Climate Change and Multi-Dimensional Sustainability in African Agriculture
June 3rd to 5th 2015
Hilux Hotel, Morogoro, Tanzania

Tuesday, June 2, 2015

Reception – iAGRI Project Management Unit Facilities

16:30 SUA Tour
18:40 Registration
19:00 Vedasto Muhikambele, Director, Research and Postgraduate Studies, Sokoine University of Agriculture
19:15 Theodosy Msogoya and David Kraybill, Co-Chairs, Planning Committee
19:20 Mary Hobbs, USAID

Wednesday June 3, 2015

8:00 Registration of Participants

9:00 Introductory Remarks

- Gerald C. Monela, Vice Chancellor, Sokoine University of Agriculture
- Steven Slack, Director, Ohio Agricultural Research & Development Center, Ohio State University
- Stefan Schlingloff, FAO/Rome, Italy
- Luc Gnacadja, Executive Director Emeritus, UNCCD, Benin
- Mary Hobbs, USAID Tanzania

10:00 Tea break

10:30 Session 1: Multi-dimensional sustainability (plenary session)
Moderator: Bal Ram Singh, Norwegian University of Life Sciences, Norway
Recorder: Lars Eik, Norwegian University of Life Sciences, Norway

Panel presentations

- Environmental sustainability: Rattan Lal, Ohio State University, USA
- Economic sustainability: David Kraybill, Ohio State University, USA
- Institutional sustainability: George Kajembe, Sokoine University of Agriculture, Tanzania
- Social sustainability: Louise Fortmann, UC/Berkeley, USA

12:30 Break for Lunch

13:30 Session 2A: Soil management – soil fertility

Moderator: Johnson Semoka, Sokoine University of Agriculture, Tanzania
Recorder: Pat Bell, Ohio State University, USA

Panel presentations

- Nyambilila Amuri, Sokoine University of Agriculture, Tanzania
- Greyson Nyamonga, Norwegian University of Life Sciences, Norway
- Selam Ataklt Hailemichael, Norwegian University of Life Sciences, Norway
- Frank Brentrup, YARA, Germany

Session 2B: Integrated systems – value chains

Moderator: Khalmadin Mutabazi, Sokoine University of Agriculture, Tanzania
Recorder: Jeremiah Makendara, Sokoine University of Agriculture, Tanzania

Panel presentations

- Richard Jones, Alliance for a Green Revolution in Africa, Kenya
- Lulama Ndibongo Traub, Stellenbosch University, South Africa
- Rashid Mohamed, Kizimbani Agricultural Training Institute (KATI), Zanzibar
- Damian Gabagambi, Sokoine University of Agriculture, Tanzania

15:30 Tea Break and Poster Session

16:30 Session 3A: Genetic resources

Moderator: Susan Nchimbi-Msolla, Sokoine University of Agriculture, Tanzania
Recorder: Paul Kusolwa, Sokoine University of Agriculture, Tanzania

Panel presentations

- Ola Westengen, Norwegian University of Life Sciences, Norway
- Charles Nhemachena, International Water Management Institute, South Africa
- Joseph Ndunguru, Mikocheni Agricultural Research Institute, Tanzania
- Dennis Kyetere, Executive Director, African Agricultural Tech Foundation, Kenya

Session 3B: Integrated systems – Conservation agriculture

Moderator: Peter Mtakwa, Sokoine University of Agriculture, Tanzania
Recorder: Sheryl Quail, University of Florida, USA

Panel presentations

- Mwatima Juma, International Fund for Agricultural Development, Tanzania
- Steve Haggblade, Michigan State University
- Jan Mulder, Norwegian University of Life Sciences, Norway
- Fred Kizito, Africa RISING, Kenya

19:30 Banquet - Nashera Hotel

Thursday, June 4, 2014

7:00 Optional SUA Tour

9:00 Opening Session

- Vedasto Muhikambele, Director, Research and Postgraduate Studies, Sokoine University of Agriculture
- Steven Slack, Director, Ohio Agricultural Research & Development Center, Ohio State University
- Marie Rarieya, Alliance for a Green Revolution in Africa, Ghana
- Luc Gnacadja, Executive Director Emeritus, UNCCD, Benin

10:00 Tea break

10:30 Session 4A: Water management
Moderator: Siza Tumbo, Sokoine University of Agriculture, Tanzania
Recorder: Frederick Kahimba, Sokoine University of Agriculture, Tanzania

Panel presentations

- Zebadayo Mvena, Sokoine University of Agriculture, Tanzania
- Conrad Heatwole, Virginia Tech, USA and Winfrid Mbungu
- Eitan Hatzor, Balton Tanzania
- Gimbage Mbeyale, Sokoine University of Agriculture, Tanzania

Session 4B: Agricultural research for sustainability
Moderator: Lusato Kurwijila, Sokoine University of Agriculture, Tanzania
Recorder: Kalunde Sibuga, Sokoine University of Agriculture, Tanzania

Panel presentations

- Isaac Minde, Michigan State University, USA
- Cargele Masso, IITA/Africa RISING, Kenya
- Maria Mullei, Virginia Tech, USA
- Ephraim Nkonya, IFPRI, USA

12:30 Lunch Break

13:30 Session 5A: Soil management – land rehabilitation
Moderator: Henry Mahoo, Sokoine University of Agriculture, Tanzania
Recorder: Filbert Rwehumbiza, Sokoine University of Agriculture, Tanzania

Panel presentations

- Menale Kassie, CIMMYT, Kenya
- Sophia Kashenge-Killenga, MAFC, Tanzania
- Luc Gnacadja, Executive Director Emeritus, UNCCD, Benin
- Moses Tenywa, Makerere University, Uganda

Session 5B: Agricultural risk and insurance

Moderator: David Hansen, Ohio State University, USA
Recorder: Adam Akyoo, Sokoine University of Agriculture, SUA

Panel presentations

- Mario Miranda and Abdoul Sam, Ohio State University, USA
- Benjamin Njenga, ACRE Africa
- Babatunde Abidoye, University of Pretoria, South Africa
- Jon Einar Flatnes, UC/Davis, USA
- Ephias Makaudze, University of West Cape, South Africa

15:30 Tea Break

16:00 Session 6: International Year of Soils 2015

Moderator: Stefan Schlingloff, FAO/Rome, Italy
Recorder: Nyambilila Amuri, Sokoine University of Agriculture, Tanzania

Panel presentations

- Stefan Schlingloff, FAO/Rome, Italy
- Bal Ram Singh, Norwegian University of Life Sciences, Norway
- Rattan Lal, Ohio State University
- P.K. Ramachandran Nair, University of Florida, USA

Friday, June 5, 2014

8:30 Session 7A: Private Sector Solutions for Sustainability

Moderator: Faustin Lekule, Sokoine University of Agriculture, Tanzania
Recorder: Bernard Chove, Sokoine University of Agriculture, Tanzania

Panel presentations

- Isaka Mashauri, Tanseed International, Tanzania
- Peter Chisawillo, Intermech Engineering Limited, Tanzania
- Kinyua MMbijjewe, Syngenta, Kenya

Session 7B: Water management

Moderator: Japhet Kashaigili, Sokoine University of Agriculture, Tanzania
Recorder: Winfrid Mbungu, Virginia Tech, Tanzania

Panel presentations

- Athuman Mahinda, University of Nairobi, Kenya
- Richard Asaba, Makerere University, Uganda
- Sixbert Maurice, Sokoine University of Agriculture, Tanzania

10:30 Tea Break

10:45 Session 8A: Extension systems for agricultural sustainability
Moderator: Dismas Mwaseba, Sokoine University of Agriculture, Tanzania
Recorder: Emmanuel Rwambali, Sokoine University of Agriculture, Tanzania

Panel presentations

- Richard Miiro, Makerere University, Uganda
- Max Olupot, African Forum for Agricultural Advisory Services, Uganda
- Robert Agunga, Ohio State University, USA
- Ruth Haug, Norwegian University of Life Sciences, Norway

Session 8B: Private Sector Solutions for Sustainability
Moderator: Maria Mullei, Virginia Tech, USA
Recorder: Gration Rwegasira, Sokoine University of Agriculture, Tanzania

Panel presentations

- Wilson Kashanga, Syngenta, Tanzania
- Ephraim Mtengeti, Sokoine University of Agriculture, Tanzania
- Lilian Mwashigadi, Bakhresa Processing Industry, Tanzania

12:45 Lunch Break

13:30 Session 9A: Landscape Approaches
Moderator: Luc Gnacadja, Executive Director Emeritus, UNCCD, Benin
Recorder: Stefan Schlingloff, FAO/Rome, Italy

Panel presentations

- Rattan Lal, Ohio State University, USA
- Sara J. Scherr, EcoAgriculture Partners, USA
- Boniface Massawe, Ohio State University, USA
- Fidelis Kaihura, FAO Kagera TAMP, Tanzania

Session 9B: International, national and local policies for agricultural sustainability
Moderator: Isaac Minde, Michigan State University, USA
Recorder: Ntengua Mdoe, Sokoine University of Agriculture, Tanzania

Panel presentations

- Chikakula Miti, COMESA, Zambia
- Bishal Sitaula, Norwegian University of Life Sciences, Norway
- John Ulimwengu, IFPRI, Kenya
- Mary Nyasimi, World Agroforestry Center, Kenya

15:30 Tea Break

15:45 Session 13: Recorder Summary Presentations
Moderator: David Hansen, Ohio State University

16:45 Session 14: Summary of all sessions Moderator: David Kraybill, Ohio State University Presenter: Rattan Lal, Ohio State University

17:30 Formal Closure of Conference **Saturday, June 6, 2014**

8:00 to 13:00 Field Trip
Fungafunga Urban Farm, Morogoro Town
Mtakwa Farm, Sangasanga Village

Multi-dimensional Sustainability and Climate Change in African Agriculture

Conference Abstracts

Morogoro, Tanzania

June 3 to 5, 2015

Hosted by Sokoine University of Agriculture and sponsored by the United States Agency for International Development (USAID) and the Innovative Agricultural Research Initiative (iAGRI). Additional support provided by the Norwegian Agency for Development Cooperation (NORAD) and the United Nations Food and Agriculture Organization (FAO).

Contents

Session 1: Multi-dimensional Sustainability

ENVIRONMENTAL SUSTAINABILITY

Rattan Lal
Carbon Management and Sequestration Center, The Ohio State University
Columbus, OH 43210 USA

Abstract

Environment encompasses physical and biological entities along with their chemical interactions which impact living organisms. In other words, it is an aggregate of surrounding things and their interaction (e.g., climate, vegetation, soil, water and species). The term environmental sustainability implies, "meeting the needs of current generation without compromising the ability of future generations to meet their needs." Specifically, it refers to the condition of balance, resilience and inter-connectedness to strengthen provisioning of ecosystem services for human well being and nature conservancy. Four pillars of sustainability are: environmental, economic, institutional and social. Environmental sustainability addresses issues beyond recycling, being "green," and over population. The strategy is to enhance resilience of managed ecosystems (e.g., agro-ecosystems) by using the nexus approach or inter-connectedness. The objective is to develop techniques of sustainable intensification or "producing more from less" by reducing by-products, eliminating redundancy, and enhancing use efficiency of inputs. Judicious management of soil has strong implications to environmental sustainability because of its impacts on the global carbon cycle and climate change; on water quality and renewability because of the coupled cycling of carbon with water, nitrogen, phosphorus and sulfur; on biodiversity because of the impact on habitat and energy source for biota; and on nature conservancy because of the impact on ecosystem goods and services. Enhancing carbon sequestration in soils and the terrestrial biosphere is a win-win strategy because of its numerous co-benefits. Being the most basic among natural resources, soil stewardship and care must be embedded in every fruit and vegetable eaten, in each grain ground into the bread consumed, in every cup of water used, in every breath of air inhaled, and in every scenic landscape cherished.

ECONOMIC SUSTAINABILITY

David Kraybill

Abstract

Lively debate has occurred within the field of economics over the past two decades about whether economic systems can be treated as independent of environmental systems. The mainstream economic view is that man-made inputs and natural resources are highly substitutable through technological innovation, and therefore economic analysis can proceed meaningfully without reference to environmental stocks and flows. This assumption is increasingly untenable as climate change brings major changes in global and local economies. To meaningfully analyze the sustainability of economic systems, economists must utilize frameworks that are conceptually rigorous with regard to underlying economic processes and, at the same time, comprehensive enough to include non-economic processes which affect the economy and which are, in turn, affected by the economy. Understanding the nature and complexity of capital (assets) is an important step in analyzing economic sustainability. In the mid 20th century, economists expanded their view of capital beyond mere manufactured physical capital by embracing the notion of human capital (skills and health). Emerging notions of capital toward the end of the 20th century included natural capital and social capital. A growing number of economists are attempting to incorporate these expanded notions of capital into theory and practice. With natural capital in the equation, it is possible to analyze the sustainability of coupled economic-environmental systems and to assess the impact of economic activity, including agriculture, on future generations as

compared to the present generation. With this expanded view of the economy, a definition of economic sustainability is that the economic activities of today result in preservation, replacement, or expansion of capital, including natural capital, to maintain at least the same level of utility (satisfaction of wants) tomorrow as today.

INSTITUTIONAL SUSTAINABILITY IN THE FACE OF CLIMATE CHANGE IN TANZANIA: EMPIRICAL INSIGHTS FROM IRRIGATION INSTITUTIONS IN IRINGA RURAL DISTRICT, TANZANIA

George C. Kajembe, Pål Vedeld, Dos Santos Silayo, Innocent H. Babili, and Devotha B. Mosha

Abstract

Adaptation and mitigation have been proposed as strategies for addressing climate change which is a predominant challenge facing society today. However, little attention has been paid to the linkage between institutional sustainability and climate change adaptation and mitigation. This paper argues that effective adaptation and mitigation to climate change depends on the sustainability of both formal and informal institutions. Institutional sustainability is understood in this paper as the point that institutions, under particular conditions, are long enduring and thus sustainable in themselves. Sustainable formal and informal institutions provide a framework that guide interactions among actors including organizations and individuals for adapting and mitigating to climatic change. Literature has pointed out a number of conditions for ensuring institutional sustainability in the climate change scenario. Drawing from empirical insights from Iringa, Tanzania case study, it is demonstrated that institutional sustainability is possible in the face of climate change and can be achieved through evolution and change, legitimacy, bricolage and performance.

CLIMATE CHANGE AND SOCIAL SUSTAINABILITY: A CASE FOR POLYCENTRIC SUSTAINABILITIES

Louise Fortmann
University of California at Berkeley

Abstract

Because neither climate change nor human societies are homogeneous, issue of climate change and social sustainability must be approached through the questions: “Which climate change?” and “Whose social sustainability?” This difference and complexity call for diverse localized innovation rather than top down homogeneous policies, that is, we must look for polycentric sustainabilities. The argument for polycentric sustainabilities is illustrated by two communities (one in Zimbabwe, one in the US) which refuse to wait for (or accept) external solutions but instead have seized the initiative and are innovating on their own.

Session 2A: Soil Management – Soil Fertility

RESEARCH AND PRACTICES IN SOIL FERTILITY MANAGEMENT FOR SUSTAINABLE AGRICULTURAL PRODUCTIVITY IN TANZANIA

Nyambilila A. Amuri and Johnson M.R. Semoka
Department of Soil Science, Sokoine University of Agriculture, Morogoro, Tanzania

Abstract

Soil fertility management is an essential component of sustaining agricultural productivity in the face of climate change. The objective of this paper is to analyze progress in scientific research, and practices in soil fertility management for improved and sustained agricultural productivity in Tanzania. Soil is a vital natural resource that provide food and fiber to support most forms of living system on earth. Thus understanding the soil body is critical for conserving the quality of soil while enhancing the capacity to produce and providing other ecosystem services. Soil fertility recommendations to enhance soil productivity is based on specific crop nutrient requirement and responses to the applied nutrient. The fertilizer recommendations are specific to agro-ecological zones, taking into consideration climate and soil type. Detailed soil characterization and classification is scattered and limited. Fertilizer recommendations are outdated in most part of Tanzania, except for Southern highlands. The increasing demand for quality food crops and the need to minimize pollution while maintaining productivity makes soil fertility management to take multiple dimensions. The current practices in soil fertility management is variable ranging from relying in natural fertility without replenishment of nutrient and soil organic matter, use of small doses of single nutrient mineral fertilizers, relying on cropping systems that incorporate legumes either in rotations or intercropping, organic farming relying on organic resources only, and integrating organic and inorganic fertilizers. Site specific fertilizer recommendations and practices is hardly practiced. Availability of soil testing services is still limited. Overall, the agricultural crop yield are still low and soil degradation due to nutrient and soil organic matter depletion, soil erosion and compaction is common in many areas. Therefore, more investment in research and practices to address multifaceted soil fertility management to improve productivity, quality of crops, conserve the environment, and yet economically profitable are needed.

POTENTIALS FOR REHABILITATING DEGRADED LAND IN TANZANIA

G.Z. Nyamoga, B. Solberg, H. Sjølie, Y.M. Ngaga and R. E. Malimbwi

Abstract

Deforestation and land degradation are of high interest in Tanzania and developing countries in general. About 40% of the land in Tanzania is covered by forests but these forests are threatened by deforestation and land degradation. These forests are also important for sustainable provision of forest products, biodiversity conservation, global carbon sequestration and carbon trade. This study has as main objectives to *(i) assess the available degraded land potential for rehabilitation in Tanzania, (ii) give a review of existing economic studies of relevant rehabilitation methods, and (iii) identify effective ways of rehabilitating degraded land and key factors affecting such rehabilitation in Tanzania.* Findings show that there is a strong decrease of woody vegetation and agricultural lands in Tanzania. During the period 2002-2012 the settlement land has increased by about 26.7% while the protected area increased by 8.5% from 2002 to 2012. Wood and non-woody production land declined by 23.8% while the scattered settlements (villages) and agriculture land decreased almost 12.9%. Agroforestry, reforestation and afforestation are potential techniques for rehabilitating degraded land providing environmental and economic benefits to local communities. Forest goods and services play a significant role for economic and livelihoods of people in Tanzania, and the size of degraded land is increasing due to increased demand for forest products and expansion of agricultural land for food production. Increased tree planting is necessary for sustainable supply of forest products. REDD+ is an important economic incentive for keeping forests intact and adding value to the forest.

WHAT DOES SUSTAINABLE INTENSIFICATION OF AGRICULTURE MEAN IN PRACTICE? PERSPECTIVES FROM ETHIOPIA

Selam Ataklt Hailemichael

After decades of reduced attention to the sector, donors and national governments in Africa are reorienting their priorities to intensify agricultural productivity to cope with projected population increase without causing further harm to the environment. The current drive to increase the level of productivity comes with a stronger emphasis on sustainability. This study addresses two critical questions on the practices of sustainable intensification of agriculture in two regions of Ethiopia. The first question asks how the current drive aimed at achieving sustainable intensification is any different in terms of goal and content from conventional intensification of agriculture. Secondly, by taking the three pillars of sustainability (social, economic, environmental sustainability) into consideration, the study examines what each of these mean for agricultural households. The research is based on explorative discussions with policy makers, researchers and farmers to understand what matters to them when thinking of sustainable agriculture and how to attain it. The diversity of the stakeholders that have been involved in the research allow for a comparison of perspectives across gender, age, wealth groups as well as among different practitioners. Our preliminary analyses indicate that without deliberate and regulated measures, the focus on intensification could quite easily override the ambition to make agricultural development sustainable.

SUSTAINABILITY OF INTENSIFICATION MEASURES IN SMALLHOLDER MAIZE PRODUCTION IN TANZANIA

Dr Frank Brentrup, Yara International ASA, Research Centre Hanninghof, Germany

Abstract

Tanzania has a young and fast growing population with increasing demand for food crops, in particular maize. Sustainable intensification is needed to cover this demand while preserving the environment and climate. A joint project of Yara, Syngenta, Sokoine University of Agriculture, and the Norwegian University of Life Sciences demonstrated that balanced supply of nutrients together with other improved practices increases maize yields and farm profitability substantially. During the project a framework was developed and applied to measure the potential impacts of different crop farming systems on climate, soil, water and biodiversity in order to evaluate the sustainability of intensification measures.

Main findings:

- Improving yields reduces the need for deforestation and thus offers potential to avoid GHG emissions.
- Low yet positive soil nutrient balances with the improved protocol indicate sustainable fertilizer use, replenishing the soil with sufficient nutrients. In contrast, farmers practice plots often showed negative balances, signifying unsustainable nutrient mining even at low yield levels.
- Increased nitrogen rates and crop productivity lead to increased soil acidification which needs to be compensated by accompanying measures such as liming.
- The improved maize protocol doubled maize stover biomass, which should be utilized to improve soil fertility.
- Maize produced according to the improved protocol consumed less water per ton of grain as compared to farmer practice.

In-field biodiversity was reduced with the suggested protocol, while on-farm biodiversity was enhanced through planting of additional trees instead of expanding cropland. About 50% less land was needed to produce one ton of maize grain, reducing pressure for land expansion with potential negative effects on biodiversity on a larger scale.

Session 2B: Integrated Systems – Value Chains

SUSTAINABLE SEED DELIVERY SYSTEMS TO INCREASE THE AVAILABILITY OF QUALITY SEED OF SUPERIOR VARIETIES

Richard B. Jones
Chief of Party, Scaling Seeds and Technologies Partnership in Africa, Alliance for a Green Revolution in Africa (AGRA), P O Box 66773-00800, Nairobi, Kenya

Abstract

Climate change poses significant risks to future crop productivity as temperatures rise, rainfall patterns become more variable, and pest and disease pressures increase. Developing new crop varieties that are more tolerant to rapidly changing environmental conditions is an important part of agricultural adaptation but unless seed delivery systems are developed to ensure that these varieties reach farmers, the benefits of crop genetic improvement will not be realized. This paper describes investments made by the Alliance for a Green Revolution in Africa to support the development and dissemination of locally adapted varieties, examines constraints to the release and dissemination of superior varieties, and then proposes a number of institutional changes to address the identified constraints.

MEGATRENDS AND THE FUTURE OF AFRICAN FOOD SYSTEMS

Lulama N. Traub, Felix K. Yeboah, Ferdinand Meyer, T.S. Jayne

Abstract

African agri-food systems are complex and interdependent systems with the following features: (1) they develop endogenously with broader demographic and economic changes in the broader economy, hence it is difficult or impossible to predict their specific growth and income distributional trajectories; (2) their future trajectories are highly dependent on policy choices and public investment patterns and hence can be molded by public action; (3) they evolve through interdependent decisions of many actors such that few emerging patterns can be linked to a particular agent within the system; and (4) the variables influencing their development change over time with the underlying structure of local, regional and international economic systems, and with changes in technologies and institutions. In this dynamic environment, notions of equilibrium may be very short-lived. Nevertheless, we believe that there are identifiable "megatrends" with a high probability of affecting African food and broader economic systems in the coming decades. This paper investigates the evidence of 'megatrends' shaping African economic, political and social landscapes and asks which ones depend endogenously on processes that are within the realm of policy influence and which ones are indeed exogenous.

Based on this analysis, we consider alternative plausible scenarios regarding the future development of African food systems that could emerge as a result of policy and public investment decisions. The authors hope to raise society's awareness of the potential to shape future outcomes through public sector policy and investment decisions and argue that the state can play a major role in anticipating and ensuring that a 'good society' evolves on the African continent.

PRO-POOR VALUE CHAINS LINKING SMALLHOLDER FARMERS AND THE ZANZIBAR TOURISM INDUSTRY

M. Rashid, M.C.C. Martinez, A.S. Ringheim, M. Åsli, B.S. Ahmed, M. Hamdu, A.S. Issa, M. Khamis, A. Moulton, D. Mushi, D. Mwaseba, M. S. Nassor, L. Rotås, K. Ryum, S.Y. Shehe, A. Viestad, L.O. Eik

Abstract

In order to improve the competitiveness of small agricultural producers in disadvantaged areas, a demand driven pro-poor value-chain between smallholder farmers and upmarket restaurants has been established in Zanzibar. Currently the tourism industry relies heavily on imported agricultural goods, but desire local produce in order to support the domestic economy, and reduce their environmental footprint.

Through this project, central actors in the high-end tourist sector identified an assortment of desired products including vegetables, edible flowers, spices and meat. At the same time lead-farmers will sustainably grow vegetables and sell meat on a regular basis while mentoring youth and fellow farmers. The potential for raising smallholder farmer income through value adding processes is promising, particularly when focusing on perishable foods needed in small quantities. In addition, quality meat from young goats and lambs is also in high demand, both at hotels and among local consumers.

We conclude that the lack of reliable supply as well as challenges of quality control are primary obstacles for value chain development based on the tourist market. Training of female farmers should be a central part of this initiative as women are essential stakeholders of the farming communities and have few alternative working opportunities.

We acknowledge the late Emerson for his inspiration and commitment to this initiative and the support from the Royal Norwegian Embassy.

Key words: Value Chain; Pro-Poor; Smallholder Farmers; Small Ruminants; Local Food; Tourism

ELECTRONIC SMART SUBSIDIES IN AGRICULTURE FOR FOOD SECURITY IN TANZANIA

Damian Gabagambi

Abstract

One of the constraints facing agriculture in Tanzania is low land productivity caused by declining soil fertility, inadequate fertilizer application and use of traditional seeds. In 2003/04, the Government introduced the fertilizer subsidy system, spending a total of TSh 2 billion to purchase 39,387 metric tons of fertilizers. Since then Government investment into input subsidies under the voucher system has increased to TSh 149 billion in 2010/11. However, since the program started it has been characterized by elite capture and other challenges making it hard for inputs to reach intended beneficiaries in the right amount. A study was conducted in four districts of Tanzania namely Mvomero, Mbozi, Sumbawanga and Bariadi to explore this problem and recommend ways for improving effectiveness of the system. It was revealed that the system is characterised by adulteration of inputs and that inputs do not reach intended beneficiaries. An innovative alternative input distribution model is recommended. This model leverages on ICT to put the cash component of the input value directly in the hands of the farmers via mobile phones. If this model was adopted, among other things, inputs would reach intended beneficiaries in the correct amount and at the right time and ultimately productivity would increase and food security would be ensured. The success factors of this system include proper registration of target farmers, a strong monitoring and evaluation (M&E) mechanism to

ensure that everything is executed as planned and new challenges are addressed, high commitment on the part of top government officials, and the system must be private sector-farmer driven with government playing a supportive role.

Keywords: Agricultural inputs, Smart subsidy, mobile phones, productivity, food security

Session 3A: Genetic Resources

CROP ADAPTATION TO CLIMATE CHANGE IN SSA: THE ROLE OF GENETIC RESOURCES AND SEED SYSTEMS

Ola Westengen and Trygve Berg

Abstract

Crop adaptation plays a key role in enabling farmers to adapt to the impacts of climate change. The IPCC (2014) found "cultivar adjustment" to be the most effective on-farm strategy in the literature assessed. The IPCC is, however, largely silent on the modalities of cultivar adjustment; what are the assumptions with regard to cultivar types used and institutional context? The objective of the current paper is to explore these modalities and enhance our understanding of the realities and potentials for crop adaptation in SSA's agriculture. We identify the key environmental impacts to which crops will have to adapt (including changes in mean and variability of temperatures and rainfall during the growing season, CO2 fertilization and biotic stresses) and adaptation options vis-à-vis these impacts. We highlight examples of crop adaptation strategies based on different types of cultivars and institutions from studies of the current role of genetic resources and seed systems. Projections show that current practices will face unprecedented climatic conditions in the near future and indicates that farmers will need access to novel genetic diversity and cultivars to adapt. The genepool in wild relatives and landraces from current analogs to the projected climates is a potential source of genetic material relevant for crop adaptation. We argue that introduction of exotic genetic resources will require nimble and evolvable seed systems that allows for interaction between formal and informal seed system approaches to cultivar development, release and distribution.

ECONOMIC ASPECTS OF GENETIC RESOURCES IN ADDRESSING AGRICULTURAL PRODUCTIVITY IN THE CONTEXT OF CLIMATE CHANGE

Charles Nhemachena, Greenwell Matchaya, Sibusiso Nhlengethwa, Charity R Nhemachena

Abstract

The main objective of this paper is to discuss the economic aspects of genetic resources in addressing agricultural productivity in the context of climate change focusing on Africa. The paper is based on review of published literature. The focus is on understanding the nexus between climate change, genetic resources and agricultural productivity; and the economic aspects involved in the conservation and improvement of genetic resources and farm-level use and adoption of these technologies to address agricultural productivity. The results show that climate change affects both genetic resources and agricultural productivity. The interaction of climate change and other stressors exacerbates the vulnerability of agricultural productions systems and genetic resources. The conservation and improvement of genetic resources should address the urgent need to step up investments in conservation and development of future adapted technologies. At the farm level, the focus should be on developing distribution and dissemination systems including awareness raising and education of

farmers on the role of genetic resource technologies in addressing agricultural productivity under climate change. In addition, it is critical to ensure that farmers have the means to purchase the improved genetic resource technologies for them to use and adopt them. Efforts to conserve; improve and promote use of genetic resource technologies in addressing agricultural productivity should be integrated in broader adaptation and development efforts.

Key words: Economic aspects; genetic resources; agricultural productivity; climate change

EXPLOITING CASSAVA BIODIVERSITY TO ADDRESS ABIOTIC AND BIOTIC STRESSES CAUSED BY CLIMATE CHANGE

J. Ndunguru
Mikocheni Agricultural Research Institute, Box 6226, Dar es Salaam, Tanzania

Abstract

Cassava plays a key role for food security and subsistence of farmers in many countries of Africa. Abiotic stresses and related biotic stresses caused by climate change represent a critical limitation and a major threat to sustainable agriculture and food security. It is necessary to develop new cultivars with tolerance to these stresses by exploiting the existing biodiversity of species. In this project we are characterizing part novel, yet unexploited cassava germplasm from East Africa and identify accessions which are adapted to these threats of climate change. Based on this information we are developing molecular markers which can be used for cassava breeding of new improved cassava cultivars with elevated stress tolerance levels for sustainable agriculture. Phenotypic evaluations of these accessions for resistance or tolerance to abiotic and associated biotic stresses are performed in field trials and bio-assays. The traits for evaluation include abiotic stresses *cold*, *drought and heat as well as* the major viral diseases in cassava. The identification of tolerant genotypes will provide directly recommendations to farmers for cultivation of these varieties in environments with adverse agro-climatic conditions, and represent at the same time valuable material for the breeding of improved cassava varieties. On the other hand we will detect candidate genes (CG) for resistance or tolerance to these stresses using different up to date molecular tools. These include RNAseq, an in silico mining approach of known genes and RAD sequencing. We will analyse the allelic variation of these CG and determine the effect of specific alleles or allele combinations in the materials through amplicon sequencing and association mapping by linking the phenotypic data of the previous evaluations with the obtained molecular data. CG detection and analyses of alleles will be also performed using a random approach, known as RAD sequencing. The results will allow us to develop markers for marker assisted selection, which can be applied to speed up conventional Cassava breeding programs. The molecular markers and Models for analysing stress adaptation in cassava can be used for efficient marker assisted breeding in cassava and related species.

INSTITUTIONAL ASPECTS OF GENETIC RESOURCES – IN RESPECT OF CLIMATE CHANGE IN SUB-SAHARAN AFRICA

Drs. Denis T. Kyetere & Kayode Sanni

Abstract

Genetic resources are central to the strengthening food security and the building of a more-resilient agricultural system in the face of climate change. It underpins today's production and provides the raw material needed for meeting the challenges of tomorrow. It has been projected that the speed and complexity of climate change pose new constraints which are expected to make the task of achieving food security more challenging, especially in the developing world, Sub-Saharan Africa (SSA) in particular. Hence, the need to develop varieties well adapted to a new and unstable environment.

Efforts to develop these new crop varieties with traits of adaptations to present and future climatic stresses envisaged in SSA, will therefore increase the demand for genetic resources. Unfortunately, climate change also threatens the sustainable existence of agricultural biodiversity, increasing genetic erosion of landraces and threatening wild species, including crop wild relatives. This will invariably increase the dependence of countries on foreign genetic resources for agricultural sustainability. Adequate attention should therefore be given to collection, conservation, sharing and use of genetic resources to mitigate climate change, with the central aim of developing timely interventions across national borders. Institutional aspects towards sustainable conservation and use of this reservoir of genetic resources should be enhanced and clear strategies put in place. This presentation will review and focus on the National and regional capacity framework, for understanding institutional aspects of adaptive capacity towards the conservation and use of Genetic resources in relation to climate change in SSA.

Key Words: Adaptive capacity, developing countries, food security, sustainable agriculture, varieties,

Session 3B: Integrated Systems – Conservation Agriculture

ORGANIC AGRICULTURE: ITS POTENTIAL FOR CLIMATE SMART AGRICULTURE IN SUB-SAHARAN AFRICA

Mwatima Juma

Abstract

The convergence of three main factors makes this a propitious time for the expansion of organic agriculture in Sub Saharan Africa. (1). Traditional agriculture is being improved independently of attempts to convert conventional agriculture; (2) Organic production relies on locally available inputs which makes it potentially more economically and environmentally sustainable; and (3) The market demand for organically certified products is growing fast and this provides an opportunity for farmers beyond traditional export crops. Organic and resource-conserving agriculture (ORCA) initiatives have been common in the tropics for several decades but there is surprisingly little available data that documents outcomes. Given the limited availability of data, both public and private sector stakeholders continue to raise questions about the real potential for organic agriculture to enhance food security and contribute to the adaptation and mitigation of climate change in the region. This article summarizes the evidence of several prior investigations concerning these questions. The results provide strong support for the conclusion that organic agriculture is climate smart agriculture and that it can well address the challenge of meeting the growing demand for food, fibre and fuel, even in the context of climate change and diminishing opportunities to convert additional land for agricultural use.

THE ECONOMICS OF CONSERVATION AGRICULTURE: IMPLICATIONS OF CLIMATE CHANGE

Philip Grabowski and Steven Haggblade

Abstract

This paper reviews available evidence on the agronomic and economic viability of conservation agriculture in Africa. The heterogeneity of physical environments, household endowments, input and output prices, and livelihood strategies leads to widely differing sets of agronomically feasible and economically viable management practices. As climate change alters physical environments, the location-specific benefits and challenges associated with any given set of CA practices are likely to

change. This paper develops and applies a simulation model to project the likely impact of changing weather on the agronomic and economic viability of various CA management practices. The simulations draw on baseline empirical data from common CA and conventional farming practices in Zambia, Malawi and Mozambique.

EFFECTS OF CONSERVATION AGRICULTURE AND BIOCHAR ON SOIL QUALITY IN ZAMBIA

Jan Mulder, Vegard Martinsen , Victor Shitumbanuma and Gerard Cornelissen

Abstract

Zambia has been a frontrunner in adopting conservation agriculture. Currently, more than 150,000 smallholder farmers use conservation farming methods integrating management of soil, water and agricultural resources in order to achieve sustainable and profitable agriculture. Here we investigate the effect of up to 12 years of conservation farming on soil quality in Eastern and Central Zambia. We focus on the contents of soil organic carbon and its labile fraction, on soil organic nitrogen and its mineralization rate, as well as on plant available phosphorus and soil water. The study included 20 sites in each of the two areas. Sites were selected based on similar soils, slopes and aspects with adjacent conservation (CF) and conventional farming as well as a reference (long term fallow). At all sites 5 plots were randomly selected for soil sampling (0-20 cm) at each of the four treatments 1) inside CF planting basins, 2) outside CF basins (in between rows), 3) conventional farming and 4) reference. In addition to this comparative study, we did a parallel study to investigate the effect of combined CF and maize-cob biochar application, on soil quality (pH, aggregation, soil water retention) and crop yield. Major findings include soil organic carbon contents in CF that do not differ from those in conventional farming. Yet, CF soils do have larger contents of labile organic matter and greater nitrogen mineralization rates. Biochar application results in significant increases in crop yield, more likely due to increased plant available water than to the biochar's liming effect.

SUSTAINABLE INTENSIFICATION IN MIXED CROP-LIVESTOCK AGRO-ECOSYSTEMS IN THE FACE OF CLIMATE CHANGE: THE CASE FOR LANDSCAPES IN TANZANIA

Fred Kizito

Abstract

Agro-ecosystem productivity is highly dependent on soil moisture fluxes yet climate change induces unpredictable dynamic interactions of water and nutrient resources. The Water-World model was used to ascertain the impact of climate change on moisture fluxes at landscape level on agro-ecosystems of Northern Tanzania. Study results indicate a steady increase in temperature and a projected increase in rainfall over the next 40 years to the 2050s with an average future precipitation of 1,300 mm yr^{-1} compared to the current baseline of 960 $mmyr^{-1}$. On-farm seasonal water balance estimates within forage grass-legume intercrops revealed that with the 645 mm of rainfall received in the 2014 rainy season, evapotranspiration (ET) was the predominant factor accounting for about 75% of the fluxes. We demonstrate that compared to the control trials, runoff levels were not significant in areas with forage grass-legume intercrops which translated to 20% lower runoff levels; there was higher soil moisture storage in areas with forages than the control areas. In doing so, perennial forages improve the sustainability of farming systems through erosion control and soil amendment beyond serving as feed resources. Anecdotal field observations revealed that farmers are shifting to more drought resilient crops such as pigeon pea and lablab compared to the common bean. Additionally, farmers in the mid-altitude high rainfall and low altitude low rainfall areas are practicing complex intercropping patterns as an adaptive mechanism. To ensure sustainability, breeding efforts are focusing on developing climate

ready varieties by addition of traits that will give these varieties the adaptive advantage. Sustainable intensification will thus require more innovative solutions that incorporate breeding solutions, shifts in crop patterns, types as well as alternative forage grass-legumes with other agronomic practices into an integrated package of interventions for sustainable land use to cope with climate change.

Key Words: Sustainable intensification, Climate Change, Adaptation, Farmer Options, Innovative Solutions

Session 4A: Water Management

THE SOCIAL DIMENSION OF WATER MANAGEMENT AND ITS CONSEQUENCES IN AN ERA OF DECLINING WATER SUPPLY: A SYNTHESIS OF PAST RESEARCH AND FUTURE DIRECTIONS

Zebadayo Mvena

Abstract

Tanzania enjoys vast water bodies and rivers as well as underground water yet the country is facing water problems in two dimensions. First, the abundant supply of water at a national level is deceiving as many households are without adequate water. The annual average of available water per capita is projected to lessen by 30% corresponding to 1400 cubic meters per capita per year in 2015 thus exceeding water stress level of below 1500 cubic meters as a result of diminution of water resources and increase of population. Second, many of the previously rich sources of water are now drying up. What were once permanent rivers are now seasonal while others have been turned into permanent dry river beds. The one time famous Lake Haubi and Lake Bicha in Central Tanzania are now dry and have become grazing areas. Even if population growth and climate change may be blamed for this predicament, human activities such as inappropriate farming practices, water transfers via industrial production, encroachment into water sources, deliberate drying of wetlands for human settlement and government inaction towards water conservation have greatly contributed to this fate. These human activities have Consequences to humanity in terms of generating future conflicts on water use and changing lifestyles to adapt to acute water shortages. In light of this gloomy future predicament various options are given.

HYDROLOGIC MONITORING OF HEADWATER CATCHMENTS FOR CLIMATE CHANGE ADAPTATION STUDIES

Conrad D. Heatwole and Winfred Mbungu
Biological Systems Engineering, Virginia Tech

Abstract

Changes in temperature regimes and precipitation patterns as a result of climate change are expected to lead to changes in water levels, flow in rivers and streams, water availability, and overall hydrologic status. Climate change is expected to be a strong driver hydrological extremes which will affect the availability of water for various uses, and countries in Sub-Saharan Africa are likely to suffer more as a majority of the population derive their livelihood directly from ecosystems and have poor capacity for adaptation. For evaluating impacts and alternatives, local and region-specific studies are needed, and data from Global Climate Models (GCMs) are at a coarse resolution that must be downscaled to higher resolution. Surface climate variables, and particularly precipitation, can be highly variable both spatially and temporally, and the normal variability in seasonal and annual climate variables may be

confused with long-term climate change. Resilient and sustainable agricultural practices must be developed through analysis that considers the scope of short-term climate variability as well as longer term cycles and the expected long-term trends brought about by changing climate.

Planning for adaptation requires analysis of impacts through the use of hydrological models. Regardless of the approach used to plan for climate change adaptation, access to accurate, sufficient and relevant data is vital. Local observation of hydro-climatic data are important for defining and reducing the uncertainties related to the hydrological impacts of climate change, and are essential for calibrating and validating climate and hydrological models. Monitoring of headwater watersheds of the Ruvu River watershed will form the basis for calibration and validation of hydrological models that will be used for impact analysis of different climate change scenarios. Results for rainfall analysis in the Mbezi, Kivumaga and Mkungazi watersheds show high variability in both the long (MAM) and the short (OND) rainy seasons. The meteorological station at the Tegetero mission receives more rainfall compared to three other rain gauges, and discharge in streams is dependent on rainfall timing and amount. Climate projections for the region for IPCC AR5 scenarios RCP 2.6, RCP 4.5 and RCP 8.5 for time periods of 2030s (2020 - 2049), 2050s (2040-2069) and 2080s (2070-2099) were downscaled using the Delta method. Climate data outputs for temperature and precipitation from four different models show an increasing trend in temperature compared to the current conditions and increased variability in precipitation with an overall result of a decrease in the precipitation in the basin.

INSTITUTIONAL WATER RESOURCES MANAGEMENT AND LIVELIHOOD ADAPTATION – A CASE FROM KILOMBERO RURAL AREAS, TANZANIA

Paul Vedeld, Edgar Liheluka, Gimbage E. Mbeyale

Abstract

The impact of irrigation schemes are studied on poor people's livelihoods in Kilombero, Tanzania. We find that total household incomes are 2 times higher for improved irrigation scheme farmers while farm incomes are 3 times higher. We further find that reported land productivity is 4-6 times higher in improved rice irrigation fields. While incomes go up, so does also costs (3 times higher input costs). Concerning water based incomes dependence, we find that households on average have 43% of their incomes from water, a dependence that is even higher for the poorer groups of households (57%).

Improved schemes come with formalized rights and duties, monitoring, control and sanctions and water user fees structures. This implies introducing new institutions on top of existing traditional systems for resource management. The new systems are molded or bricolaged into existing systems, and in practice traditional and modern irrigation schemes are not very differently managed. Local people generally seem to manage irrigation systems well and within reasonable conflict levels under climate change scenarios.

Some worries do remain; to what extent will the new policy, advertised as a devolutionary system of water rights down to local communities de facto lead to an increased central control over rural water, and where especially hydropower (40%) priorities constrain dry season irrigation and where large scale commercial farmers access the brunt of water to the agricultural sector. And will increased use of tariffs be used as a way to introduce a general tax on rural households.

AGRICULTURAL RESEARCH FOR SUSTAINABILITY

Isaac J. Minde and Stephen Nyaki

Abstract

Climate change is now a reality. There is therefore a dire need to creatively and innovatively change the way we prioritize and conduct agricultural research so as to continuously reduce the negative impact of climate change. This paper discusses the importance of orienting agricultural research to address the multi-dimensional sustainability components—environmental, economic, social and institutional.

This paper adopted the following methods: First, we assessed from the literature the existing research paradigms—agricultural research, agricultural research and development, agricultural research for development and agricultural research for sustainability. We assessed the extent to which they address one or more of the multi-dimensional features of sustainability. Second, we reviewed and modified indicators found in the literature that are helpful in measuring in an ex ante and or post-ante manner the degree to which a research study will or has addressed and contributed to the four sustainability features. Third, we conducted a quick assessment of the kinds of agricultural research conducted by selected institutions in the region (Sokoine University of Agriculture, Ministry of Agriculture, Food Security and Cooperatives, Association for Strengthening Agricultural Research in Eastern and Central Africa) to establish the extent to which those research studies cautiously or unconsciously addressed one or more of the sustainability features.

Relationships among the kinds of research (basic or disciplinary, applied or problem solving, subject matter and other variants), and concern about sustainability were explored. In general, we found that the closest relationship exists between problem solving research and sustainability concerns while the furthest from sustainability concerns was basic or theoretical research. Another finding was that the most popular dimension of sustainability is environmental sustainability. Literature is abundant and the awareness is highest when ranked with the other three. However, there is a clear recognition that the rest of the sustainability dimensions are not less important. It is only that awareness has not been as much emphasized.

This study concludes by urging agricultural research institutions to firmly adopt the indicators on agricultural research for sustainability and make use of them in an ex-ante and ex-post manner. Obviously, it will be difficult for a researcher to address the four dimensions of sustainability at the same level of rigor for all research topics. Most likely, a researcher will have a priority sustainability dimension out of the four and this will very much depend on the objective of the research.

POTENTIAL ROLE OF COMMERCIAL BIOLOGICAL INOCULANTS IN INCREASING SUSTAINABLE FOOD PRODUCTION IN SUB-SAHARAN AFRICA

Cargele Masso

Abstract

Meeting the increasing demand for food in Sub-Saharan Africa (SSA) in the face of dwindling arable land, high cost of agricultural inputs and climate change will require scientists and policy makers to develop sustainable methods for use of finite resources. There is also increased awareness on the need to increase food production with minimum adverse effects on the environment as has been witnessed in other continents, and to reverse it where it has occurred in SSA. Advances in science have revealed the intricate relationship between plant-microbe interactions with resultant isolation and culture of

single or multiple species of microbes which can then be used to inoculate plants. Commercial biological inoculants have increasingly received attention for their potential in mobilizing nutrients, disease control, promoting plant growth and increasing crop resilience to both biotic and abiotic forces. We review the specific roles that commercial biological inoculants can play in addressing challenges related to food production in SSA with evidence of what has been achieved elsewhere and to a limited extent in SSA. We also highlight current efforts and gaps (both technical and practical) that need to be addressed to ensure adoption and sustainability of such technologies both in the short and long term.

INNOVATION PLATFORMS FOR AGRICULTURAL SUSTAINABILITY: THE IAGRI CASE

Maria Mullei

Abstract

This paper describes the potential role an innovation platform can play in catalyzing and sponsoring projects and business cases that, if completed, can mitigate disruptions caused by climate change, disaster, and failure. In addition, this paper illustrates how successful adoption of an innovation platform requires concurrent changes in the formal system of its sponsoring institution in order to incentivize participation and increase market attractiveness for the potential research projects and business cases represented by the innovation platform. An example of an innovation platform for water management within an agroforestry system integrates temperature and humidity sensor systems to monitor microclimates; low-cost solar-powered controllers for autonomous drip irrigation systems; and locally made affordable drip irrigation emitters that deliver precise levels of water directly to the roots of trees and cash crops. The result is better management of water deficits and prevention of soil erosion.

THE ECONOMICS OF INVESTMENT IN AGROECOLOGICAL SYSTEMS TO ENHANCE ADAPTATION TO CLIMATE CHANGE AMONG SMALL SCALE FARMERS IN SUB-SAHARAN AFRICA

Ephraim Nkonya

Abstract

The low and unpredictable precipitation in the arid and semi-arid lands (ASAL) have posed daunting challenges to farmers, who in turn, have gained ecological knowledge and experience in building resilience and coping strategies. Crop diversity is one of such strategies. Using household survey data and crop and livestock simulation, we evaluate the returns to farmer investments and production risks in specialized and diversified crop and livestock production systems in the ASAL of SSA. The results show that intercropping and mixed cropping systems have significantly greater returns to both land and labor and lower yield variance than monocropped systems. Additionally, even after taking account purchased foods, dietary diversity of household with intercropped/mixed cropping systems were greater than households with monocropped systems. Soil fertility, dietary diversity and quality of households who grow crops and raise livestock were significantly higher than those who are either crop or livestock producers only. Livestock ownership also reduces climate-related production risks and increases the propensity to adopt integrated soil fertility management (ISFM).
The results suggest that diversified agroecological systems simultaneously increase adaptation to climate change and improve dietary diversity and quality.

Controlling for livestock ownership however, crop diversity reduced the propensity to adopt mechanization – an aspect which highlights challenges of mechanization in diversified systems. Farm size also reduced crop diversity suggesting that beyond a certain threshold, crop diversity is more relevant to smallholder farmers than to large-scale farmers.

Policy implications of the results are that, production technologies targeted to diversified crop production are required to enhance their adoption. Current production recommendations are based on monocropping systems. For example, legume breeding efforts to develop cultivars with shade tolerance are limited. Yields of leguminous crops intercropped with taller cereal crop is significantly reduced compared to monocropped legumes - largely due to competition for light and other factors. The new Food and Agriculture Organization (FAO) promotion of agroecology is a welcome initiative but it needs to carefully target multiple cropping and other agroecological systems to different groups of farmers.

Session 5A: Soil Management – Land Rehabilitation

EXTENT OF SALT AFFECTED SOILS AND THEIR EFFECTS IN IRRIGATED AND LOWLAND RAIN-FED RICE GROWING AREAS OF SOUTH WESTERN TANZANIA

Kashenge-Killenga, S., Meliyo, J., Urassa, G and Kongo, V

Abstract

Increasing salt affected soils has become a major abiotic constraint for rice production in lowland areas (both irrigated and rainfed) in south western Tanzania. Meager information on salt affected soils distribution is currently available in the country. This study aimed at (a) establishing salt status of salt affected soils by types in selected irrigation schemes in the south-western Tanzania rice growing corridor and (b) establish farmers' perception on the extent of salt problem and associated crop losses in the respective rice irrigation schemes. Participatory diagnosis and observation survey was conducted in five major rice producing regions of Katavi, Rukwa, Mbeya, Iringa and Morogoro. Composite samples were collected from salt affected hot spot areas in 21 selected irrigation scheme and analyzed. Visual observation and laboratory results showed 100 per cent and 67 per cent of the schemes visited respectively had salt problems. Three types of salt affected soils (Saline, Sodic and Saline – Sodic) with extreme salinity (4 – 15 dS/m), sodicity (10-34 SAR) and high soil pH (up to 10) values identified. Sodicity was a common problem followed by saline – sodic. About 90 per cent of the surveyed irrigation schemes had inadequate irrigation infrastructures which seem to contribute to the problem. Land loss ranges from 5 to 25 percent of the schemes and crop losses range from 5 to 100 per cent. Measures including rehabilitation of irrigation infrastructure to improve drainage systems, use of salt tolerance cultivars and embarking on salt soil management options should be taken to avert arable land losses.

Keywords: Salinity, Sodicity, Abiotic stresses, salt tolerance, Southern corridor, south western Tanzania

INSTITUTIONAL ASPECTS OF LAND DEGRADATION AND REHABILITATION IN AFRICA

Luc Gnacadja

Abstract

Land is the strategic resource for sustainable transformation in Africa given the challenges and potentials of the region in the face of climate change, population dynamics and globalization.

Addressing the institutional aspects leading to land degradation and land rehabilitation will be key for realizing such potential.

More than half of the additional two billion people who will live on Earth by 2050 will be born in Africa, while nowadays the region is the world's champion in poverty hunger and food insecurity, youth unemployment, agriculture vulnerability to climate change, land degradation, resource-based conflicts and migrations leading to economic, social and political instability.

But Africa is well endowed to respond to these challenges and to the exploding global demand for food, energy and water. For instance a new farmland equal to the size of South Africa will be needed globally just for meeting by 2030 the world's demand for food without encroaching on existing forests. Africa accounts for 60% of the world's uncultivated arable land and more than one third of the world's degraded land with potential for restoration. The continent is already a global hotspot for success stories in land rehabilitation but in that regard innovations in technology and social engineering are mostly occurring at local level.

What are the changes needed at governance level for a sustainable transformation to take place in Africa using land as its strategic resource? What institutional transformations to scale up and roll out land rehabilitation in the continent?

SOIL AND NUTRIENT LOSSES AND THE ROLE OF GENDER IN LAND DEGRADATION IN SOUTHWESTERN UGANDA

Kizza, C.L.; Majaliwa, J.G.M; Gabiri, G.; Zizinga, A.; Tenywa M.M.

Abstract

Land degradation is rapidly increasing in South-western Uganda leading to loss of soil productivity, increased water body pollution and reduction in vegetation and wetland cover. Soil erosion is one of the leading observable indicators of land degradation. This study evaluated runoff, soil and nutrient losses under the different land uses and landscape positions within L. Bunyonyi Catchment covering approximately 334 km^2 in Kabale District South-western Uganda. Erosion plots were established in the four major land uses namely perennial crops, annual crops, woodlots and grazing. Erosion trap plots measuring 15 m x 2 m were established in the each of the land uses replicated four times at each of the landscape position of summit shoulder, mid-slope and foot-slope using a pipe sampler collecting approximately 1% of the plot runoff. Runoff was measured using a measuring cylinder the following day following a rain event. All the runoff with its soil sediments were collected into plastic bottles and delivered to laboratory for soil and nutrient losses. Land use cover change was studied covering the two periods from 1987 to 1999 and from 2005 to 2014 using Landsat imagery. In addition, the study evaluated the role of women in and the driving factors in land degradation using a social survey questionnaire administered a total of 120 women respondents.

More runoff was observed in the annuals (175 $m^3\ ha^{-1}\ yr^{-1}$) followed by woodlots and perennials (159 $m^3\ ha^{-1}\ yr^{-1}$) and (141 $m^3\ ha^{-1}\ yr^{-1}$), respectively, and least in grazing land (136 $m^3\ ha^{-1}\ yr^{-1}$). However, more soil loss was recorded in the woodlots (431 kg $ha^{-1}\ yr^{-1}$), and followed in decreasing order by grazing land (143 kg $ha^{-1}\ yr^{-1}$), perennials (78 kg $ha^{-1}\ yr^{-1}$) and annuals (72 kg $ha^{-1}\ yr^{-1}$). The mid-slope had significantly more soil loss (274 kg $ha^{-1}\ yr^{-1}$) over foot slopes (152 kg $ha^{-1}\ yr^{-1}$) and lowest at the summit shoulders (144 kg $ha^{-1}\ yr^{-1}$). The runoff did not follow a similar trend to that of the soil loss and though the variations were not significant it was more observed at foot-slope (163 $m^3\ ha^{-1}\ yr^{-1}$) then summit shoulder (157 $m^3\ ha^{-1}\ yr^{-1}$) and least at mid slope (138 $m^3\ ha^{-1}\ yr^{-1}$). Significantly high nutrient losses were registered under woodlots over all the other land uses. There were six (6) land uses studied for land use cover change namely: small scale farmlands, tropical high forest, grasslands, open water, wetlands and Eucalyptus woodlots. During the period between 1987 and 1999, apart from the small

farmlands, all the other land uses experience net reduction in size with wetlands most affected. However, during the period between 2004 and 2014, only Eucalyptus woodlots and to a little extent small farmlands experienced an increase in land cover. Whereas, women do not own land, they are primarily responsible for domestic food security contributing over 70% of domestic labor. On average, women spend over eight hours daily in the field using manual labor. Occasionally, these women provide hired labor to supplement domestic agricultural activities in order to access other necessities. Most of the soil conservation and soil fertility improving practices are too laborious and costly for women to undertake leading to environmental and resource depletion problems and subsequently land degradation. The heavy burden of sustaining the rapidly increasing population on the diminishing resources is escalating land degradation for which the women have a despicable share. Had the men fully participated in land management and especially contributing the much needed labor and resources, the state of land degradation in south-western Uganda would have been much better.

Key words*:* Soil erosion, soil fertility, land management, erosion traps and land use

Session 5B: Agricultural Risk and Insurance

AGRICULTURAL INDEX INSURANCE IN AFRICA SINCE 2000: LESSONS LEARNED AND WAYS FORWARD

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The Ohio State University, USA
and
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African Center for Economic Transformation, Accra, Ghana

Abstract

Unlike conventional agricultural insurance, which indemnifies policyholders for verifiable production losses arising from multiple perils, index insurance indemnifies policyholders based on the observed value of a specific "index" or other variable that is highly correlated with losses, most commonly rainfall. Index insurance exhibits lower transaction costs than conventional insurance, potentially making it more affordable to poor farmers in the developing world. However, it also offers less effective individual risk protection due to lack of coverage of losses unrelated to the index. Our presentation offers a general introduction to index insurance and provides a review of lessons learned from pilot programs and theoretical and empirical research on index insurance in Africa since 2000. We will also discuss current trends in index insurance research and product and market development.

AGRICULTURAL RISKS IN AFRICA AND POTENTIAL FOR HAZARD BASED INSURANCE

Babatunde Abidoye

Abstract

Households and farmers around the world are faced with different kind of risk that affects livelihoods and life. In Africa, majority of the risks to farmers are environmental/climate related - include drought/irregular rains, floods, landslide/erosion and pests and diseases. However, other risks may also pose serious threat to income and poverty alleviation including volatility of input and output prices. This study seeks to quantify the impact of adverse weather events on farmers and optimal coping strategies, using micro level panel data (2009 to 2011 for Uganda) from the World Bank Living

Standard Measurement Survey. Households were asked the type of shocks experienced (drought, floods, landslides, etc.) during the past year and how long the shock lasted. The duration of the shock is used to proxy intensity of the shock. This data is then linked to net revenue of the farmer to estimate the impact of the shocks on farm revenue. Data on the impact of the hazards will be useful in evaluating the potential for weather based insurance in the country.

IMPROVING INDEX INSURANCE QUALITY WITHOUT COMPROMISING COSTS: A SATELLITE BASED CONDITIONAL AUDIT APPROACH

Jon Einar Flatnes

Abstract

While index insurance offers a compelling solution to the problem of covariant risk among smallholder farmers in developing countries, such contracts generally suffer from poor quality due to a low correlation between the index and farmer losses. On the other hand, individual indemnity insurance contracts are typically infeasible because of prohibitively high monitoring costs. This paper proposes and analyzes an alternative index insurance contract, which combines a satellite based index with the potential for a second-stage audit, essentially creating a fail-safe contract at a relatively low cost. The satellite index is created using a model which takes freely available high-resolution satellite data and converts them into a set of vegetation indicators. Using plot-level panel data from a retrospective yield survey among smallholder rice farmers in Tanzania, we estimate a model of yields as a function of these vegetation indicators. The predicted yields are then used as the basis for the insurance index. If the index fails to predict losses, an audit, in the form of a crop-cutting exercise, can be invoked at farmers' request. Our results suggest that the vegetation indicators significantly predict average rice yields in our pre-defined insurance zones and explain approximately 60% of the variation in zone-level yields across years. Hence, a contract based on this index would require only the occasional audit, and thus would constitute a fail-safe, yet affordable insurance product for smallholder farmers.

THE USE OF *EL NINO*-BASED SEASONAL CLIMATE FORECASTS AS RISK MITIGATION FACTORS BY SMALLHOLDER FARMERS IN ZIMBABWE

Ephias M. Makaudze

Abstract

This study demonstrates the potential value of seasonal forecasts as risk mitigation factors to smallholder farmers in Zimbabwe - a majority who often suffer severely from the impact of drought. Using crop simulation models to compare yield performances of farmers *with* and *without* forecasts, results indicate that for a drought year, farmers *with forecasts* (WF) record higher yield gains (28%) compared to those *without forecasts* (WOF); in particular, farmers located in the most arid regions (NR V) record the highest yield gains (42%). A similar trend is observed during a neutral/average year as farmers WF obtain predominantly higher yield gains (20%) than those WOF. However during a good year, results show a different pattern as no yield gains are observed. In fact farmers WOF perform better; suggesting forecasts in this case may not make much difference. Using gross margin analysis, results show farmers WF obtaining higher returns during a drought (US$0.14ha^{-1}) and neutral year (US$0.43ha^{-1}) but again not for good year as farmers WOF outperform those WF. To summarize, forecasts can play an important role as *loss-minimization* instruments especially if the underlying year is a *El Niño* (drought) year. In conclusion, seasonal forecasts could play an important role as climate change risk mitigation factors particularly if complementary policies (currently missing) such as effective communication, improvement in forecast extension skills and promotion of farmer participatory and outreach activities are put in place.

SOIL – A LIMITED RESOURCE UNDER CHANGING CLIMATE

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Abstract

Soil is a limited resource and must be handled and used in a sustainable way to protect it for the use by the present and future generations. The renewed recognition of the multifunctional and central roles of soil resources for assuring food security and the increased awareness that soils play a fundamental role in climate change adaptation and mitigation has triggered numerous discussions and research efforts. Soil faces many threats and the gradual degradation of soil by erosion, loss of organic matter, salinization or destruction of its structure is transmitted to other ecosystem components-water resources, vegetation cover, fauna and soil microorganisms. Thus, leading to reduction in many ecosystem services. The Norwegian Society of Soil Science is making efforts in spreading soil awareness to all stakeholders and general public in commemoration of the International Year of Soils (IYS) - 2015 by organizing seminars and symposia and special sessions at national and international conferences like this one.

Of the many threats mentioned above, the climate change is considered very serious one for Africa and will be focused in this presentation. Sub-Saharan Africa (SSA) is the most vulnerable region to climate change due to multiple challenges. It will adversely affect agricultural production, livelihoods and food security of millions of people in SSA countries. The need to find adaptation and mitigating options is widely felt. Climate-resilient sustainable agriculture (CRSA) is one way of coping with climate change and variability in SSA. CRSA comprises an array of technologies that may help to cope with the climate change in SSA. Some of these technologies will be presented in this presentation. Building CRSA is a local phenomenon. Thus, the local and scientific knowledge must be integrated to develop adaptive technologies Achieving CRSA in SSA also requires partnerships between the government, private sector, and NGOs >> multi-sectorial and multi-agency approach.

INTERNATIONAL YEAR OF SOILS AND IUSS

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Abstract

The International Union of Soil Science (IUSS), initiated in 1924 as International Society of Soil Science (ISSS), represents about 60,000 soil scientists of the national soil science societies from around the world. Mission of the IUSS is: 1) to facilitate and promote the improvement of the scientific understanding of soil in all contexts, 2) to support soil science in all parts of the globe, and 3) to make people of the world aware of the importance of soil for the sustainability of human kind and all life-support systems. The IUSS vision is: 1) to be recognized as the world leading organization for the facilitation, collection and dissemination of soil knowledge, and 2) to strive, support and value the global community of scientists who generate soil knowledge and increase understanding of soil. IUSS has four divisions: 1) Soil in Space and Time, which has six commissions, 2) Soil Properties and Processes, which has five commissions, 3) Soil Use and Management, which has five commissions, 4) The Role of Soils in Sustaining Society and the Environment, which has five commissions. The IUSS addresses global issues including climate change, food security, soil degradation, water quality, and biodiversity. It organizes the World Congress every four years, and the 21st Congress will be held in

2018 in Brazil. With support from His Royal Highness, the King of Thailand, IUSS celebrates the World Soil Day on 5th December, which is the birthday of His Royal Highness King Bhumibol of Thailand. During 2015 International Year of Soil, IUSS will celebrate the World Soil Day, in cooperation with IAEA, at its new Head Quarters in Vienna, Austria on 7th December 2015. The mission of IUSS is to restore soils. If soils are not restored, crops will fail even if rains do not; hunger will perpetuate even with emphasis on biotechnology and genetically modified crops; civil strife and political instability will plague the developing world even with sermons on human rights and democratic ideals; and humanity will suffer even with great scientific strides. Political stability and global peace are threatened because of soil degradation, food insecurity, and desperateness. The time to act is now, during 2015 International Year of Soil.

ENVIRONMENTAL ASPECTS OF MEASUREMENT OF AGRICULTURAL SUSTAINABILITY

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Abstract

The destruction of earth's natural systems caused by economy-driven development, as it happens today, is not a new phenomenon. The decline of the Maya empire in Mexico (2000 BC – 600 AD), for example, is attributed to forest clearing leading to soil erosion and soil-fertility loss. In recent times, the Green Revolution that helped avert large-scale hunger in some parts of the world has exacerbated global ecological problems such as climate change, water pollution, and biodiversity depletion. In the wake of this "Ecology–Economy" Conflict, the concept of sustainability has become a forceful rallying theme. Sustainability is *transdisciplinary;* is focused on the *interactions* between the resource systems (earth/life sciences), its users, and the governance system (social sciences); is *problem-driven* to manage complex social-ecological systems to deliver what people value; and, is *beyond the* confines of classical disciplines. In short, the science that provides the basis for measurement sustainability, including agricultural sustainability, is about understanding the dynamics of social-ecological systems for bridging the ecology–economy divide. Agroforestry is one example of a sustainable approach to land-use. The ecosystem services provided by agroforestry systems, such as soil productivity improvement, climate-change mitigation through carbon sequestration, and reduction in biodiversity decline, constitute the essence of environmental sustainability of these systems; measurement of these attributes and evaluation of their relative values in the overall social-ecological context will therefore be the key to measurement of the systems' environmental sustainability. The methods for doing such measurements and evaluations, however, are not fully developed.

Session 7A: Private Sector Solutions for Sustainability

WEALTH CREATION FROM CLIMATE CHANGE: THE CASE OF TANSEED INTERNATIONAL LTD.

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Abstract

The private sector plays the most important role in financing agricultural investments, innovation and information dissemination where constraints on government investment render private sector actions more important. In East Africa, little is known about the participation of small businesses, independent traders, farmer organizations, large-scale wholesalers, marketing boards and cooperatives in climate-

PRIVATE SECTOR ACTIONS TO ENABLE CLIMATE-SMART AGRICULTURE IN SMALL-SCALE FARMING IN EAST AFRICA

Sheryl Quail, Leah Onyango, John Recha, and James Kinyangi

Abstract

The private sector plays the most important role in financing agricultural investments, innovation and information dissemination where constraints on government investment render private sector actions more important. In East Africa, little is known about the participation of small businesses, independent traders, farmer organizations, large-scale wholesalers, marketing boards and cooperatives in climate-smart agriculture (CSA) and their potential role in its diffusion to small-scale farmers. In particular, small companies and the informal sector are out of view. Yet such information is critical in exploring how best to harness private sector comparative advantage to benefit small-scale farmers. This study is an attempt to fill this research gap and examines patterns of, and incentives for, private sector investments and activities in climate-smart agriculture at three pilot projects implemented by Climate Change, Agriculture and Food Security (CCAFS) in Nyando, Kenya; Hoima, Uganda; and Lushoto, Kenya.

This study examines relationships between private sector actors and farmers and subsequent flows of information and services for the following: climate, crop and livestock extension, credit and banking, and legal. It also examines supply chains of agricultural inputs, as well as agricultural product value chains. Seed supply chains and the potential of farmer seed production of CSA germplasm is examined as well as the impact on crop seed diversity. Finally, farmer trust of private sector actors and uptake of ICT platforms is evaluated. Focus group discussions and surveys were administered to 289 farmers. Local businesses were also interviewed. Local-level linkages with national agricultural organizations to determine if they play a role in facilitating CSA.

APPLICATION OF TEMPERATURE SENSORS IN REGULATING MICRO-CLIMATE IN AGROFORESTRY SYSTEMS

Jacqueline Kajembe

Abstract

This study was conducted to assess soil and air temperature levels of dominant tree species in agroforestry systems which have potential influence on coffee productivity in Moshi District, Tanzania. Specifically, the study aimed at identifying tree species commonly used in agroforestry systems in different agroecological zones, determining the soil and air temperature regulation ability of dominant tree species in a given agroecological zone and assessing the performance of a given tree species in regulating air and soil temperature in different agroecological zone. Purposive sampling technique was employed to select sample villages and farms from different agroecological zones.To acquire information on preferred tree species, data collection methods involved questionnaires, focus group discussions with key informants. Soil temperature was measured at the soil depth of 5cm and air temperature on a wooden stick at 1.5m above the ground in a plot of 5m x 5m where one temperature sensor was under tree shade and the other with no shade. Data were recorded at 1 hour interval for 24 hours. General Linear Models in SAS program was employed to analyse temperature and SPSS for socio economic data. The dominant tree species were found to be Grevillea robusta, Albizia schimperiana and Rauvolfia caffra. There was a significant difference in soil and air temperature regulation among tree

species in the midland (p-values<0.05). Grevillea robusta significantly regulates soil and air temperature in both highland and midland zone (p-values <0.05) compared to other studied tree species. Since moderate temperature favour coffee productivity, Grevillea robusta is recommended in both midland and highlands. However, it is imperative to investigate how the soil impacted by Grevillea robusta affects coffee productivity.

ECONOMIC IMPACT OF DRIP IRRIGATION ON SORGHUM'S PRODUCTION IN SEMI ARID AREAS OF TANZANIA

Athuman Mahinda

Abstract

In the context of increasing yield production that would justify economic returns and improve food security while sustaining water resource under the challenging climate change and variability; a promising drip irrigation regime has to be developed. Field trials were conducted in semi arid area of central Tanzania with the aim of assessing the impact of three drip irrigation watering regimes on the production and economic returns of *Sorghum bicolor*. The irrigation treatments were: EM (early in the morning), EL (late in the evening) and ELE (both early in the morning and late in the evening). Each treatment was replicated three times in a RCBD. The maximum yield of 13.12 ton/ha with economic returns of Tanzania shilling 6,675,900 /= was obtained when sorghum was irrigated twice a day in the dry season. Although irrigating twice a day in the dry season resulted into higher yield, the net income was higher (7,607,780/=) in dry-wet season. This is because during dry season a lot of water had to be bought for irrigation; thus caused the total cost of production to be higher. Irrigating early in the morning or late in the evening resulted into more yield than under rainfed condition however, it was economically viable to irrigate twice a day as this had the benefit of giving more economic returns in the study area.

Key words: Semi arid, Sorghum production, Watering regimes, Drip irrigation, Economic returns

SOCIAL ASPECTS OF WATER GOVERNANCE IN THE CONTEXT OF CLIMATE CHANGE AND AGRICULTURE

Richard Asaba

Abstract

Climate change is undoubtedly one of the greatest threats to humankind. Changes in temperature and precipitation affect the supply, access and governance of water resources in many developing communities. The ecological, physical and technological impacts of climate change on water have largely been studied, but there is little and sketchy evidence on the links between climate change, human relations, water and agriculture. The social dimensions of climate change, particularly in the governance of water in resource poor African agricultural-based contexts have not been given much attention, yet they are essential in adaptive and sustainable water management. Thus, this paper seeks to identify the key social issues and impacts of climate change on water governance among farming communities in Sub-Saharan Africa. The social issues are identified basing on a sociological view of water governance, which encompasses the interrelated aspects of resources, 'mechanisms' or arrangements of access to water, outcomes and water management processes. The available evidence suggests that the major social factors that are central to water governance in the context of climate change in farming communities include: deterioration of water resources, which leads to reduced basic access to water for crops, livestock and humans; perceptions of climate change and the resulting effects on water governance; institutional and policy bottlenecks; changing property rights; conflicts resulting from climate change induced water scarcity and droughts; cultural norms and values; and gender relations, which cut across all the other factors. These issues need to be integrated in vulnerability analysis, adaptation planning and interventions so as to improve the adaptive capacity and sustainability of water governance among communities that rely on rain-fed agriculture in Sub-Saharan Africa.

ASSESSMENT OF CLIMATE CHANGE IMPACTS ON COMMON BEAN (PHASEOLUS VULGARIS SAVI, L.) PRODUCTION IN TANZANIA

Mourice, S.K, Tumbo, S. D. and Rweyemamu, C. L.

Abstract

Common bean (*Phaseolus vulgaris*) Savi, L. has a C3 carbon fixation pathway which is normally constrained by low ambient CO_2 concentration. As atmospheric CO_2 concentration increases due to fossil fuel burning and other anthropogenic activities, it is being hypothesized that most C3 crops including common bean will benefit from CO2 increase in terms of grain yield increase. However, these gains will likely be offset by high temperatures associated with increased levels of greenhouse gases. In Tanzania, it is yet to be ascertained as to what the climate change effects will be on overall productivity of common bean, given the fact that impact assessment for other crops such as maize show projected yield decline. The understanding of how bean crops may respond to future climate is important in designing agronomic and breeding programs for future climate scenarios. A study was conducted to assess the climate change impacts on common bean yield in major producing regions of Tanzania namely Kagera, Kigoma, Mara, Manyara, Mbeya and Ruvuma. Five CMIP5 global circulation models (GCMs), namely, CCSM4, GFDL-ESM2M, HadGEM2-ES, MIROC5 and MPI-ESM-LR with two emission scenarios (Regional concentration pathways -RCPs) each, were evaluated. Three future time periods for each RCP (near term; 2011-2039, mid-century 2040-2069 and end century; 2070-2099) were weighed against baseline climate (1981-2009) in terms of common bean yields. BEANGRO sub module of the Decision Support System for Agrotechnology Transfer (DSSAT v4.5) was used to simulate bean yields for all study locations. BEANGRO Model input files and simulations were made using AgMIP protocols. Comparing baseline and future time periods, common bean yield was bound to increase, generally for all study locations and for all GCMs. Profound bean yield increase with respect to base climate was in mid- and end-century time periods under all emission scenarios. Increasing common bean yield with increasing CO_2 as a result of intensified emissions indicates climate change will be beneficial to the bean crop production. Photosynthesis will be preferred to photorespiration under high CO2 emission scenario, unlike in the base climate with low CO_2 concentration where much of the photosynthates are consumed away by photorespiration in C3 crops, including common beans. The outlook for future bean cultivars should be on those with high photosynthetic efficiency under elevated atmospheric CO_2 concentrations for increased productivity.

Key words: AgMIP, C3, DSSAT, rain fed agriculture, RCP

Key to abbreviations
AgMIP- Agricultural Model Inter-comparison and Improvement Project
CMIP5 - Coupled Model Inter-comparison Project Phase 5

Session 8A: Extension Systems for Agricultural Sustainability

RE-POSITIONING EXTENSION SYSTEMS TO RESPOND TO EMERGING ISSUES IN AFRICAN AGRICULTURE

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Abstract

Africa's agriculture is facing a range of challenges in the twenty first century threatening its sustainability. These coupled with emerging opportunities have resulted in new needs by the farming community and other actors. Consequently, extension systems in many countries are being re-positioned to accommodate new players (including the private sector and civil society), and to undertake new roles besides their historical function of agricultural information and technology transfer. Based on a review of literature and experiences of various countries around the world, the paper draws policy and practice implications of re-positioning pluralistic agricultural extension systems to address key emerging challenges and opportunities, namely—(i) How to respond to needs of diverse clients--youth, men, and women; profit motivated market oriented farmers, agribusinesses and other value chain actors; (ii) How to cope with climate change and other pressures on natural resources arising from unprecedented population growth; (iii) How to take advantage of new opportunities—regional markets, more educated clients, ICT and other technologies; (iv) How to cope with lower budgets and more competition from other sectors for dwindling national resources as the contribution of agriculture to the GDP reduces. The paper draws implications regarding new capacities needed and how they can be developed; new approaches and methodologies; organizational configurations; policies and new mandates for extension, and the role of the public sector.

TOWARDS AN ECOLOGICAL PARADIGM FOR AGRICULTURAL EXTENSION IN AFRICA

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Abstract

The impact of climate change is sweeping through Africa and smallholder farmers and pastoralists are feeling its brunt in terms of erratic rainfall patterns and increasing household food insecurity. It is estimated that climate change, as a significant "hunger risk-multiplier," can cause an additional 24 million malnourished children by 2050, and almost half of them will be in Sub-Saharan Africa. With smallholder farmers and pastoralists accounting for almost 80% of Africa's population the challenge to extension becomes paramount. This author argues that climate change and global warming are the result of human action on agriculture and the environment and proposes an ecological paradigm approach to extension. This approach focuses on climate smart agriculture technologies, environmentally friendly farming practices and socially responsible development communities. The author concludes that effective extension in the 21st century will require a holistic approach to development, based on a systems view. The author also argues that the new extensionist for the 21st century will need post-graduate Master's training, particularly in communication and development, to

effectively cope with the increasing complexity of rural development programming, particularly in addressing human dimension concerns, such as local participation, interagency collaboration and capacity strengthening.

FROM UJAMA TO BIG RESULTS NOW: SUSTAINABLE TRANSFORMATION OF TANZANIAN AGRICULTURE?

Professor Ruth Haug, Norwegian University of Life Sciences

Abstract

The purpose of this paper is to assess why different political actions and technological innovations only to a limited degree have contributed towards the planned transformation of Tanzanian agriculture. Persistent rural poverty, chronic undernourishment, low productivity in agriculture, and uncertainties around future impacts of climate change on food production are challenges faced by the Tanzanian Government. The objective of this paper is to discuss the role of conducive political frame conditions and enabling environments in relation to agrarian change and adoption of new technologies including the space for pluralistic and successful agricultural extension. The paper is based on literature review and qualitative interviews with different key informants such as women and men farmers, extension agents, agro-dealers, NGOs and private sector representatives, researchers and other civil officers at district and national levels during the last five years. The main finding in relation to achieving the overall aim of sustainable transformation of Tanzanian agriculture is the need to involve farmers and their organizations in policy formulation and implementation as well as to restore trust towards public institutions and the many changing initiatives put in place by the Government and donors over the past 30 years. Predictability in relation to stable frame conditions and measures to reduce risks are important factors as regards women and men farmers' willingness to adopt new technologies as well as extension services' ability to contribute towards scaling up promising innovations in agriculture.

Session 8B: Private Sector Solutions for Sustainability

EFFECT OF IMPROVED PLANT NUTRITION ON MAIZE AND RICE GRAIN CHEMICAL COMPOSITION UNDER SMALLHOLDER FARMING SYSTEMS IN TANZANIA

Ephraim J. Mtengeti, Eva Mtengeti, Frank Brentrup, Lars Olav Eik, and Ramadhani Chambuya

Abstract

Maize and rice are the primary cereal crops constituting more than 50 % of the dietary energy to the population of Tanzania. The current increased demand of food to feed an increasing population in the country has called either for an expansion of cultivated land or intensification of these two crops. Expansion of cultivated land is limited by high land use pressure and the concern over natural resources conservation. The only way to grow more food is then through agricultural intensification by improving plant nutrition and protection. Smallholder farmers however lack information on appropriate use of agro-inputs and the effect of inorganic fertilizers on these cereals grain quality. This has led to either improper or disproportionate use of inorganic fertilizers resulting to disappointing low yield and frequent household food insecurity. To address this matter, a public-private partnership comprising two public universities and multinational companies dealing with fertilizer and crop protection was initiated in December 2010, aiming at demonstrating the effect of appropriate inorganic fertilizers use on the yield and chemical composition of maize and rice grains. In total four farms of maize and three of rice crops in different villages and districts were selected for the demonstration that

was carried out from 2011 -2014. The demonstrated treatments were famers' practice and appropriate use of inorganic fertilizers. Maize and rice grains were harvested, oven dried and analyzed for N, P, K, Mg, S, Ca, Bo, Cu, Fe, Mn, Mo and Zn. Regardless of location, practice and year of demonstration the concentrations of N, P, K, Mg and S for were moderate to normal ranging from 1.21 - 1.69, 0.18 – 0.34, 0.24 – 41, 0.08 – 0.13 and 0.09 – 0.12 % for maize grain, and 0.97-1.19, 0.26 – 0.31, 0.28 – 0.41, 0.09 – 0.12 and 0.07 – 0.10 % for rice grain, respectively. Calcium concentration was high in rice grain but rather very low in maize grain. Both maize and rice grains had very low concentration of Bo and Mo but had rather moderate to normal concentrations of Cu, Fe, Mn and Zn. These results showed that appropriate improvement of plant nutrition did not affect unfavorably the chemical composition of maize and rice grains grown in different locations in Tanzania but increased the amount of harvestable nutrients through high grain yield.

Keywords: Public-Private Partnership, agricultural intensification, inorganic fertilizers, macronutrients, micronutrients

BAKHRESA FOOD PRODUCTS LIMITED - REDUCTION OF CO2 POLLUTION

Lilian Mwashigadi

Abstract

Bakhresa CSD division has 3 plants one which produces processing soft drinks, CO2, and fruit pulps.

Bakhresa Group of Companies is one of the leading industrial houses in Tanzania and across the region and boasts of six companies that provide food products, transport and logistics services. Said Salim Bakhresa is the Chairman of Bakhresa Group of Companies. Mr Bakhresa is one of the leading, contemporary businessmen in Tanzania with over 30 years of experience of managing various business ventures in East Africa.

Bakhresa Food Products Limited (BFPL) is one of the group companies and is one of the largest producers and suppliers of food and beverages in the country.

Mwandege Operations is a part of BFPL. The operations were established to produce mainly soft drinks, fruit juice drinks and drinking water in PET bottles to take advantage of the high volumes of fruit readily available in the market as well as to provide an affordable range of soft drinks to a large number of low income earners on the local market.

SUSTAINABLE INCREASE IN MILK OUTLET FOR SMALLHOLDERS AND PASTORALISTS THROUGH PRIVATE SECTOR COLLABORATION: THE CASE OF THE SHAMBANI GRADUATE ENTERPRISES LIMITED

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Abstract

Former students of Sokoine University of Agriculture (SUA) established the Shambani Graduates Ltd. in 2003. The company collects and processes cow's milk sourced from 250 suppliers, predominantly Maasai pastoralists. Collaboration between pastoralists and the dairy company has ensured a stable milk supply, providing pastoralists a revenue of 90 000 USD in 2014. Within the pastoralist sector, a market-oriented and possibly more sustainable system is emerging due to the profitability of increasing milk outputs.

Because of its desirable nutritional profile and cultural recognition as being beneficial to human health, goat milk also has a high potential market value in Tanzania. The SUA-led initiative to introduce

Norwegian dairy goats to rural areas has resulted in approximately 400 000 animals today, providing households and communities with milk, meat and animal by-products. Although successful in diversifying poor people's diets, farm group's efforts to distribute surplus milk to larger markets have been a challenge. Low education levels in entrepreneurship, milk handling and marketing, are noted to be key explanatory factors.

To secure sustainable markets for goat's milk, we conclude that involvement of an established dairy company is required. We also discuss the potential value of milk in human nutrition and the sustainability of a pro-poor value-chain for goat milk processing based on the collaboration between farmers groups, Shambani Graduates and SUA. The environmental benefits of introducing this new integrated agroforestry-livestock system in the mountain areas of Mgeta are also highlighted.

Keywords: Cows and goats milk, economic and environmental sustainability, human nutrition, processing, public private partnership

Session 9A: Landscape Approaches

MANAGING LANDSCAPE FOR ENVIRONMENTAL SUSTAINABILITY

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Abstract

The basic foundation of landscape management for environmental sustainability is restoration of soil quality through recarbonization of the biosphere. Soil C sequestration can be studied and assessed at a scale ranging from 10-9 to 109m. The scale for management of landscape may range from 102 to 106m within a watershed. The principal strategy of C sequestration within the landscape is to create positive soil and ecosystem C budgets by: (i) increasing the input of biomass-C above and belowground, (ii) decreasing losses of soil C through erosion by water and wind by adoption of conservation effective measures at the landscape scale, (iii) moderating mineralization of soil organic matter by management of physical, chemical and biological protective mechanisms, and (iv) strengthening recycling of soil C pool within the landscape unit. The goal is to create sustainable landscape by: (i) conserving biodiversity, (ii) averting irreversible environmental change, (iii) allocating spatially scarce resources, and (iv) integrating multiple functions. These goals can be realized by managing water (reducing losses by runoff and evaporation, maximizing soil water storage), managing nutrients (enhancing recycling, increasing biological N fixation, accentuating mycorrhizal association), and improving ecosystem services (food, feed, fiber, fuel, C sequestration, biodiversity). Promoting ecological restoration is critical to managing landscape for environmental sustainability through risk assessment and management. A judicious combination of biological and engineering techniques of landscape restoration is needed to harness multiple benefits. Long-term environmental sustainability is a higher priority, but immediate needs must also be met. The stewardship concept is valid only if the basic necessity are met and guaranteed. In this regards, integrated management of natural resources (soil, water, forests, microclimate and biodiversity) at landscape level is of paramount importance.

INTEGRATED LANDSCAPE MANAGEMENT IN AFRICA: SYNTHESIS OF FINDINGS FROM A CONTINENTAL REVIEW

Sara J. Scherr, PhD, President, EcoAgriculture Partners

Abstract

In 2011, international research partners of the Landscapes for People, Food and Nature Initiative (LPFN) began an assessment of the state of integrated landscape management globally. A continental survey of large integrated landscape initiatives (ILI's) in Africa was undertaken by EcoAgriculture, the World Agroforestry Centre and TerrAfrica, completing a standard questionnaire (in English or French) of 87 such initiatives, in which multi-stakeholder partnerships collaboratively pursued objectives to jointly achieve sustainable agriculture, ecosystem or biodiversity conservation and rural livelihoods, often also including food security, water, climate change adaptation and mitigation and or land restoration objectives. Key characteristics of stakeholder participation, activities, impacts, and scale of activity were documented. In parallel, various LPFN partners undertook scoping studies on more than 20 specific themes, including financing landscape investments, business engagement in landscape partnerships, landscape governance, climate-smart landscapes, agrobiodiversity conservation at landscape scale, agroecological practices with biodiversity and ecosystem benefits, et al. Findings showed widespread implementation of multi-stakeholder ILI's led by government agencies, NGOs, regional entities, producer organizations and a few cases of private company leadership. There is considerable expertise now across the continent in designing and implementing such initiatives, and growing policy interest and support. However, there are also major gaps in knowledge and capacity, and the enabling environment remains weak in relation to finance, national policy and business engagement. Syntheses of evidence for Africa informed the development of 19-point African Landscapes Action Plan at a regional forum of landscape experts and practitioners in Africa held in July 2015. The plan identifies priorities to advance research on integrated landscape management in Africa.

UPDATING LEGACY SOIL MAPS FOR CLIMATE RESILIENT AGRICULTURE: A CASE OF KILOMBERO VALLEY, TANZANIA

Boniface H J Massawe, Brian K Slater, Sakthi K Subburayalu, Abel K Kaaya, Leigh Winowiecki

Abstract

Since the first documented soil survey in Tanzania by Milne in 1936, a number of other soil inventory exercises at different scales have been made. The main challenge has been the fragmented nature of the often outdated detailed soil maps and small scale-less informative country-wide soil maps. Recent advances in information and computational technology have created vast potential to collect, map, harness, communicate and update soil information. These advances present favourable conditions to support the already popular shift from qualitative (conventional) to quantitative (digital) soil mapping.

In this study, two decision tree machine learning algorithms; J48 and Random Forest (RF) were applied to digitally predict *k*-means numerically classified soil clusters to update a 1959 produced soil map. Predictors were derived from 1 arc SRTM digital elevation data and 5 m RapidEye satellite image. Both J48 and RF predicted the soil units of legacy maps with greater details. However, RF showed superiority for predicting clusters which J48 could not predict, and for showing higher pixel contiguity. No significant difference ($p = 0.05$) was observed between the soil properties of predicted soil clusters and the actual field validation points. This study demonstrates the usefulness of DSM techniques to update the conventionally prepared legacy maps to offer soil information at improved details to agricultural land use planners and decision maker of Tanzania to make evidence based decisions for climate resilient agriculture and other land uses.

Keywords: Kilombero Valley, Digital soil mapping, Machine learning, Legacy soil maps

EVALUATION OF THE PERFORMANCE OF CORDEX REGIONAL CLIMATE MODELS IN SIMULATING PRESENT CLIMATE CONDITIONS OF TANZANIA

Luhunga, Philbert, George Djolov, Frederick Kahimba and Joel Botai

Abstract

Regional climate models (RCMs) are currently one of the most fundamental tools for downscaling General Circulation Models (GCMs) output from large to regional or local scales. The prerequisite part before confidently utilizing climate simulations from any RCM is the evaluation and quantification through comparison with observations. In this paper, the ability of four RCMs from the Coordinated Regional Climate Downscaling Experiment (CORDEX) to simulate present climate condition of Tanzania is evaluated. Simulated and observed maximum, minimum temperatures and rainfall data for the period of 1971-2005 was used. The inverse distance weighted average (IDWA) interpolation techniques was used to transfer model climate simulations from grid points to observation stations inside the grid points. Two assessment criteria are used to assess the credibility of the RCMs. The first assesses the ability of the RCMs to reproduce observed maximum and minimum temperature climatology and the second assesses the ability of the RCMs to reproduce observed inter-annual and inter-seasonal rainfall variability. Results show that, all RCMs capture the seasonal cycle of rainfall in both unimodal and bimodal regions. However, all RCMs suffer to reproduce the inter-annual variability of minimum, maximum temperatures and rainfall. Generally the performance of the models depends on the location, and the types of weather variable simulated by the models.

Session 9B: International, National and Local Policies for Agricultural Sustainability

Relating Greenhouse Gases and Transformation in a Changing Climate

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Abstract

Dramatic changes in land use have taken place in larger part of Africa, South Asia and other part of the world, as a result of economic growth and increasing demand for production. Forestlands are converted into agricultural land and are intensified for food production. Hence, the ongoing and unsustainable intensification of cropping systems will result in increased emissions of climate gases, mainly N_2O and CH_4. The increasing trend is N input to agro ecosystem with large N losses could be dark side of agricultural intensification, however. We have conducted researches on N_2O and CH_4 in different land uses mainly from Nepal and India. The study conducted in intensified agricultural land showed significantly higher N_2O emission compared to traditional agricultural system. Similarly N_2O emissions were very high in upland and grazing land as compared to emissions from forestland and lowland. Similarly CH_4 sink was highest in forestland and CH4 emission was highest in periodically flooded lowland area. The field emissions carried out in rice field with SRI techniques, showed a reduced CH_4 and N_2O emissions in SRI compared to non-SRI rice fields. Likewise, emission study on biochar applied agricultural lands in Nepal indicated a lower N_2O emission in the field where biochar was applied. A similar study was conducted in heavily grazed forest in India, which showed reduced net CH_4 uptake rate and hence increases the net global warming potential of forest soil. These early studies in Nepal and India provide useful data to illustrate magnitude and mechanism of the problem. However due to the urgency of emerging climate crises, incremental change in technology may not address the ecological problem at their source. There is a need transformative change in our consumption

behavior, lifestyle that are linked to demand for choices of food that has an important implication for N fluxes and climate change. After the entire climate change is a multi-dimensional problem, including more than just social or environmental issues. The growing need for interdisciplinary work across the natural, social and noetic sciences demands that each achieve a common understanding about current and emerging global crises as multidimensional issues with linked contexts. To understand this better, one must first identify the linkages between environmental problems deeply rooted in human greed and manifested in various forms such as biodiversity losses, climate change and land degradation. To address these problems at their source, we propose to link these with human desires and how they can be balanced using noetic science of personal and social transformation. These linked problems require a rarely seen collaboration among scientists and masters of various wisdom traditions. The science of wellbeing including noetic/consciousness-based noetic sciences coupled with environmental science is essential in our time. The quest is how to develop science and tailor course curricula in universities that effectively establishes the linkage among environmental, noetic and science of wellbeing.