIST employs local people with bicycles and GPS units to visit farmers and count their trees to monitor compliance. Automated systems based on remote sensing could conceivably reduce such costs by even more, though of course establishing such systems will be expensive.

Institutional capacity and political stability

A major challenge to attracting more tree-based carbon sequestration projects in Africa is the shortage of organizational capacity to manage carbon projects and establish links to international buyers. This is particularly a challenge for attracting CDM projects with their strict guidelines.

Another constraint many African countries face is political instability or violence that undoubtedly deters international investors.

Summing up, forestry-based carbon sequestration projects come in many forms, for example targeting the CDM or the voluntary market, and focusing on investor profits or local community benefits. Key issues vary across these project

[16] Expansion of the global market could conceivably raise market prices sharply, making the challenge of reducing transaction costs more manageable.

types. For the CDM, the most important consideration is to be able to meet the guidelines and negotiate the approval process, making institutional capacity the biggest constraint. The voluntary market is easier to access, without the need for a government intermediary, though some form of institutional capacity is required. For community-based projects, critical issues are developing viable systems that incorporate carbon sequestration into local land use systems, keeping transaction costs low, adapting to local land tenure systems, and developing effective contractual arrangements with farmers. Commercial plantation projects are likely to be independent of government and international donors and will likely have their own administrative capacity. For such projects, key concerns are ensuring that plantation projects do not harm local livelihoods, either by interfering with their access to local natural resources or by damaging the hydrologic regime. Governance capacity is essential in this realm. Additional factors like attracting donor or investor support and choosing the right tree species cut across all project types. Furthermore, any project being planned for Africa should be cognizant of issues of governance and political instability, although these are by no means unique to Africa. For each of these concerns, we have provided explanations and illustrations, with examples of projects that have resolved some of these issues. However, we do not yet know of a project that has resolved all of them.

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