BIOENERGY CONTRIBUTION OF LATIN AMERICA, CARIBBEAN AND AFRICA TO THE GSB PROJECT

A briefing on LACAf – Cane-I

Project Overview

Modern and sustainable bioenergy production may be an effective way to substitute substantial portions of energy demand for transportation in the future. Since the overall scale of bioenergy production will in part depend on the availability of fertile land with good climatic conditions, it is clear that, if food production is to be increased to meet future needs and biodiversity protected, basically the world will consider the Latin America, the Caribbean and Africa for future expansion of bioenergy.

LACAf Project objective is to create a robust and updated perspective for sustainable bioenergy development in these regions, particularly considering the use of sugarcane as feedstock for producing biofuel and bioelectricity; and focusing on some countries (Colombia, Guatemala, Mozambique and South Africa), aiming to build a base for consistent decision making and offering a possible approach for similar contexts.

In addition to consider national development objectives, LACAf is in line with GSB Project goal, i.e., to sustainably meet a substantial fraction of future demand for energy services while feeding humanity and meeting other needs from managed lands, preserving wildlife habitat, and maintaining environmental quality.

Coordination: Luís Augusto Barbosa Cortez, NIPE/UNICAMP
Financing Institution: FAPESP

LACAf currently includes three subprojects, oriented towards the most general and methodology aspects, and other complementary projects are in discussion, focusing on environmental and social aspects.

Subproject 1. Regional diagnosis and Integrated analysis

Team: Prof. Luiz Augusto Horta Nogueira (Leading Researcher), PhD Klaus Dalgaard, Paulo Manduca, Mauro Berni, Cindy Sarmiento (Ms student)

Objective

To assess the conditions to foster sustainable bioenergy production, especially from sugarcane, exploring perspectives and drives, proposing methodologies and evaluating the resources and constraints, in a broad sense, as well as developing an integrated analysis of the available information and data.

Papers in preparation

The Replicability of the Brazilian Bioenergy Model in Africa
Dalgaard, K.G. and other

Skepticism abounds regarding the extent to which the Brazilian bioenergy model can be replicated in other countries. This research addresses the question of whether the Brazilian bioenergy model is replicable in Africa. It begins with a brief process tracing of Brazil's foreign policy initiative to promote biofuels in African states, followed by a description of what is meant by the "Brazilian bioenergy model". This research then seeks to identify the various bioenergy production models that the Brazilian government transfers through its international agreements with African states, in order to assess to which extent the so-called "Brazilian bioenergy model" is fully replicated. It is argued that one cannot legitimately discuss the concept of "replicability" where the Brazilian model is not fully replicated in all its aspects. Instead, any form of partial replication implies adaptability, rather than replicability, of the Brazilian bioenergy model.

The challenging image and public acceptability of biofuels in Africa – a conceptual and empirical analysis
Dalgaard, K.G. and other

Bioenergy development in Africa is often obscured by popular images of resource and land grabs, and is portrayed in the media as carrying several negative environmental and social impacts, with much concern expressed about its potential risks. Such an unfavorable discourse suggests that biofuels suffer from a negative image problem, which may be as important a factor for bioenergy development as any other factor (e.g., socioeconomic, edaphic, climactic). This research starts with a review of the literature on the subjects of public acceptance, discourse and opinion of biofuels, in order to confirm the importance of deliberation and better communication between decision-makers, technical experts, other stakeholders and the public, when deciding to

implement new bioenergy projects. The research then seeks to discover empirically, through interviews with experts and stakeholders, what the prevalent opinions and concerns about biofuels are in this project's selected case-study countries: South Africa and Mozambique. These findings will help identify the main challenges that arise from public concerns about bioenergy development and form the basis for recommendations on how to overcome these challenges.

Reports to be prepared

1. Diagnosis and Integrated Analysis of biofuels programs
2. Basic data and information on bioenergy in Colombia, Guatemala, Mozambique and South Africa
3. Consultation and Communication in Bioenergy: issues and principles

Subproject 2. Determining Land Use and Physical Near-Term Potential for Bioenergy Production in Latin America and Africa

Team: Prof. Edgar E. F. de Beauclair (Leading Researcher), André Nassar, Marcelo Cunha, Fernando Bertolani, Rubens Lamparelli

Objective

To assess the land use impacts of biofuels production in Latin America and Africa, by: building a base map of land cover; analyzing recent land use dynamics and identifying a pattern of land use change; simulating land use change according to biofuel production scenarios; evaluating potential GHG emissions due to land use change; identifying potential areas to sugarcane production in African and Latin American countries; quantifying the different production potential of sugarcane crops in these countries and modeling a crop to estimate final production.

Papers in preparation

Determining Bioenergy Potential in Latin America and Africa: the cases of Colombia, Guatemala, South Africa and Mozambique
Beauclair E.G.F. de and other

Subproject 3. Productive Models & Innovation Studies

Team: Prof. Manoel Regis Lima Verde Leal (Leading Researcher), PhD João Guilherme Leite, Dr Antonio Bonomi

Objective

To determine the most important items and the corresponding road map that will conduct the sugarcane ethanol production technologies from the present stage to a desired stage of performance, bearing in mind the specificities of each country under consideration.

Papers in preparation

Key points in the selection of the sugarcane ethanol production model: scale of distillery and the mechanization level in cane production
Leal, M.R.L.V. and other

The selection of the sugarcane ethanol production model is a very important decision with respect to the sustainability of the whole system. The best alternative will be highly dependent on the local conditions, the driving forces of the ethanol production and use and on a good equilibrium among the three pillars of sustainability: economic, environmental and social. The experience shows that the economic forces tend to drive the process at an early stage due to the necessity to attract investors, but the social aspect, especially in developing countries must be also be taken into account as soon as possible, before important decisions are taken. The environmental aspects are normally considered when the biofuel and feedstock are chosen, since this determines the GHG mitigation potential and the land demand for the intended production; nevertheless a full assessment of the environmental impacts will be necessary once the whole value chain of the sugarcane ethanol is defined. Among the key issues, the production costs and jobs and wealth creation should rank high due to the impacts on the long term survival of the business and the welfare benefits for the local community and for the country; the main points affecting these issues are the scale of the distillery, due to the economies of scale, and the mechanization level of the agricultural production of sugarcane, since it has a major impact on the quantity and quality of the jobs created by the enterprise.

This work will present some preliminary data on the impact of the choices made with respect to these two key points of the production model, based on the Brazilian conditions, and along the project the methodology will be adapted to the case studies context. This is expected to contribute to the discussion of the best production model with all project stakeholders.

Agroecological and socioeconomic impacts of sugar cane cultivation in Southern Africa

Leite, J. G. and Leal, M.R.L.V.

Despite the acknowledged opportunities, biofuel production still faces many challenges as failed initiatives (projects) keep mounting, with many barely reaching the feedstock production stage. A main limitation rests on resource (crop land, water, infrastructure, capital) competition between food and biofuel feedstock production and its consequences on food security, displacement of rural communities, job creation and environmental protection. Although farmers, as feedstock suppliers, can be integrated in biofuel value chains under different arrangements depending on the defined production scale and technology level (production model), limited knowledge is available on the opportunities and limitations of 'new' biofuel crops, i.e. sugar cane, *vis-à-vis* current farm activities. This information is essential to understand the impact of any bioenergy project and its ability to comply with the objectives of local communities while, at the same time, meeting the aspirations of entrepreneurs and government bodies. The main analytical components of our approach are based on data collection among farmers and local experts (scientists and development practitioners), and the assessment of different agricultural activities, such as sugar cane and other traditional crops (maize, cassava, sesame), on the selected indicators. Optimization models, among other analytical tools, might also be used during the impact assessment phase.

Reports to be prepared

1. Key Sustainability Issues to Be Considered in the Sugarcane Ethanol Production Model Selection Process: The Cases of South Africa and Mozambique.
2. The Need for Technology Improvement: A Road Map Suggestion for South Africa and Mozambique.

LACAf [and GSB] project[s] Meetings, March 2014
Terms of Reference

Rationale.

LACAf [and GSB] Projects, in the framework of BIOEN Project/FAPESP, aims to explore the main questions, potentials and constraints for implementing ethanol programs in tropical countries, particularly considering the cases of Colombia, Guatemala, Mozambique and South Africa, aiming to support consistent decision making towards to implement modern and sustainable bioenergy. In this context, one essential task is to study the reality of developing countries in Africa, Latin America and Caribbean in order to identify, model and evaluate production models for biofuels and bioenergy that could be successful in these countries. Possibly the Brazilian production model is not directly transferable to the different local characteristics of the studied countries, but offers a good starting point, for planning and evaluating purposes.

It is worth to note that the concept of "production model" is more comprehensive than "production system" (FAO, 1996; von Maltitz and Setzkorn, 2012), because it goes beyond the technological aspects of the biofuel production usually evaluated (Mandal et al., 2002; Wicke et al., 2007) and includes also direct and indirect socio-economic implications and institutional conditions, as schematized in Figure 1. Thus, the production model includes the production system.

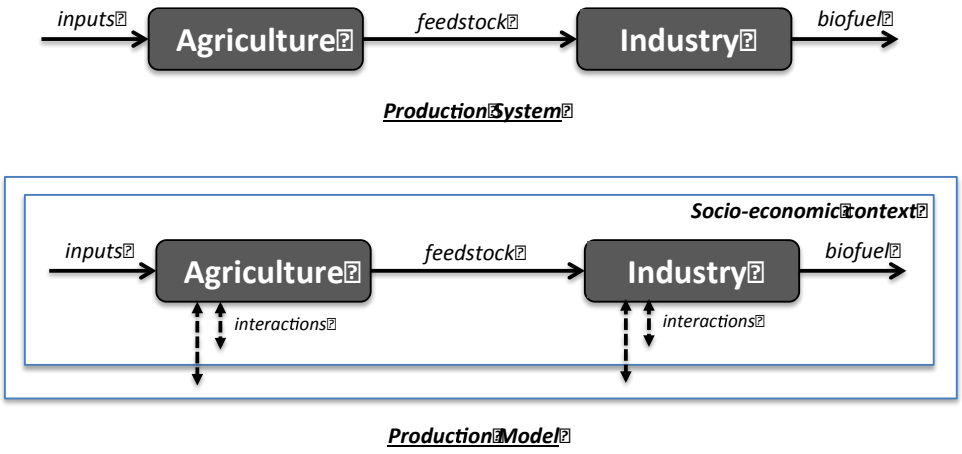

Figure 1. Production System and Production Model concepts

Since information from the field and direct interlocution with local stakeholders are essential aspects to be taken into account, the LACAf project combines experts from different fields and countries with the aim of exploring sustainable sugarcane ethanol production systems, establishing an open and fruitful discussion, where the participation of local players are very important. Under these guidelines, two sequential 3-day meetings of the Global Sustainable Bioenergy and LACAf projects are proposed during March, 31th

to April, 6th in South Africa (Kruger National Park) and Mozambique (Maputo) with the following objectives:

1) Update participants on activities associated with various parts of the project.
2) Include, hear from, and interact with representatives from the LACAf countries.
3) Enrich project participants with new perspectives.
4) Advance development of a vision for project-responsive environmental research.

Format, Participants, and Draft Schedule.

Both meetings are structured in terms of sessions considering:

1) Progress of LACAf-I Project, http:// 208.67.2.44/gsb/lacaf/index.php/lacaf-cane-i (NOT FULLY WORKING)
2) The GSB Project, http://bioenfapesp.org/gsb/
3) Perspectives from the LACAf countries, particularly South Africa and Mozambique,
4) Bioenergy & the LACAf countries (discussion),
5) New proposals on Geospacial Analysis, Socio-Economic Aspects, and Environment Impact.

In addition, the program features four "Topical Presentations" from persons who the GSB and LACAf projects are interested in interacting with and can learn from. Funding is requested to support travel and lodging expenses for Brazilian and international participants.

Invited participants.

Already covered by LACAf-I Project (10):
Edgar Beauclair- Department of Agriculture, ESALQ/USP
Luís Augusto Barbosa Cortez- FEAGRI, UNICAMP
Luiz Augusto Horta Nogueira- UNIFEI
André Nassar – ICONE
Manoel Regis L V Leal- CTBE
Fernando Bertolani – CTC
Felipe H. Gomes (Pedológica)
Klaus Dalgaard – Post-Doc LACAf-I, NIPE-UNICAMP
João Guilherme Leite - Post-Doc LACAf-I, NIPE-UNICAMP
Rubens Lamparelli, NIPE-UNICAMP

Brazilians (8): Covered by additional Fapesp Fundings

Luiz Martinelli- Center of Nuclear Energy and Agriculture, ESALQ/USP
Jansle Rocha- FEAGRI, UNICAMP
Suani Coelho, IEE-USP
Marcelo Cunha, IE-UNICAMP
Antonio Bonomi, CTBE
Marco Ospina, FEAGRI, UNICAMP
Rui da Maia, Universidade Técnica de Mozambique
João Chidamaio, Ahead Energy

Foreigners (10):

Americans (6):
Virginia Dale– Environmental Sciences Division, ORNL
Keith Kline- Environmental Sciences Division, ORNL
Lee Lynd- Thayer School of Engineering, Dartmouth College
John Sheehan- Institute on the Environment, University of Minnesota
Steve Perterson, Dartmouth College, USA
Tom Richards, PennState University, USA

Africans (4):
Mosad El-Missiry - Regional Integration and Infrastructure, NEPAD (Africa)
Ibrahim Assane Mya, NEPAD
Francis Yamba – CEEEZ, Zambia
Others suggested by NEPAD

South Africans are not counted here, because they will probably find funds to cover their costs.

Suggested topics for discussion:

-Sugarcane and cassava as feedstock: potential and constraints

- Biofuels in African countries: perspectives, recent evolution and national programs

- Capacity building requirements in African countries for biofuel production.

- Potential for ethanol use as fuel (in transport and cooking)

- Legal and regulatory aspects of biofuels production in Mozambique (feedstock, processing, distribution, etc.)

- Biofuels in Africa: for domestic or/and global markets?

Bioenergy Workshop Kruger National Park

April, 1-2, 2014

Kruger National Park – South Africa

PROGRAM

DAY 1 – APRIL, 1

8:30 – 9:00	**WELCOME & MEETING OVERVIEW** Emile van Zyl, Stellenbosch University (South Africa) ***Welcome & Workshop objectives*** Luís Cortez, UNICAMP (Brazil) ***LACAf Project overview*** Lee Lynd, Dartmouth University (USA) ***GSB Project overview***
9:00 – 10:30	**SESSION I: DISCUSSION ABOUT WHY BIOENERGY IN AFRICA?** ***Chair: Emile van Zyl, Stellenbosch University (South Africa)*** **Sustainable Energy for All and NEPAD Bioenergy Project Incubator** ***20 min*** Mosad Elmissiry, New Partnership for Africa's Development – NEPAD (South Africa) **Communication and Consulting Challenges in Biofuels** ***20 min*** Luiz Augusto Horta Nogueira, UNIFEI & UNICAMP (Brazil) **The Replicability of Brazil's Bioenergy Model in Africa** ***20 min*** Klaus Dalgaard, LACAf's pos-doc (Brazil) ***Round table and Discussion with*** ***30 min*** Lee Lynd, Dartmouth University (USA) Luís Cortez, UNICAMP (Brazil) ***Reporteur: Mauro Berni, UNICAMP (Brazil)***
10:30 – 11:00	**COFFEE BREAK**
11:00 – 13:00	**SESSION II: DETERMINING THE BIOENERGY POTENTIAL IN AFRICA - HOW MUCH CAN BE PRODUCED CONSIDERING SUGARCANE?** ***Chair: Luís Cortez, UNICAMP (Brazil)*** ***Constraints in Land Use for Biomass Production in Mozambique*** ***20 min*** André Nassar, AGROICONE (Brazil) **Determining the Biomass Potential in South Africa and Mozambique** ***20 min*** Fernando Bertolani, Sugarcane Technology Center – CTC (Brazil) Edgar De Beauclair, School of Agriculture - ESALQ/USP (Brazil) **Increasing ethanol production in Southern Africa: Opportunities and challenges** ***20 min*** Johann Gorgens, Stellenbosh University (South Africa) ***Round table and Discussion with*** ***60 min*** Rui da Maia, Technical University of Mozambique (Mozambique) John Sheehan, University of Minnesota (USA) Kalaluka Munyinda, CEEEZ (Zambia) ***Reporteur: Paulo Manduca, UNICAMP (Brazil)***
13:00 – 14:30	**LUNCH**
14:30 – 16:30	**SESSION III: GEOSPACIAL ANALYSIS IN AFRICA: CAN LAND USE BE OPTIMIZED?** ***Chair: Keith Kline, Oak Ridge National Laboratory – ORNL (USA)*** **Land use mapping/Change analysis using time series of satellite images** ***20 min*** Jansle Rocha, UNICAMP (Brazil) **Mixed crop-livestock detection/mapping using remote sensing** ***20 min*** Rubens Lamparelli, UNICAMP (Brazil) **Pasture Intensification** ***20 min*** John Sheehan, University of Minnesota (USA)

	Round table and Discussion with ***60 min*** Mosad Elmissiry, New Partnership for Africa's Development – NEPAD (South Africa) André Nassar, AGROICONE (Brazil) João Chidamoio, Ahead Energy (Mozambique) ***Reporteur: Felipe H. Gomes, Pedológica (Brazil)***
DAY 2 – APRIL, 2	
8:30 – 9:40	**SESSION IV: FOOD AND ENERGY SECURITY IN AFRICA** ***Chair: João Chidamoio, Ahead Energy (Mozambique)*** **Modern bioenergy and its potential role towards enabling a sustainable future for southern Africa** ***20 min*** Annie Chimphango, Stellenbosch University (South Africa) **Socioeconomic impacts in Mozambique due to sustainable sugarcane bioethanol production scenario** ***20 min*** Marcelo Pereira da Cunha, UNICAMP (Brazil) ***Round table and Discussion with*** ***30 min*** Rui da Maia, Universidade Técnica de Moçambique (Mozambique) Manoel Regis Lima Verde Leal, CTBE (Brazil) ***Reporteur: Marco Ospina, UNICAMP (Brazil)***
9:40 – 9:55	**COFFEE BREAK**
9:55 – 11:25	**SESSION V: ENVIRONMENT ISSUES FOR BIOFUELS PRODUCTION IN AFRICA** ***Chair:*** **Suani Coelho, USP (Brazil)** **Opportunities to Design Biofuel Systems for Multiple Environmental Services and Socioeconomic Benefits** ***20 min*** Virginia Dale, Oak Ridge National Laboratory – ORNL (USA) **What we know about environmental and social consequences of biofuels production and we should avoid in the future** ***20 min*** Luiz Martinelli, Center of Nuclear Energy and Agriculture - ESALQ/USP (Brazil) **Energy Security and Human Development: Pathways to Sustainability** ***20 min*** Tom Richard, Pennsylvania State University - PSU (USA) ***Round table and Discussion with*** ***30 min*** Mike Jacobson, Pennsylvania State University - PSU (USA) Edgar De Beauclair, School of Agriculture - ESALQ/USP (Brazil) ***Reporteur: João Guilherme Dal Bello, Post-Doc LACAf-I (Brazil)***
11:25 – 12:45	**SESSION VI: ISSUES CONCERNING THE PRODUCTIVE MODEL AND INDUSTRY** ***Chair: Emile van Zyl, Stellenbosch University (South Africa)*** **An overview of the South African sugar industry** ***20 min*** Luke Brouckaert, South African Sugar Industry (South Africa) **The New Approach of the Sugar Industry to Diversity Processing to Include Biorefineries and Integrate Bioenergy and Valuable Bio-Product Production** ***20 min*** Steve Davis, SMRI (South Africa) **What Scale Should We Consider?** ***20 min*** Manoel Regis Lima Verde Leal, CTBE (Brazil) ***Round table and Discussion with*** ***20 min*** Antonio Bonomi, CTBE (Brazil) Nico Stoltz, South African Sugar Industry (South Africa) ***Reporteur: Klaus Dalgaard, Post-Doc LACAf-I (Brazil)***
12:45 – 13:30	**LUNCH**
13:30 – 17:00	**TSB TECHNICAL VISIT**

Bioenergy Workshop Kruger National Park

André Nassar	Institute for International Trade Negotiations – ICONE (Brazil)	amnassar@agroicone.com.br
Annie Chimphango	Stellenbosch University	jgorgens@sun.ac.za
Antonio M. Bonomi	Brazilian Bioethanol Science and Technology Laboratory - CTBE (Brazil)	antonio.bonomi@bioetanol.org.br
Edgar De Beauclair	Luiz de Queiroz College of Agriculture - Esalq (Brazil)	beauclair1@gmail.com
Emile (WH) van Zyl	Stellenbosch University	whvz@sun.ac.za
Erica Smithwick	Pennsylvania State University - PSU (USA)	smithwick@psu.edu
Fabiana Gama Viana	University of Campinas - Unicamp (Brazil)	fabianagviana@nipeunicamp.org.br
Felipe Haenel Gomes	Pedológica (Brazil)	felipe@pedologica.com.br
Fernando César Bertolani	Centro de Tecnologia Canavieira – CTC (Brazil)	fcbertolani@ctc.com.br
Graham von Maltitz	CSIR	
Jansle Rocha	University of Campinas - Unicamp (Brazil)	jansle.rocha@feagri.unicamp.br
Joao Chidamoio	Partnersforinnovation (Mozambique)	chidamoio@gmail.com
João Dal Belo Leite	University of Campinas - Unicamp (Brazil)	dalbeloleite@yahoo.com.br
Johann F Gorgens	Stellenbosch University	jgorgens@sun.ac.za
John Sheehan	University of Minnesota (USA)	sheeh179@umn.edu
Keith Kline	Oak Ridge National Laboratory – ORNL (USA)	klinekl@ornl.gov
Klaus Dalgaard	University of Campinas - Unicamp (Brazil)	klausgdalgaard@gmail.com
Lee R. Lynd	Dartmouth University (USA)	lee.r.lynd@dartmouth.edu
Luis A. B. Cortez	University of Campinas - Unicamp (Brazil)	luisabcortez@yahoo.com.br
Luiz A. H. Nogueira	Universidade Federal de Itajubá - Unifei (Brazil)	horta@unifei.edu.br
Luiz Martinelli	Centro de Energia Nuclear na Agricultura – CENA / University of São Paulo - USP (Brazil)	martinelli@cena.usp.br
Luke Brouckaert	TSB	BrouckaertL@tsb.co.za
Manoel Regis L. V. Leal	Brazilian Bioethanol Science and Technology Laboratory - CTBE (Brazil)	regis.leal@bioetanol.org.br
Marcelo Cunha	University of Campinas - Unicamp (Brazil)	marcelocunha@eco.unicamp.br
Marco Ospina	University of Campinas - Unicamp (Brazil)	marco.ospina@feagri.unicamp.br
Mauro D. Berni	University of Campinas - Unicamp (Brazil)	mauro_berni@nipeunicamp.org.br
Mike Jacobson	Pennsylvania State University - PSU (USA)	mgj222@gmail.com
Mosad Elmissiry	NEPAD	mosade@nepad.org
Nelda Rousseau	Bioenergy workshop organizer	BrouckaertL@tsb.co.za
Nico Stoltz	TSB	StolzN@tsb.co.za
Oliver Ruppel	Stellenbosch	achimpha@sun.ac.za
Paulo Manduca	University of Campinas - Unicamp (Brazil)	manduca@unicamp.br
Rubens Lamparelli	University of Campinas - Unicamp (Brazil)	lamparel@unicamp.br
Rui da Maia	Technical University of Mozambique (Mozambique)	damaia.rui59@gmail.com
Steve Davis	SMRI	neldar@telkomsa.net
Suani Coelho	Brazilian Reference Center on Biomass – CENBIO / University of São Paulo - USP (Brazil)	suani27@hotmail.com
Tom Richard	Pennsylvania State University - PSU (USA)	tlr20@engr.psu.edu
Virginia Dale	Oak Ridge National Laboratory – ORNL (USA)	dalevh@ornl.gov

LACAf Workshop Mozambique

André Nassar	Institute for International Trade Negotiations – ICONE (Brazil)	amnassar@agroicone.com.br
Antonio M. Bonomi	Brazilian Bioethanol Science and Technology Laboratory - CTBE (Brazil)	antonio.bonomi@bioetanol.org.br
Edgar De Beauclair	Luiz de Queiroz College of Agriculture - Esalq (Brazil)	beauclair1@gmail.com
Fabiana Gama Viana	University of Campinas - Unicamp (Brazil)	fabianagviana@nipeunicamp.org.br
Felipe Haenel Gomes	Pedológica (Brazil)	felipe@pedologica.com.br
Fernando César Bertolani	Centro de Tecnologia Canavieira – CTC (Brazil)	fcbertolani@ctc.com.br
Jansle Rocha	University of Campinas - Unicamp (Brazil)	jansle.rocha@feagri.unicamp.br
Joao Chidamoio	Partnersforinnovation (Mozambique)	chidamoio@gmail.com
João Dal Belo Leite	University of Campinas - Unicamp (Brazil)	dalbeloleite@yahoo.com.br
Klaus Dalgaard	University of Campinas - Unicamp (Brazil)	klausgdalgaard@gmail.com
Lee R. Lynd	Dartmouth University (USA)	lee.r.lynd@dartmouth.edu
Luis A. B. Cortez	University of Campinas - Unicamp (Brazil)	luisabcortez@yahoo.com.br
Luiz A. H. Nogueira	Universidade Federal de Itajubá - Unifei (Brazil)	horta@unifei.edu.br
Manoel Regis L. V. Leal	Brazilian Bioethanol Science and Technology Laboratory - CTBE (Brazil)	regis.leal@bioetanol.org.br
Marcelo Cunha	University of Campinas - Unicamp (Brazil)	marcelocunha@eco.unicamp.br
Marco Ospina	University of Campinas - Unicamp (Brazil)	marco.ospina@feagri.unicamp.br
Mauro D. Berni	University of Campinas - Unicamp (Brazil)	mauro_berni@nipeunicamp.org.br
Paulo Manduca	University of Campinas - Unicamp (Brazil)	manduca@unicamp.br
Rubens Lamparelli	University of Campinas - Unicamp (Brazil)	lamparel@unicamp.br
Rui da Maia	Technical University of Mozambique (Mozambique)	damaia.rui59@gmail.com
Suani Coelho	Brazilian Reference Center on Biomass – CENBIO / University of São Paulo - USP (Brazil)	suani27@hotmail.com

Author: André Nassar – AGROICONE

Title: Land use impacts of biofuels production in Latin America and Africa, with an emphasis in Mozambique

Agricultural activities have altered our planet's land surface. The expansion of agricultural feedstock for biofuel production has potential to change land cover and land use in Latin American and African countries. Besides being economically viable, sustainable biofuels production must consider its impacts the environment, food production and in local livelihood, which are greatly affected by land use. A comprehensive assessment of biofuel sustainability requires an analysis of land use.

The main objective of the presentation is to explore the land use impacts of biofuels production in Latin America and Africa. Special attention will be given to the case of sugarcane ethanol expansion in Mozambique. To fulfill the main objective, the following specific objective must achieved:

(1) Build a base map of land cover;
(2) Analyze recent land use dynamics and identifying a pattern of land use change;
(3) Simulate land use change according to biofuel production scenarios;
(4) Evaluate potential GHG emissions due to land use change.

Having good quality and updated GIS information on land cover and land use is a pre-requirement of land use analysis. Such information was not available for Mozambique, so researchers identified the need for building the most actual land cover and land use map for Mozambique. Two maps were produced for the reference years of 2001 and 2013, merging satellite imagery, secondary data and maps based on and local information. Sugarcane mapping received special attention. Land use trends were identified and historical (2001-2013) GHG emissions due to sugarcane expansion were accounted.

Next steps of the project consist of forward-looking analysis of the potential sugarcane ethanol in Mozambique and its impacts. Such analysis will build on achievements presented above and will consider national legislation, logistics and infrastructure, profitability of sugarcane mills, internal and international market restrictions and incentives.

Author: Annie Fabian Abel Chimphango – Stellenbosch University

Title: Modern bioenergy and its potential role towards enabling a sustainable future for Southern Africa

The roles of modern bioenergy in the fuel transport system as a greenhouse gas mitigation strategy and a damper to fluctuating oil prices are globally recognised. However, for Africa, the modern bioenergy is a potential catalyst for meeting the critical needs beyond the transport fuel. Modern bioenergy is considered a backbone for meeting food and household energy securities, providing improved health and education services, and a tool for job creation & gender upliftment and agricultural development, thus, boosting local economies. These diversified needs can only be achieved if the needs and interests of the rural poor are mainstreamed in the designing of the bioenergy systems. Therefore, the implementation of sustainable bioenergy systems in Africa should consider business models that are inclusive of all stakeholders to ensure ownership and empowerment of the African poor. This requires identification and optimisation of areas in the bioenergy value chain, thus feedstock production to energy product utilisation, where most of these needs can be met. The paper presents some local initiatives in Southern Africa where bioenergy has potential to improve rural livelihoods. Furthermore, the paper identifies some gaps and weaknesses in the current bioenergy value chain analyses concerning the real impact of bioenergy on rural livelihoods in Southern Africa, which might inform some of the LACAf/GSB activities.

Author: Antonio Bonomi

Title: Integrated Assessment of Different Sugarcane Scenarios. The Virtual Sugarcane Biorefinery

The Virtual Sugarcane Biorefinery (VSB) is an innovative framework that integrates computer simulation platforms with economic, social and environmental evaluation tools to assess technical and sustainability impacts of different sugarcane biorefinery alternatives, considering all the phases of the sugarcane production chain: agricultural sugarcane production, feedstock transport, industrial biorefinery conversion, products transport and commercialization and final use and/or disposal of the products.

The VSB performs mass and energy balances integrating the complete sugarcane production chain. While for agricultural, feedstock and product transport and product commercialization and use operations the mass and energy balances are performed using electronic spreadsheet models, the complexity of the industrial technology requires the use of a simulation platform such as AspenPlus®. The obtained mass and energy balances are used as basis for elaboration of integrated inventories on the entire sugarcane chain. These inventories are then linked to an economic assessment tool for calculation of economic impacts and to a life cycle assessment tool (e.g. SimaPro®) for evaluation of its environmental impacts. In this way, the VSB framework links all the sugarcane chain, allowing an integrated assessment of sustainability indicators such as economic parameters (internal rate of return and products production costs), as well as emissions, energy requirements and other environmental aspects. This framework has great potential for application in the sugarcane biorefinery sustainability optimization process.

Examples of assessments performed using the VSB are: flexibility of first generation plants – ethanol x sugar; integration of second generation process (fully integrated first and second generation x stand-alone second generation plants); flexibility of second generation plants – ethanol x electricity; different sugarcane straw recovery systems in the field; different alternatives of vinasse use for ferti-irrigation; controlled traffic structure for sugarcane harvesting; different strategies for operation extension of sugarcane biorefineries; anhydrous x hydrated ethanol uses.

Author: Edgar G.F.de Beauclair – ESALQ/USP

Title: Modelling Sugar Cane Productivity

Principles and concepts of different levels of yields due to determining, limiting and reducing factors and its relationships are discussed with the ecophysiology of sugar cane. Conceptual models are also named and discussed toward simplification to achieve an usable tool to determine cane production potential for first generation of biofuels.

Knowledge gaps will have to be treated under certain conditions to provide liability. The remote sense studies will define suitable areas to grow the crop, divided into 3 big general groups of yield potential by technical criteria.

The math model is described under a SWOT analysis to give a better idea of the limitations and the advantages of using it, as much as the need and directions for future upgrades.

Authors: WH (Emile) Van Zyl*[1], R den Haan[1], SH Rose[1], M VIljoen-Bloom[1], AFA Chimphango[2], JF Görgens[2], and JH Knoetze[2]– Penn State University

Title: Modern bioenergy and its potential role towards enabling a sustainable future for southern Africa

NRF Senior Chair in Energy Research: Biofuels,
Departments of [1]Microbiology and [2]Process Engineering,
Stellenbosch University, Stellenbosch, South Africa

Bioenergy, particularly biofuels, have played a pivotal role in Africa in the past and could help address the need for energy expansion in the future, especially when considering up to 80% of African countries rely on traditional firewood to meet their energy needs for that Africa has to embrace modern bioenergy technologies with higher efficiencies. Lignocellulose is globally recognized as the preferred biomass for the production of a variety of fuels and chemicals that may result in the creation of a sustainable chemicals and fuels industry. Within the African context bioenergy/biofuels production has to be integrated with food production to (i) provide local energy and (ii) promote food security by providing alternative markets, and very important, should be (iii) socially-beneficial to the rural population at large.

The Chair of Energy Research (CoER): Biofuels focuses on the technological interventions required to develop commercially-viable advanced (2^{nd}) generation lignocellulose conversion technologies to biofuels in Southern Africa. The CoER : Biofuels research program undertook to develop both biochemical (CBP yeast development) and thermo-chemical technologies for complete conversion of plant biomass to biofuels. Some examples for energy integration between lignocellulosic conversion processes and adjacent industrial processes (including existing bio-based industries) to achieve more attractive financial returns, will be discussed.

Finally, the sustainable production of sufficient food and modern bioenergy/biofuels to enable social transformation in southern Africa will be contextualized in a common vision and road map established in close collaboration between Stellenbosch University, NEPAD as political implementation arm of the African Union, and the fast experience from the Bioenergy programme of FAPESP in Brazil, coordinated by the CoER: Biofuels.

Author: Jansle V. Rocha – FEAGRI/UNICAMP

Title: Land use mapping/change analysis using time series of satellite images

Agriculture dynamics is a challenge for keeping an updated global land use dataset, which is essential to fully analyse land potential for bioenergy crops and callibrate yield potential models. Multitemporal satellite imagery has high potential for mapping and monitoring agricultural dynamics such as land use changes and land use intensification. The recent increase in availability of satellite sensors with a variety of spatial, spectral, radiometric and temporal resolution has resulted in new demands for the development of digital classification methods that could be adapted for global scale mapping. The main goal is to present methodologies for detecting land use changes/intensification with examples in Brazil and potential applications in Africa.

Author: JF Görgens, - Stellenbosch University

Title: Increasing ethanol production in Southern Africa: Opportunities and challenges

Bio-ethanol is today the most important biofuel in the global economy, representing the largest volumes of biofuel production and consumption. Most of the global bio-ethanol production is in Brazil (sugarcane) and the USA (corn), although there is significant global interest to increase production in various parts of the world, also in Southern Africa. Sugarcane ethanol is widely considered to be more environmentally beneficial than corn-based ethanol, due to improved carbon- and energy-balances.

Previous studies have shown potential availability of up to 6 million hectares of agricultural land for sugarcane cultivation in Southern Africa, without negatively affecting food production, biodiversity or ecologically sensitive areas (Watson et al., 2011). Furthermore, Southern Africa has a well-established sugar industry, with various plans for expansion outside of South Africa. Sugar producers in South Africa primarily supply the local market, but also export a portion of sugar produced. However, international sugar prices are not attractive, providing possible economic incentives for conversion of part of the available sugar stream into ethanol, as per the Brazilian model. A third option for increasing production of ethanol is through the use of lignocellulosic plant biomass, preferably in the form of agricultural and forestry residues/wastes, as feedstock. Significant progress has been made towards commercialisation of technologies for cellulosic ethanol production, but cost of production remains a key barrier.

Expansion of ethanol production in the Southern Africa context is therefore not limited by feedstock availability, with various opportunities for expansion of sugarcane (and grain-based) feedstocks, diversion of export sugar and use of lignocellulose as feedstock. There are concerns around sustainability of such feedstock supply, which warrants further investigation, but substantial opportunities remain even when taking such considerations into account. The economics of ethanol production remains as a key barrier to expanded production. The South African sugar industry awaits clarification on pricing of bio-ethanol for blending into the local fuel pool, to ensure economic benefits in diversion of export sugar to ethanol. Similarly, previous efforts at establishing dedicated ethanol production facilities based on first generation technology, have been hampered by lack of coordination in regulations and mandated blending. The production of cellulosic ethanol is likely to be best achieved by either (i) utilising a zero-cost or negative-cost waste stream for biomass processing, such as paper sludge from paper/pulp mills and xylose-rich effluents from such facilities, or (ii) integration of cellulosic ethanol production into a first generation production plant, to maximise process integration and conversion efficiency, as a means to minimise capital and operational expenses for cellulosic ethanol production. Concerted efforts are required

from governments in the region to create sufficiently attractive commercial opportunities that will warrant economic viability of expanded ethanol production.

Author: John Sheehan – University of Minesota

Title: Climate Bins model for calculating land pasture potential intensification

Sustainably increasing agricultural production on existing managed lands is a key strategy for meeting anticipated food and energy needs from a finite amount of land. Use of climatically-defined "bins" is a leading approach for evaluating the potential of intensifying per hectare agricultural production and related yield gaps. This approach is well developed for row crops (Licker et al, 2010, Mueller et al, 2012), but has not previously been applied to pasture land.

The potential for intensifying global pasture-based livestock production is evaluated based on the gap between today's lowest and highest livestock density within climatically similar bins. Increasing densities to their climate-appropriate, maximum currently-attainable level would allow existing pastureland to support 3.75 fold more animals. Bringing the poorest- performing pastures up to 50% of their maximum attainable density would double the global stock of grazing animals. The potential for intensifying pasture appears to be several-fold larger than that for grain cops determined using a similar approach, although further study is needed to address several key points. In particular, including animal performance (weight gain per ha per year) may substantially increase the intensification potential estimated here.

Future work and potential implications for bioenergy and economic development will be briefly discussed.

Licker et al (2010), "Mind the gap: how do climate and agricultural management explain the yield gap of croplands around the world?" *Global Ecology and Biogeography,* **19***, pp. 769-82.*

Mueller et al (2012), "Closing yield gaps through nutrient and water management," *Nature*, **490**(7419), pp. 254-7.

Author: Klaus Guimarães Dalgaard – NIPE/UNICAMP

Title: The Replicability of Brazil's Bioenergy Model in Africa

During his administration, Brazil's president Lula (2003-2010) repeatedly stated in official visits to African countries that "helping Africa to realize its full development potential is [official] state policy" in Brazil. The help offered by the Brazilian government to many African states almost invariably included assistance to develop bioenergy programs in those countries. In his speeches, Lula touted the idea that his country's successful experience with biofuels could easily, and should, be replicated throughout the African continent, wherever the soil and climate conditions are similar to Brazil's. However, skepticism abounds regarding the extent to which the Brazilian bioenergy model can be replicated elsewhere, or even if its success is unique to its own context. This paper begins with a description of what is meant by "the Brazilian bioenergy model", followed by a brief process tracing of Brazil's foreign policy initiative to promote biofuels in African states. Next, the paper discusses some of the opportunities that Brazil's bioenergy model can offer to African countries, according to the Brazilian government's official discourse. Lastly, the paper raises some of the challenges faced by two cases of Brazilian government initiatives to promote biofuel programs in Africa: Pro-Renova and Pro-Savana. It is concluded that, if these challenges can be surmounted, the opportunities presented by the Brazilian bioenergy model outweigh its potential hazards in Africa.

Author: Lee Lynd – Dartmouth College

Title: Bioenergy, Transformation, and Development

Perspectives will be offered on the dynamic public opinion landscape for bioenergy, including a swing toward the negative in the 2008 to 2013 timeframe, and signs that the factors underlying this negative swing are dissipating. Within this context, efforts such as the GSB and LACAf projects, SCOPE, and the NEPAD-FAPESP partnership are working to develop a positive vision for the need and merit of bioenergy, in which development is an increasingly prominent focus. Thoughts will be presented on the possibility that a transformation of understanding is underway with respect to bioenergy, that this will enable a transformation of human livelihoods in land- and biomass-rich areas of the developing world, and actions that could accelerate these trends.

Author: Luiz Antonio Martinelli – CENA/USP

Title: What we know about environmental and social consequences of biofuels production and we should avoid in the future

Biofuels are produced worldwide because countries are seeking alternative energy sources due to energy security issues, and because countries also intend to use biofuels as a way to foster rural development and produce a more environmental-friend source of energy. As a consequence several countries of the world have mandates to add biofuels to their energy grid. One of the main crops used in tropical areas of the world as a feedstock to biofuels is sugarcane. The harvested sugarcane area in 2012 according to FAO was approximately 26 million hectares; of this total 50% is produced in the Americas, 42% in Asia and 6% in Africa. Sugarcane area has been growing constantly since the 60's and the growth of rate has been similar among the three continents (Figure 1). At country level main producers are Brazil and India. Considering that Africa has 55 countries, 40 of them (73%) produces sugarcane, and the main producers are South Africa, South Africa, Egypt, Cameroon, Madagascar, and Kenya.

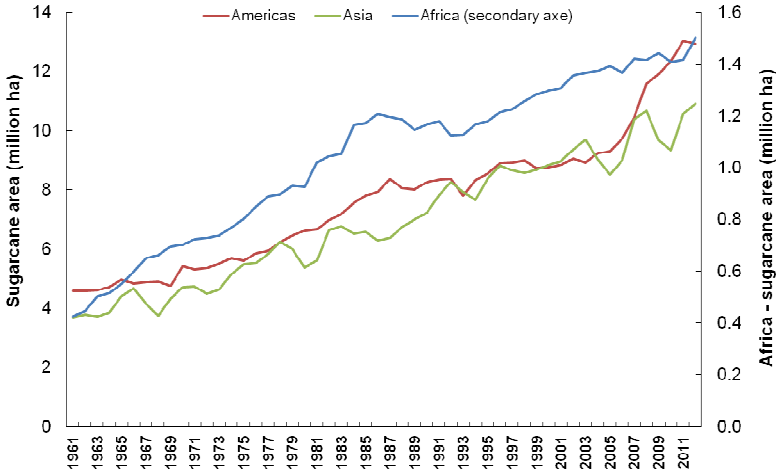

Figure 1. Sugarcane harvested area in the Americas, Asia and Africa (secondary axe).

As any crop, if not well managed sugarcane and sugarcane industry (sugar and ethanol) may have several unattended consequences to the environment and to social aspects. In this presentation I would like to discuss what we know about environmental and social consequences of sugarcane expansion in the world with the hope to bring attention to these concerns as a way to avoid them in the future. Special attention will be given to a comparison between Brazil and Africa main producers and Guatemala and Colombia, which are part of the LACAf project.

I propose to take one of the working hypotheses of the Global Sustainable Biofuel initiative as our overarching question (*Is it physically possible to "make room" for bionergy while honoring other land use priorites?*) and add a related second question: *"What will be the "environmental and social prices" that we have to pay to "make room" for bioenergy?*

During his administration, Brazil's president Lula (2003-2010) repeatedly stated in official visits to African countries that "helping Africa to realize its full development potential is [official] state policy" in Brazil. The help offered by the Brazilian government to many African states almost invariably included assistance to develop bioenergy programs in those countries. In his speeches, Lula touted the idea that his country's successful experience with biofuels could easily, and should, be replicated throughout the African continent, wherever the soil and climate conditions are similar to Brazil's. However, skepticism abounds regarding the extent to which the Brazilian bioenergy model can be replicated elsewhere, or even if its success is unique to its own context. This paper begins with a description of what is meant by "the Brazilian bioenergy model", followed by a brief process tracing of Brazil's foreign policy initiative to promote biofuels in African states. Next, the paper discusses some of the opportunities that Brazil's bioenergy model can offer to African countries, according to the Brazilian government's official discourse. Lastly, the paper raises some of the challenges faced by two cases of Brazilian government initiatives to promote biofuel programs in Africa: Pro-Renova and Pro-Savana. It is concluded that, if these challenges can be surmounted, the opportunities presented by the Brazilian bioenergy model outweigh its potential hazards in Africa.

Author: Manoel Régis, L.V. Leal, Otávio Cavalett, Mateus Ferreira Chagas, João Guilherme Leite and Antonio Bonomi – CTBE/BRAZIL

Title: Key points in the selection of the sugarcane ethanol production model: scale of the distillery and the mechanization level in cane production.

The selection of the sugarcane ethanol production model is a very important decision with respect to the sustainability of the whole system. The best alternative will be highly dependent on the local conditions, the driving forces of the ethanol production and use and on a good equilibrium among the three pillars of sustainability: economic, environmental and social. The experience shows that the economic forces tend to drive the process at an early stage due to the necessity to attract investors, but the social aspect, especially in developing countries must be also be taken into account as soon as possible, before important decisions are taken. The environmental aspects are normally considered when the biofuel and feedstock are chosen, since this determines the GHG mitigation potential and the land demand for the intended production; nevertheless a full assessment of the environmental impacts will be necessary once the whole value chain of the sugarcane ethanol is defined. Among the key issues, the production costs and jobs and wealth creation should rank high due to the impacts on the long term survival of the business and the welfare benefits for the local community and for the country; the main points affecting these issues are the scale of the distillery, due to the economies of scale, and the mechanization level of the agricultural production of sugarcane, since it has a major impact on the quantity and quality of the jobs created by the enterprise.

This work will present some preliminary data on the impact of the choices made with respect to these two key points of the production model, based on the Brazilian conditions, and along the project the methodology will be adapted to the case studies context. This is expected to contribute to the discussion of the best production model with all project stakeholders.

Author: Marcelo Pereira da Cunha – IE/UNICAMP

Title: Socioeconomic impacts in Mozambique due to sustainable sugarcane bioethanol production scenario

Bioenergy has been considered as one of the alternatives routes of energy production to mitigate greenhouse gases (GHG) emissions, as well as to improve energy security and to promote the rural economic sector – the last one especially in tropical developing countries. Considering liquid fuels, sugarcane bioethanol is recognized as the best current option for sustainable biofuel. In the context of LACAF project, the purpose of this study is to quantify the socioeconomic impacts of a sustainable sugarcane bioethanol production scenario in Mozambique, including all direct and indirect effects along the production chain – depending on the socioeconomic variable, the indirect effects can be the most important one. The scenario includes the estimation of suitable sugarcane expansion area as well as the commercial available technologies in agricultural and industrial phases (these information will be provided by the others researchers involved in the LACAF project) . The methodology used for the socioeconomic impacts evaluation is based on Input-Output Analysis – one of the most used approaches in applied economics for socioeconomic evaluation in the World. The methodology considers the intersectoral relationship in the region of the study – in this case, in Mozambique. Changes on sectors output level, jobs, income and gross domestic product (GDP) are among the socioeconomic variables to be evaluated.

Author: M.M.Elmissiry – NEPAD

Title: Sustainable Energy for All and NEPAD Bioenergy Project Incubator

The Secretary General of UN Launched last year an initiative for energy access for all by 2030 which has three main objectives. One of the objectives is to double the renewable energy share in the total energy mix by 2030.Utilization of Bioenergy, being a renewable energy , in Africa stands to benefit from the opportunities the initiative opens for it. This paper outlines the opportunities that the initiative opens for the sustainable utilization of bioenergy resources in Africa and the roles that NEPAD has played so far in facilitating the implementation of the initiative in Arica.

One of the main challenges that faces the sustainable utilization of bioenergy resources in Africa is the development of bankable projects that are attractive to investors. In this regards, NEPAD is setting up an incubator which will assist S&M African entrepreneurs to develop bankable sustainable bioenergy projects and to see to its implementation. An outlines of the bioenergy incubator, its structure and the services it will provide will be also presented in this paper.

Author: Rubens Lamparelli – NIPE/UNICAMP

Title: Mixed crop-livestock detection/mapping using remote sensing

Compared to cropland and forestland, pastureland appears considerably more promising as a large-scale source of bioenergy. The potential to intensify food production from pasture, thereby making land available for other purposes including bioenergy, appears to be much larger than for cropland. A substantial literature supports the notion that planting bioenergy crops, especially perennials and especially on degraded land, can improve pasture organic matter and fertility in. In this context It is ironic that while pastureland likely has the greatest potential for bioenergy production, the main criticisms of bioenergy from a land use perspective are directed at clearing of forestland and competition with food crops. There are many initiatives trying to assess how much are pasture area available to, mainly which that are based on statistics data but none of those conclusive. An indirect way to assess it could be to identify where is occurring the pasture intensification that in most of cases have found as a management system mixing crop and livestock. The Space-based remote sensing using time-series has been used successfully in land use mapping. Therefore the goal of this work is explore the possibilities of identify this type of system using Modis time-series through its spectral behavior. Assuming that is true will be possible identify this kind of pattern in other places and assess indirect area available to energy expansion.

Authors: Rui da Maia, Timi Gaspari, Universidade Técnica de Moçambique

Title: Inventory of bibliographic resources on sugarcane and biofuels in Mozambique

The Mozambican sugarcane sector has seen an impressive growth in the last ten years, increasing from about 397.276 tonnes[1] of processed cane in 2000 to 3.3 million in 2012[2]. The sugar industry is also the second largest employer at national level (29.922 workers in 2010) representing, therefore, an important source of wage income for the majority of rural households in the producing villages. These results were possible thanks mainly to foreign investments in the Mozambican sugar estates and mills, and to a set of national and international policies[3], agreements[4] and incentives to the industry. The majority of the sugarcane is cultivated in the southern provinces of Maputo and Gaza, as they have good infrastructural facilities and are located next to South Africa, the main trade partner for Mozambique. The sector is dominated by four commercial industries and, as each of them owns sugar estates and mills, the number of small outgrowers is limited, and their income largely dependant on the prices fixed by the above mentioned private companies[5]. The Mozambican sugarcane sector has recently attracted even more attention by several actors due to the fact that sugarcane is one of the most efficient crop feedstocks for biofuels, in terms of biofuels yields per area[6], and to the large extensions of non-cultivated areas apparently still available in the country[7]. However, along with the spreading of biofuels projects, many issues have come into question: from their environmental sustainability to the social and economic impacts[8]. Water resources depletion, land access, water and land pollution, food security and poverty reduction are amongst the issues that have been raised by the Mozambican civil society and the local communities in the last few years[9]. It is evident that much still needs to be done in terms of negotiation and communication between private sector and communities, and in terms of bridge-building actions and mediation by the Mozambique Government to ensure the conditions for a participated and sustainable thrive of the Mozambican sugarcane bioethanol[10]. As stated by Arndt et al. (2009) "an outgrower approach to producing biofuels is more pro-poor, due to the greater use of unskilled labor and accrual of land rents to smallholders, compared with the more capital-intensive plantation approach. […] These results should not be taken as a green light for unrestrained biofuels development. Rather, they indicate that a carefully designed and managed biofuels policy holds the potential for substantial gains." Besides, strong education actions are needed to improve technical skills and knowledge amongst the small-scale farmers in order to empower the Mozambican rural people. This intervention presents an inventory of the existing bibliographic resources on national policies, public acceptability of biofuels amongst Mozambican civil society, biofuels and poverty reduction, cases and studies on agroecological and socioeconomic impacts of sugarcane bioethanol in Mozambique.

[1] Dias, 2013.
[2] Macauhub, 2013.
[3] Serra, Cunha, 2008; Conceição dos Quadros et al., 2004.
[4] EU, 2006.
[5] Dias, 2013.
[6] Elbehri, Segerstedt & Liu, 2013.
[7] Meyer, 2008.
[8] O'Laughlin, Ibraimo, 2012; Norfolk, Hanlon, 2012.
[9] Justiça Ambiental, UNAC, 2010.
[10] Burgess, 2012.

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Author: Suani T Coelho – CENBIO/USP

Title: Sustainability indicators for Brazilian sugarcane ethanol – recent updates on the methodology developed by GBEP/FAO

Biofuels sustainability is currently seen as a controversial issue, being discussed in several forums and scientific papers, as well as among governments in the international level.

The case of sugarcane-ethanol in Brazil is indeed an interesting case, mainly when considering the comparison with ethanol from other crops.

Despite recent difficulties (due to climate and economic conditions) in the sector, global (agricultural and industrial) productivity of sugarcane mills is still high in Brazil mainly in Sao Paulo. The energy balance of ethanol from sugarcane, up to 8-10, allows this fuel to be the best one to replace gasoline with the highest carbon avoided emissions (up to 85% emissions avoided), when compared with the other crops (corn, wheat, sugar beet).

However there are still improvements to be achieved, such us further reduction in water consumption (reduced from 5 m^3/tc to 0.85 m^3/tc but still higher than in corn ethanol, when not considering irrigation in corn crops). Fauna corridors and riparian forests (considered a main issue to increase biodiversity in sugarcane crops) present good results in areas where they have been implemented such as Rio Pardo Basin but needing to be increased

There are still several concerns related to biofuels in terms of environmental and social aspects and many authors consider the use of biomass/biofuels as responsible for negative impacts and with GHG emissions higher than fossil fuels.

Regarding other developing countries, sustainability issues may also be important and special attention must be addressed to water consumption (mainly in semi-arid regions), implementation of mechanical harvesting of sugarcane (since most sugarcane is harvested manually and without burning, which is forbidden by Brazilian labor legislation) and a special need to implement agricultural productivity.

Agricultural production in semi-arid regions/countries is highly dependent on rain fed with high risks for investors. This is also a significant challenge for biofuels production. In some countries sugarcane agricultural productivity is one third of the Brazilian one, according to figures obtained from personal field visits in Kenya and Uganda. In Sub Saharan countries only 4% of agricultural crops is irrigated.

Considering sustainability issues, besides the existing certification programs, there are other scientific tools that allow a more precise evaluation of these impacts, as developed by GBEP/FAO and still starting to be developed for Brazil.

The Global Bioenergy Partnership (GBEP) aims to promote the sustainable production and use of modern bioenergy, particularly in the developing countries, where traditional

use of biomass is prevalent. GBEP together with FAO (United Nations Food and Agriculture Organization) have developed 24 indicators of environmental, social and economic sustainability, regarding the production and use of modern bioenergy.

Under GBEP coordination, several countries are already evaluating the indicators for biofuels such as Germany, the Netherlands, Colombia, Indonesia, Ghana and Jamaica. In November 2014, a study developed by ECOFYS (2013) presented the lessons learned in such assessments, as well as recommendations for improvements in future ones, to be discussed in the GBEP meeting in FAO (Rome, December, 2013).

A general overview on sugarcane ethanol sustainability will be presented, including recent figures on land use change, water consumption, air emissions, consumption of fertilizers and pesticides, among others, as well as social aspects of ethanol production in Brazil, compared to other ethanol crops. It will also discuss the proposed methodology by GBEP/FAO, starting to be developed in the Brazilian sugarcane sector, together with the discussion of the preliminary conclusions from ECOFYS and from the discussions in the Roma meeting.

Authors: Suani T. Coelho[1] and José Goldemberg[23] – CENBIO/USP, USP

Title: Use of biomass to increase Energy Access: lessons learned in Brazil and perspectives for replication in other developing countries

Energy access has been singled out by the AGECC in 2010 as one of the important problems to be tackled in the next few decades in a world where 1.3 billion people do not have access to electricity and 2.7 use primitive fuels - mainly fuel wood - for cooking and heating.

To solve such problems, innumerous small scale projects have been implemented around the world either on the improvement of cooking stoves, biogas and others, as well as in generating electricity in decentralized systems.

We discuss here the governmental program (*Luz para Todos* –LPT – Light for all) introduced more recently to extend the electricity grid to around 10 million people, reducing considerably the number of people without access to electricity in the rural areas of the country. The centralized approach based on extending electricity lines to slum areas and distant villages previously not connected to the grid - as adopted in Brazil - has succeeded in making electricity access universal and allowed increased economic activity with megawatts of electricity available. The strategy procedure is also making significant progress in other countries, particularly Mauritius, South Africa, China and Egypt.

However, in more than 5,000 remote villages in Amazonia, other options to increase energy access must be used mainly aiming energy for productive uses.

At the level of basic energy services there were projects on improved cooking stoves, biogas production and the production of small amounts of electricity to households using small hydropower plants and photovoltaic panels. These efforts were mainly decentralized and were conducted by non-governmental organizations. In some cases mini-grids were installed to supply a few houses or villages. The amount of energy produced (at level of kilowatts for electricity) from such systems, in general, was small and not sufficient for significant economic activity.

The use of biomass to produce electricity at the level of kilowatts and higher is possible and is being installed in the Amazonia and Sub-Saharan countries.

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1 CENBIO, National Reference Center on Biomass, Institute of Eletrotechnics and Energy, University of São Paulo.

2 University of Sao Paulo. Address: Av Professor Luciano Gualberto 1289, 05508-000, São Paulo, Brazil. University of São Paulo. Phone + 55 11 30912591; fax + 55 11 30912653

3 This paper is based on Coelho, S.T., Goldemberg, J., Energy access: Lessons learned in Brazil and perspectives for replication in other developing countries, Energy Policy (2013), http://dx.doi.org/10.1016/j.enpol.2013.05.062

Although basic living conditions and access improved, in many cases, the livelihood of people, it is nuclear yet if poverty and income distribution have been changed significantly.

Such experiences and the corresponding lessons learned could be replicated in other developing countries, contributing significantly to poverty alleviation.

Authors: Tom Richard – Penn State University

Title: Energy Security and Human Development: Pathways to Sustainability

Energy in all of its forms is one of the enabling features of human civilization. For millennia people have used energy to satisfy basic needs and extend our capabilities – to stay warm in the cold, to see in the dark, to make and trade goods, to transport ourselves long distances at high speeds. Throughout much of the developing world, basic energy needs are still provided by bioenergy resources, often using inefficient stoves whose smoke contributes to serious respiratory health concerns. In many countries modern biofuels are now also part of the mix – commercial-scale combustion for electricity production and combined heat and power, household, farm and industrial anaerobic digestion for electricity and heat, biodiesel and ethanol for transportation. In this context, energy security has two important frameworks within which bioenergy can play a critical role. The first focuses on traditional bioenergy: how can the integrated agricultural, forest and agroforestry systems that provide most basic energy needs improve their productivity and environmental outcomes and feed cleaner utilization technologies to increase efficiency, expand energy availability, and protect human health. The second focuses on modern bioenergy: to what extent can sustainable large scale feedstock production provide large quantities of renewable energy to satisfy growing demand for electricity, power, and transportation? This presentation will discuss these two frameworks, and how effective strategies within each framework can provide available, accessible, usable and stable sources of energy to meet household and community needs.

Author: Virginia H. Dale – ORNL

Title: Opportunities to Design Biofuel Systems for Multiple Environmental Services and Socioeconomic Benefits

Characterizing conditions under which resource uses are sustainable can be done using indicators to assess and monitor trends over time. Indicators are needed to assess both socioeconomic and environmental sustainability of bioenergy systems. A team at Oak Ridge National Laboratory (ORNL) has selected key indicators of bioenergy sustainability and proposed how they are best used in particular contexts. The proposed environmental and socioeconomic indicators represent a suite designed to reflect major sustainability considerations for bioenergy. We identified major environmental categories of sustainability to be soil quality, water quality and quantity, greenhouse gases, biodiversity, air quality, and productivity and discussed 19 indicators that fit into those categories. We also identified 16 socioeconomic indicators that fall into the categories of social well-being, energy security, trade, profitability, resource conservation, and social acceptability. The utility of each indicator, methods for its measurement, and applications appropriate for the context of particular bioenergy systems are described along with future research needs. Together, this suite of indicators provides a basis to quantify and evaluate sustainability of bioenergy systems across many regions in which they are being deployed.

The importance of interpreting these indicators of bioenergy sustainability in particular contexts is described. The context of an application strongly affects the choice, measurement and interpretation of sustainability indicators. Context considerations include the purpose of the analysis, the specific fuel production and distribution system, policy influences, stakeholders and their values, baseline attributes, available information, and spatial and temporal scales of interest. Knowing the context is essential for setting priorities for assessment, defining the purpose, setting the temporal and spatial boundaries for consideration, and determining practicality and utility of measures. We consider how this approach might be applied in the context of different systems in Africa.

The ORNL team has also worked with agronmists to analyze how agricultural sustainability can consider the effects of farm activities on social, economic, and environmental conditions at local and regional scales. Adoption of more sustainable agricultural practices entails defining sustainability, developing easily measured indicators of sustainability, moving toward integrated agricultural systems, and offering incentives or imposing regulations to affect farmer behavior.