



CONTENTS

Editorial	1	Summary of activities.	2
Project objectives	1	Summary per Work Packages.	2
Contractors involved	1	Conference "Africa and Carbon Cycle"	5
Work plan.	2	Eddy covariance site in the Bontioli Nature Reserve, Burkina Faso	5

CarboAfrica: the second year!

Editorial

Dear reader,

The second year of CarboAfrica activities has already finished. It is still early to present reliable results on the carbon balance of the Sub-Saharan Africa (SSA), however all the activities carried out during the first two years of CarboAfrica are going towards this direction. In this 6th issue of the CarboAfrica NewsLetter you can find a short introduction of the project objectives, and a summary presentation of the work performed and the preliminary achievements per work package. Moreover an overview of the CarboAfrica conference on "Africa and Carbon Cycle" (Accra, Ghana, 25-27 November 2008) is presented.

Finally we are happy to present a new eddy covariance field site that will contribute to the CarboAfrica database.

About one year remains before the project end, and we believe that at the end CarboAfrica will provide new important information for a better quantification of the terrestrial carbon budget of SSA, and for the estimation of the potential of SSA for carbon sequestration and emission reduction. We hope that this effort will continue also after the project end, and this last year will be important also to find additional resources to secure the continuation of most of the project activities.

The CarboAfrica Secretariat

CarboAfrica - Project objectives

CarboAfrica is an international project funded by the European Commission under the 6th Framework Programme.

The project duration is 3 years (01/10/06 - 30/09/09).

The general CARBOAFRICA goals are the following:

- a) to support and expand a network of continued and enhanced observations of carbon stocks, fluxes, atmospheric concentrations and ecological processes in sub-Saharan Africa (SSA);
- b) to improve biogeochemical models representing the main African ecosystem types;
- c) to better understand the role of fire emissions from SSA in the global carbon cycle;
- d) to enhance African capabilities to undertake mitigation and adaptation actions.

Contractors involved

The CarboAfrica partnership includes 15 Institutions from Europe (Italy: University of Tuscia, National Council for Researches, Institute of Agronomy for Overseas, and Second University of Naples; UK: Natural Environment Research Council, King's College London, and University of Leicester; France: Centre de Coopération Internationale en Recherche Agronomique pour le Développement, and Commissariat à l'Énergie Atomique; Sweden: Lund University; and Germany: Max-Planck-Institute for

Biogeochemistry) and Africa (Congo: Unité de Recherche sur la Productivité des Plantations Industrielles; South Africa: Council for Scientific and Industrial Research; and Sudan: Agricultural Research Corporation), and the Food and Agriculture Organization of the United Nations. An agreement has been signed with the AMMA (African Monsoon Multidisciplinary Analyses) consortium in order to establish a link between these two initiatives. Directly involved African countries are: Benin, Botswana, Burkina Faso, Ghana, Ivory Coast, Mali, Niger, Congo, South Africa, Sudan and Zambia.

Workplan

The work is organized in a multi-disciplinary integrated research approach through the division of main tasks in the following seven complementary work-packages:

WP1: Observation system & data integration & consolidation

WP2: Ecosystems processes understanding of carbon fluxes

WP3: Modelling for up-scaling to region and continent

WP4: Fire-Climates-Carbon cycle interactions

WP5: Communications and Capacity Development

WP6: Evaluation of a sustainable carbon sequestration

WP7: Project Management

Summary of activities

CarboAfrica provided practical and scientific coordination to the current Sub-Saharan Africa terrestrial monitoring network of carbon and other GHGs gases. All the main actors responsible for the networking sites are involved in the project and accepted the same data processing rules. Therefore the CarboAfrica database has been collecting data and processing them with the accepted standard harmonised method. Moreover, the network was also expanded through the installation of a new flux tower in South Africa and another one in the Evergreen Moist Tropical Forest in Ghana. This last is a new key site to the network, because it is the first field station measuring Carbon and other fluxes in an African tropical forest, and will give new essential information on the African global role in the climate system. Furthermore a new site in Burkina Faso from an external partner (see last article) will share its data with the CarboAfrica consortium, feeding the database. The connection with the AMMA network is ensured by an agreement.

Field campaigns in key regions for biomass and other ecological processes (leaf gas exchange and soil properties and fluxes, etc.) were conducted in order to have direct in situ measurements in support to the flux estimations and the remote sensing. Moreover the satellite images were also used to estimate aboveground carbon stock. The fire analysis considered a new burned area product, together with improved biomass burning carbon emissions estimates. Flux data, from soil and vegetation, and atmospheric CO₂ data, were integrated with the above field and fire data in a complex modelling framework, in order to generalize and upscale ecosystem level observations. All the above activities contributed to a better understand of the Sub-Saharan Africa GHG budget and its associated spatial and temporal variability.

Project activities aimed also to assess the current land use change and evaluate the mitigation potential of Sub-Saharan Africa through: i) sequestering C through Afforestation and Reforestation (A/R) projects and ii) reducing emissions from deforestation and forest degradation (REDD). Towards this objective the main ongoing activities are: developing a strategy for assessing C; quantifying losses of carbon and nutrient by run-off; improving of the growth model; analysing the variability of both below- and above-ground C stocks; assessing the impact of land use change on C sequestration potential and the impact of logging on C stocks.

Finally many communication and capacity building activities, dedicated in particular to African stakeholders, were carried out, in order to maximise the outreach of the project and the exploitation of the project's achievements.

Summary per WorkPackages

WP1: Observation system & data integration & consolidation

The eddy covariance flux network within the defined key regions is now completed and fully operational. The network even increased through the collaboration with a flux site in the Burkina Faso savanna (see the specific section below). Moreover the first eddy covariance flux site in an African tropical forest is now operational, improving the representativeness of the vegetation types considered by the CarboAfrica network. Data collection in the database is at a good point: all the sites of the network are currently submitting the requested flux and meteo data to the database, in some case even going back prior the project start. The harmonized and georeferenced maps and remotely sensed products at continental scale are now available (<ftp://ftp.bgc-jena.mpg.de/pub/>)

[outgoing/CAMIC/](#)). Finally the methodology initially proposed for biomass estimation, based on land cover and ecological data, has been modified and improved with the use of satellite data to develop a preliminary model based on satellite and land cover data to estimate biomass stock at national scale.

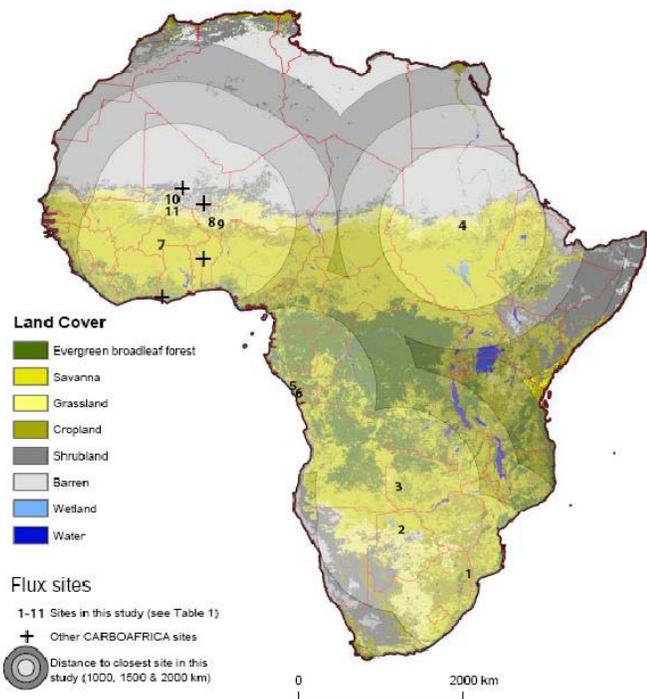


Figure 1. The most common land cover types in Africa and the locations of eddy-covariance sites.

WP2: Ecosystems processes understanding of carbon fluxes

Progress was made in site characterization and process analysis at all sites. Basic site characterization was continued at all sites and successfully completed at most sites, and process studies on soil respiration were conducted at core sites. More in details: the soil rewetting experiment after drought was conducted at 4 sites in Southern and Tropical Africa. Leaf gas exchange measurements were conducted at 2 sites in Zambia and South Africa. Detailed studies on heterogeneity of soil properties and fluxes were conducted at Mongu site (Zambia), Phalaborwa site (South Africa) and Ankasa site (Ghana) - only soil properties). Detailed studies on above- and belowground biomass dynamics of vegetation have been conducted in herbaceous savanna at Point Noire (Congo). Experiment on greenhouse gas fluxes after rewetting was conducted at Pointe Noire site (Congo), Mongu site (Zambia), Phalaborwa site and Skukuza site (both South Africa).

WP3: Modelling for up-scaling to region and continent

This workpackage is developing a complex modelling framework to generalize and upscale ecosystem level observations by integrating local and spatial data into data- and process-oriented models together with land surface schemes of different complexity. The following activities were carried out towards project objectives. Uncertainty estimation and synthesis of existing ongoing CO₂ and H₂O flux observations: first results show that maximum photosynthetic uptake is highly correlated with mean annual rainfall, and temperature is a main driver on ecosystem respiration at all sites. Modelling short-term CO₂ and energy fluxes in response to climate at flux tower sites and larger scales. Models of different complexity (LPJ-DGVM, JULES, ORCHIDEE, and LPJ-GUESS) were run: these models exhibit largest interannual variability in southern and eastern Africa. Six-month seasonal forecasts of NPP made with the ORCHIDEE model have been evaluated. Non-CO₂ GHGs emissions from soil were modelled: a model of both soil C and N is being developed, considering soil moisture and soil heterotrophic respiration. Climate-vegetation-fire dynamics were modelled. Models were improved by an improved representation of root water uptake, the adaptation of key parameters for vegetation distribution, the simulation of tree-grass coexistence in savanna ecosystems, and the introduction of new plant functional type. Atmospheric CO₂ concentration was measured to be incorporated by inverse modelling experiments. A new station, the Station de Géophysique de Lamto, Ivory Coast was set up to sample air CO₂ concentration at 50m elevation.

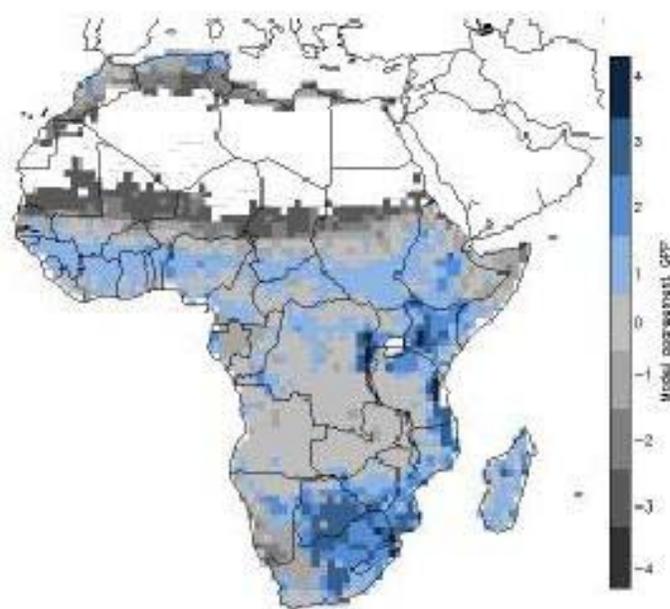


Figure 2. Model agreement based on standardized interannual variability of NEP (1982 - 2006). Greater 1 (blue scale, positive counts), smaller -1 (grey scale, negative counts).

WP4: Fire-Climate-Carbon cycle interactions

The following activities were carried out at level of WP4. A global daily burned area product L3JRC was delivered. It is derived from SPOT-VEGETATION, covers 7 years (2000-2007) and has 1 km resolution. An additional satellite analysis was carried out to derive burned area maps from the (i) AATSR/ENVISAT (Along-Track Scanning Radiometer) images and (ii) from MODIS. Fire-related carbon emissions were modelled for the period 2001-05 by scaling burned area estimates from the state-of-the-art satellite remote sensing product L3JRC, a map recently generated from remote sensing of burn scars instead of active fires. Carbon fluxes were calculated by using the SPITFIRE fire model embedded within the dynamic vegetation model framework LPJ-GUESS, using daily climate input. Initial analysis of human vs. lightning ignition on fire patterns and emissions was started in order to investigate the influence of human ignition on burned area and trace gas emissions. The importance of the various drivers of burnt area was assessed using a regression tree statistical modelling approach, from the 500m resolution MODIS (MOD45) burnt area product. The extent to which burnt area varies between years and the extent to which this can be predicted by variation in weather conditions were investigated by using long term (> 20 years) field data on burnt area together with multi-year (7 years) satellite-derived burn area products (MOD45). An analysis of the biomass burning patterns contained within "version 0" of the geostationary fire radiative power product for Africa was conducted. A synergistic combination of geostationary and polar-orbiting fire radiative power products was done to improve the biomass burning emissions assessment. The biomass burning carbon emissions estimates were also derived from the MODIS active fire record.

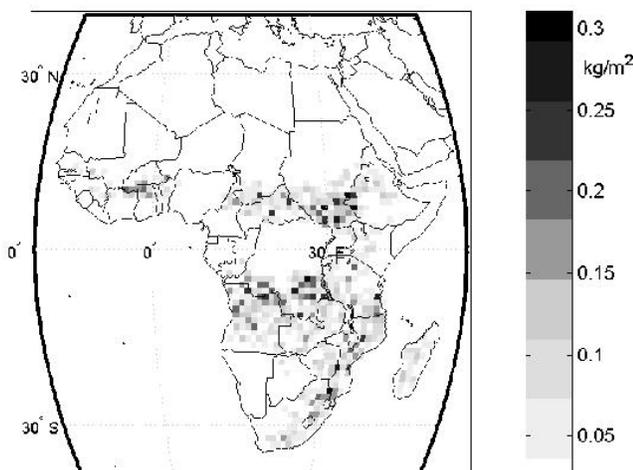


Figure 3. Average total annual C emissions by wildfires expressed as kgC m⁻² (2001 - 2006) simulated by LPJ-GUESS-SPITFIRE with burnt area prescribed from L3JRC.

WP5: Communications and Capacity Development

The activities related to the communication and dissemination tools (web portal; the mailing list server; the networking of organizations, agencies, students and individuals; the four-monthly newsletter; the publication of dissemination material) started on the first year, are still ongoing and will last until the end of the project, and even beyond. The WebPortal, the mailing list server, the four-monthly newsletter and the networking activities were improved and showed an increased impact towards the relevant audience, as confirmed by statistics showed in the table below.

Total Visitors	27698
Average Visitors per Day	75.7
Average Time Spent (min:sec)	0.1
Total Unique IPs	10933
Total Hits	255266
Average Hits per Day	697.4
Average Hits per Visitor	9.2

People registered in the mailing list server exceeded 300 units, increasing by 60% respect to the 1st year. Through the CarboAfrica consortium, currently more than 20 African and European university of PhD students are working on the project (and will work at least until the end of the project), in Europe and/or in Africa. This number has increased respect to the previous year. Two training workshop were held in order to train young African expert on carbon related issues. The first workshop was on "functioning, Biomass and carbon markets", Brazzaville (Congo), 10-14 December 2007 was attended by about 50 people on average (see the CarboAfrica NewsLetter N. 4, for more details). The second workshop was on "Carbon Cycle Measurements", , South Africa, 10-15 March 2008, and was attended by 14 African students (see the CarboAfrica NewsLetter N. 5, for more details). Support was given to African people for participating in the above workshops, and in the conference "Africa and Carbon Cycle: the CarboAfrica Project" (Accra, Ghana, 25-27 November 2008). Finally, scientific publications were produced; in particular, a Special Issue on "cycling in Sub-Saharan Africa" (Editors: R. Valentini, J. Canadell, and A. Bombelli) under publication in BioGeoScience (http://www.biogeosciences.net/special_issue37.html).

WP6: Evaluation of a sustainable carbon sequestration

The second year of WP6 was dedicated to the following actions: write a book on the estimation of

biomass and nutrient content in forest (in both English and French languages); pursue the field work and analyse the first sets of data; integrate results and knowledge into growth models. Among the results obtained, we can emphasize the following ones: the overall optimum strategy for assessing C stocks in a given forest was obtained through a cost-precision approach and will be applied during the third year of the project in Congo; the losses of carbon and nutrient in Eucalyptus plantations in Congo by run-off is to be quantified by the end of spring 2009; the methodology relating indicators of soil functioning and site index is about to be completed; the growth model that will be used for the Tier 3 estimation of carbon stocks and nutrients in Eucalypt plantations was improved (connection soil/plant) and completed for the new clones of interest; synthetic documents on REDD are regularly provided to follow the international negotiations and the state of the scientific debate, in order to respond as best as possible to African needs; the variability of both below- and above-ground C stocks at the continental scale were considered; impact of land use change on C sequestration potential as well as the impact of logging on C stocks in natural forests were studied in different ecological zones, and the final results will be available during year 3 of the project.



Figure 4. Experimental design for the artificial rainfall simulations.

Conference “Africa and Carbon Cycle”

Accra (Ghana), 25-27 November 2008

CarboAfrica organized a conference on “Africa and Carbon Cycle” in Accra (Ghana) from 25 to 27 November 2008, right after the Annual Project Meeting. The conference focused on the Africa's contribution to the global carbon cycle and climate system through an overview of the carbon related studies in Sub-Saharan Africa carried out both by the

project CarboAfrica and other African and international initiatives.

A number of talks presented current results from field campaigns, remote sensing and model estimates. Current results show that Africa plays a significant role in the global carbon cycle with potentially important climate change implications. African emissions by fossil fuel are still low, even if rapidly increasing. On the contrary Africa plays already a globally important role in fire and land use emissions (mainly by deforestation and forest degradation), though the magnitudes of these terms are highly uncertain.

Main conclusion is that there is a strong need for continued and enhanced observations of Africa's carbon stocks, fluxes and atmospheric concentrations. The current CarboAfrica network of GHGs measurements could provide future unique data sets to enable more precise assessments of Africa's carbon balance and its sensitivity to natural and anthropogenic pressures and future climate.

The European Commission, the funding organization of CarboAfrica, confirmed that Africa is a priority for the European Union, and further cooperation initiatives, especially on environmental issues, will be supported by UE.

The Conference brought together about 100 participants from 28 nations from Europe, Africa and rest of the world, presenting plenary talks and parallel contributions. A poster session was also organized, especially involving African students and young researchers.

The CarboAfrica Secretariat takes this opportunity to thank all participants for coming to Accra, for their valuable presentations and for the excited and fruitful discussions.

Eddy covariance site in the Bontoli Nature Reserve, Burkina Faso

Ulrike Falk (ZEF, University Bonn)

Nicolas Brüggemann (IMK-IFU)

A new eddy covariance site external to the project agreed to contribute to the CarboAfrica database. The site is located in a near-natural reserve in the southwest of Burkina Faso (province of Ioba, 280 km from the capital Ouagadougou). Measurements include an eddy covariance system, measuring CO₂, water and energy exchange and a climate station comprising different radiation sensors, i.e. long- and shortwave components of net radiation, PAR, and soil heat flux, soil moisture content and temperature, as well as air temperature and humidity. Measurements to investigate trace gas exchange and soil respiration were carried out on campaign

basis. The initial setup and work on EC measurements and additional research on trace gas exchange was part of a PhD work in the framework of a Virtual Institute, a joint project by the Institute of Meteorology and Climate Research Atmospheric Environmental Research Division (IMK-IFU) – Research Center Karlsruhe and the Center for Development Research (ZEF) – University Bonn, funded by the Helmholtz Association (Brümmer et al., 2008a, 2008b). Ongoing research at the site is currently supported by the joint framework of the BIOTA West and GLOWA Volta projects, funded by the German Federal Ministry for Education and Research.

The research site is classified as Sudanian savanna that up to now was not subject to human interference except for the annual burning as a measure by local authorities to prevent extensive wildfires during the dry season. The nature reserve consists of both shrub and wood savannah. The flux measurements are conducted in an area mainly dominated by grasses and shrubs. Dominating grass species during the rainy season, i.e. from May to October, are *Andropogon gayanus* and *Loudetiopsis kerstingii* across large parts of the reserve, reaching a height of 0.7m. Early in the dry period, the dry grass cover is removed by controlled fires arranged by the local environmental authority. Throughout the dry season, the vegetation consists of nearly equal portions of the shrub and tree species *Vitellaria paradoxa*, *Detarium microcarpum*, *Entada africana*, *Terminalia laxiflora*, *Combretum glutinosum*, *Acacia dudgeoni*, *Combretum collinum* and *Linnea microcarpa*. The height of the shrubs (1-2 m) and trees (max. 12 m) remains more or less constant (Brümmer et al. 2008b).

Since 2006, operation of the flux site was mainly realized with the help of the infrastructure of the GLOWA Volta project and a technician, carrying out calibration procedures at the site in monthly intervals. Sustaining a flux site in Africa, can be extremely prone to errors (Scholes, Fluxletter 2009). Besides the climatic conditions, i.e. air temperatures above 40°C, relative humidity varying from below 10% during the dry season and 90% during wet season, poses a hard test to any technical equipment. Additionally, technical infrastructure is poor, communication does not always work fast due to cultural and language barriers and technical problems mostly end up in data gaps of several weeks or months. Besides these problems, EC measurements in the Bontoli Nature Reserve are ongoing since 2005. Future planning involves a setup of the measurements in about 7 m height to also capture the signal from lower bushes and trees.

To our knowledge, the present study provides the first long-term dataset of EC measurements of carbon dioxide and energy exchange in a savanna in Sub-Saharan West Africa (Southern Sudanian Savanna).

Although each year considerable quantities of C were released again during burning of the senescent vegetation at the beginning of the dry season, the ecosystem acted as a remarkable C sink, however, with significant year-to-year variability. Additional research on the quantification of the amount of carbon released by burning is still needed. An important finding was that especially during the transition months between dry and wet season (April to June) as well as between wet and dry season (October) the ecosystem atmosphere CO₂ flux responded immediately to changes in water availability. Although during the dry season grass and lower bush vegetation is virtually dead, some tree species are still bearing green leaves, suggesting an access to lower ground water tables.

The first rains at the beginning of the wet season stimulated soil respiration more quickly and intensely than plant growth, leading to a burst in soil CO₂ efflux, whereas the drying out after the last rain at the beginning of the dry season led to a quicker cessation of photosynthetic activity than soil respiration. These findings stress the sensitivity of this ecosystem to inter-annual climate variability and changes in rainfall patterns, not only as a result of natural year-to-year variability, but also as a consequence of global climate change. However, to get a better insight of the effect of climate change on C sink/source strengths of savanna ecosystems, more long-term and additional manipulation studies, also comprising different savanna and land use types, are required (Brümmer et al, 2008a).

The research site is associated with the CarboAfrica project, and will be included into a joint paper on African ecosystems (Merbold et al. 2009). Data is currently uploaded into the CarboAfrica database.

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Related Links

ACE – African Carbon Exchange (ACE) Project
<http://www.nrel.colostate.edu/projects/ace>

AfDevInfo - African Development Information Services
www.afdevinfo.com/htmlreports/newsletter_7.aspx

AMMA - African Monsoon Multidisciplinary Analysis
<http://amma.mediasfrance.org>

CARBOEUROPE (Integrated Project CarboEurope-IP, Assessment of the European Terrestrial Carbon Balance)
<http://www.carboeurope.org>

Climate Change and Africa
www.climate.org/CI/africa.shtml

EO-LANDEG (Earth Observation initiative in a former homeland of South Africa in support of EU activities in land degradation and integrated catchments management)
<http://www.eolandeg.com>

ESASTAP - European South Africa Science and Technology Advancement Programme
<http://www.esastap.org.za/esastap/home/index.php>

European Commission - Evaluating protected areas in Africa
www.tem.jrc.it/PA/index.html

FIRMS - Fire Information for Resource Management System
<http://maps.geog.umd.edu/firms>

FLUXNET (Integrating Worldwide CO₂ Flux Measurements)
<http://www.fluxnet.ornl.gov/fluxnet/index.cfm>

GCP - Global Carbon Project
<http://www.globalcarbonproject.org>

ILEAPS - Integrated Land Ecosystem-Atmosphere Processes Study
<http://www.atm.helsinki.fi/ILEAPS/>

Marien Nguouabi University - University of Brazzaville, Congo
<http://www.univ-mngb.net/>

NEPAD - New Partnership for Africa's Development
<http://www.nepad.org/>

PASS - The Pan African START Secretariat
pass-africa.org/index.html

ROSELT - Réseau d'Observatoires de Surveillance Ecologique à Long Terme
mdweb.roselt-oss.org/index.php?la=eng

SAFARI 2000 Project
daac.ornl.gov/S2K/safari.html

TCO - Terrestrial Carbon Observation
<http://www.fao.org/gtos/TCO.html>

TroFCCA - Tropical Forest and Climate Change Adaptation
<http://www.cifor.cgiar.org/trofcca>

CarboAfrica Bibliographic Archive

CarboAfrica aims to create an archive of a comprehensive bibliography of papers related to Africa, carbon cycle, GHG and Climate Change. Therefore, please send to CarboAfrica@fao.org any document, publication, and presentation relevant to the topics mentioned above and CarboAfrica in particular. Then we will put them in the website <http://www.carbofrica.net> as downloadable documents, or just as references. In any case please let us know if there are any intellectual property rights and/or citation rules to be respected.

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