SUMMARY PROCEEDINGS

First FAO Technical Consultation on Bioenergy and Food Security

16-18 April 2007
Rome

FOREWORD

The past year has been an important one for bioenergy work at FAO. We launched the International Bioenergy Platform (IBEP), our strategy to bridge the many areas of work related to bioenergy, and we are actively working to create a Bioenergy Programme Facility, to support the many diverse areas of energy-related work throughout our Organization. FAO also hosts the Global Bioenergy Partnership (GBEP) Secretariat, supported by the Government of Italy, which provides a worldwide forum for bioenergy activities. The Bioenergy and Food Security (BEFS) Project, funded by the Government of Germany, became operational as of January 2007. The project aims to mainstreaming food security concerns into assessments of bioenergy potential through targeted analysis and field activities that support rural development.

Few topics have such an important place in the international agenda as bioenergy and food security. The shift to bioenergy raises concerns for food security, as land and other productive resources may be taken away from food production.The current debate surrounding the scope and sustainability of bioenergy as it relates to food security has escalated over the past few years. The impact on food security is highly context-specific and aggregate analysis must be complemented with system specific regional analyses. Sustainability and certification criteria, role of ecosystem services, climate change, biodiversity and pressures on land use patterns are key areas for further research.

The insights of the First FAO Technical Consultation on Bioenergy and Food Security have helped us advance our understanding of the fundamental and complex linkages between bioenergy and food security. The expertise shared at the Consultation has helped us assess our way forward and point us and our member countries in the best possible strategic direction. We urgently need to study the many uncertainties regarding bioenergy potentials and their impacts on food security, the environment, society and the way agro-products contribute to the economics of industrialized or developing societies. The contributions of the experts have helped guide our collective future strategy and work planning in the further elaboration of appropriate and replicable analytical framework and decision-making tools.

FAO is ready to play its role as an international forum for dialogue and negotiation on bioenergy matters FAO will continue to focus on how rural people can benefit from bioenergy systems and analysing the best possible systems to ensure sufficient land and biomass to meet future food, feed, fibre, fuel and biomaterial demands. The results of this first Consultation have provided an important initial set of recommendations and next steps for FAO and partners that will help answer important questions related to bioenergy, the environment and food security.

We thank all the experts and colleagues who participated in this Consultation, which we believe has set the stage for future work on the linkages between bioenergy and food security.

Gustavo Best
Senior Energy Coordinator
Environment, Climate Change and Bioenergy Division

ACKNOWLEDGEMENTS

The Summary Proceedings of the first FAO Technical Consultation on Bioenergy and Food Security documents the first time that experts in bioenergy, food security and the environment met to discuss the complex linkages between these sectors. The experts agreed that the current expansion of bioenergy production in developing countries presented potential costs as well as benefits; it could compromise food security and result in environmental damage, but also offered significant opportunities for sustainable development and poverty reduction in rural communities. The role of Government was seen as crucial in addressing food security and environmental concerns.

International organizations can play an important role in providing an objective forum for debate and policy support. The participants agreed that the FAO International Bioenergy Platform should develop a series of guidelines related to bioenergy and food security for Governments, international organizations and civil society. The FAO Interdepartmental Working Group (IDWG) on Bioenergy provided funds that helped make the consultation possible.

Valuable contributions to the organization, content and participation in the consultation were provided by the following FAO colleagues: Astrid Agostini, El Mamoun Amrouk, Pedro Arias, Gustavo Best, Patricia Carmona Redondo, Romina Cavatassi, Merritt Cluff, Linda Collette, Andre Croppenstedt, Roberto Cuevas Garcia, Alemneh Dejene, Léa Jenin, Ingmar Juergens, Liliane Kambirigi, Parviz Koohafkan, Rainer Krell, Eric Kueneman, Yianna Lambrou, John Latham, Tomas Lindemann, Christopher Matthews, Alexander Mueller, Jennifer Nyberg, Shivaji Pandey, Francisco Perez Trejo, Terri Raney, Simmone Rose, Mirella Salvatore, Alexander Sarris, Josef Schmidhuber, Peter Steele, Miguel Trossero, Jeff Tschirley, Jessica Vapnek, Stephanie Vertecchi, Koji Yanagishima, Monika Zurek.

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A particular note of gratitude is extended to Gustavo Best, Senior Energy Coordinator, FAO, overall Chair of the Consultation, to Jennifer Nyberg, who prepared the final proceedings document, and André Faaij, Copernicus Institute, University of Utrecht, and Francis Johnson, Stockholm Environment Institute, Chairs of the Consultation Working Groups. The contributions of the core organizing group, session chairpersons and rapporteurs, speakers and those presenting to the plenary and working group sessions are gratefully acknowledged, as well as those colleagues who provided comments on the draft proceedings.

Presentations and papers from the First FAO Bioenergy and Food Security (BEFS) Technical Consultation are available at www.fao.org/NR/ben/BEFS. Further information and announcements related to the Second BEFS Technical Consultation (October 2007) will be posted on the same website.

CONTENTS

1.0 SUMMARY

Bioenergy can contribute to sustainable development and make a major contribution to the global energy supply during this century. The transition to bioenergy, however, does heighten concern for food security, as land and other productive resources may be directed away from food production. The First FAO Technical Consultation on Bioenergy and Food Security represented an important contribution towards understanding how further development of bioenergy sectors may represent both risks and opportunities to food security. A general consensus was that further expansion of bioenergy could provide significant long-term benefits to rural communities in developing countries, but only if accompanied by vigilant efforts to support food security and prevent environmental damage.

Clear concerns emerged in regard to food security. Available food supplies may decline if increased demand for food crop feedstock for bioenergy production is not adequately balanced with measures to increase agricultural yields or alter land use patterns to increase planted areas to food crops. Further use of food crop feedstock for biofuel, such as ethanol or biodiesel, may compromise food security over the near to medium term if increased demand pressures food prices and alters land use patterns. Future potential for bioenergy may thus be as closely linked to increased agricultural efficiency as food security.

Agricultural commodity prices have already been influenced by increased demand for feedstock to produce biofuel, with prices for sugar, maize and oilseeds showing significant statistical relationships to crude oil prices. Rising commodity prices may benefit some producers but may be negative for some poor consumers. For net food importing countries, this may erode the purchasing power of poor households, and have an adverse effect on the ability of the poor to access food. Net food and net energy importing countries may face even greater challenges in future. Although the introduction of second generation biofuel made from lignocellulosic biomass may mitigate some of these challenges, the timeline and availability of these new fuels remains unclear.

Bioenergy could help diversify agricultural output to energy feedstock crops, contribute to the development of rural infrastructure and increase employment in agricultural sectors, especially in rural areas. Certain types of bioenergy feed stock may be best produced in landscape mosaics, grown with food crops and vegetation, in order to provide windbreaks, restoration of degraded areas, habitats for native biodiversity and a range of ecosystem services. Diversification of domestic energy supply would increase energy security, and possibly provide greater access to energy for rural enterprises and reduce the often time-consuming household energy burdens of rural women. Biofuel made from non-food crops, for example, such as castor beans or jatropha, provide ways for small farmers to grow cash crops and access new market outlets. Biofuel production could benefit the environment and increase food security if smallholders farmed biomass as a source of energy for themselves, local communities or strengthened linkages to commercial markets.

Rapid bioenergy development may result in unintended consequences to food security and the environment, and these risks warrant further attention. Demand for food crop feedstock has already increased, and commodity prices have increased competition for biomass inputs to food and energy production. This competition may pressure the costs of other inputs, such as fertilizers and related services. Further intensification of large scale industrial production of bioenergy, particularly liquid biofuel, may not necessarily be the best model for sustainable development; small and medium-scale systems may be preferable for improving livelihoods and mitigating overall environmental impacts, which must be weighed against the higher cost-effectiveness of large-scale systems. The extent to which bioenergy can mitigate climate change is highly dependent upon feedstock choices and cropping systems, as well as on the complicated relationships with land use changes and the carbon cycle. Poorly designed bioenergy systems may have an adverse impact on ecosystems, leading to increased environmental pressure, polluted water, loss of biodiversity and land degradation.

New ways to increase both food and fuel output are necessary. Generally, rotating crops for energy output with food crops could improve yields and enhance disease and pest resistance, while providing some possibility of value addition and diversification for producers. The importance of exploring the potential for multi-purpose crops and using Agro-Ecological Zones (AEZ) as entry points for understanding biomass potentials was noted, as well as the role that certain crops, such as jatropha, as a nitrogen-fixing biofuel crop, could play for utilization of arid, semi-arid, degraded and marginal lands generally unsuitable for food production was highlighted.

Severe data constraints currently hinder quantitative analysis, and there is a pronounced need to establish common inventories of databases, tools, strategies and policies to increase information exchange. Bioenergy crops that compete with land and water for food production should not be grown in areas facing food security challenges, according to the experts, and bioenergy systems should be environmentally sustainable and socially equitable. Existing famine early-warning systems that integrate assessments of food security, environmental risk or access to resources, are already well established and should assist in the understanding of potential food security risks to vulnerable populations due to bioenergy developments.

Sustainability and certification criteria, role of ecosystem services, climate change, biodiversity and pressures on land use patterns were highlighted as key areas for further research. The shift to bioenergy raises concerns for food security, as land and other productive resources may be directed away from food production, and experts stressed that risk assessments and country case studies integrating bioenergy and food security were necessary. Analysis of the potential trade-offs between food and energy production need to consider the carrying capacity of the whole ecosystem and its ability to provide sustainable ecosystem services, particularly to ensure that food security considerations are given priority. Policymakers need to understand these trade-offs and the complex interactions across policy domains related to energy, environment, agriculture and trade to ensure that food security is given priority where vulnerable populations may be affected.

The core objectives of the Consultation were to provide a platform to discuss ways to integrate research, insights and knowledge, to advise FAO on ways to mainstream food security and sustainability concerns into bioenergy development strategies, and to provide recommendations and suggested next steps. [1] The summary recommendations and next steps are discussed in Sections 2 and 3. Two working groups were established, with Working Group 1 focused on bioenergy potentials and Working Group 2 focused on food security, bioenergy and the environment. Section 4 presents background information and guidance provided to the working groups. A brief conclusion is presented in Section 5. Annex 1 presents highlights from the plenary and working group discussions, Annex 2 the Consultation Agenda and Annex 3 the List of Participants.

2.0 RECOMMENDATIONS AND NEXT STEPS

This section presents key recommendations from the Consultation working groups and plenary discussion upon which FAO and other stakeholders could base future activities and work planning.

There are clear needs to develop tools and identify information necessary for policymakers to design appropriate methods for the collection and analysis of information, specifically the socio-economic impacts of different scenarios and production systems.

[1] Bioenergy work at FAO has focused on supporting knowledge generation and transfer, providing direct technical assistance to member countries in the field, assessing funding and financing mechanisms related to bioenergy and developing networks and partnerships at national, regional and global levels. FAO work on commodity-specific projections and agricultural markets, food security, nutrition and the environment, as well as more than two decades of research and project activities in various bioenergy fields will serve to promote a better understanding of the linkages between bioenergy and food security, poverty alleviation, climate change and sustainable development. Bioenergy work at FAO is organized through the International Bioenergy Platform (IBEP), a framework launched in May 2006 to facilitate collaboration on bioenergy based on knowledge management and mobilization. FAO also hosts the Secretariat of the Global Bioenergy Partnership (GBEP), funded by the Italian government since start-up in September 2006. Refer to ftp://ftp.fao.org/docrep/fao/009/A0469E/A0469E00.pdf.

The recommendations of the working groups focused on the need for more detailed global and regional assessments of bioenergy systems as related to food security and the environment in the form of reference case studies, which could be applied to specific country contexts.

The experts noted that severe data constraints hinder quantitative analysis and that more detailed inventories of databases, tools, policies and programmes was needed. This includes data/model fusion exercises that adapt the Agro-Ecological Zones (AEZ) approach to bioenergy reference cases. The potential for multipurpose crops as an entry point for understanding biomass potentials was recommended.

Finally, the interests of stakeholders, from small farmers to the private sector, must be reflected that key risks and opportunities are understood and included in national bioenergy policy and programme initiatives. Governments may need to consider transitional schemes for small-scale bioenergy producers and/or assist in creating institutional mechanisms to help achieve greater technical efficiency while still allowing broad participation by the rural population.

Five main thematic areas were identified by the Consultation: policies, potentials, reference systems and food security implications, land and water, and climate change and biodiversity. The three primary types of follow-up activities (activity pillars) included (i) data and information collection; (ii) analysis, assessment and application; and (iii) development of guidance and tool kits. Specific recommendations are listed under each of the five main themes, with the activity pillar (i), (ii) or (iii) listed.[2]

One of the recommendations, to create an *international bioenergy information system (iBIS) that would address food security, sustainability and energy indicators as well as dealing with proprietary data*, was cross-cutting through each of the five thematic areas and activity pillars.

I. Policies

- Undertake a survey of bioenergy policies to build upon the FAO legal review and the GBEP policy survey (i).
- Operationalize criteria and indicators covering ecological (for example, water resources, erosion, leakage), social (for example, employment), economic (such as impacts on rural economy and trade balance) (iii).
- Develop a policy impact assessment tool to provide input into national policy discussions on bioenergy and food security (iii).
- Develop a policy database that includes information on public spending, bioenergy legislation and policy measures, particularly in regard to different trade regimes (iii).
- Participate in multi-lateral mechanisms such as CBD (Biodiversity), CCD (Desertification) and FCCC (Climate change) by attending events such as CBD SBSTTA-12 (Paris, July 2007) and its event on linkages between biodiversity, food security and bioenergy (i).
- Develop a training manual on cost-benefit analysis for bioenergy (iii).
- Develop guidance on bioenergy investment frameworks and structures (iii).

II. Potentials

- Develop common methodologies for bioenergy related data collection and maintenance, particularly as data is likely to be a major problem from the perspective of analysing bioenergy potential (i).

[2] A simple matrix of the summary recommendations by the five thematic areas and three identified activity pillars has been prepared to guide work planning on bioenergy activities at FAO. Several of the recommendations were clearly applicable to more than one thematic pillar, however, for this section, these have been grouped into the most relevant thematic area.

- Use the Agro-Ecological Zones (AEZ) framework in assessing bioenergy potentials and a basis for data collection and analysis; complement it with other data sets, particularly related to food security (ii).
- Develop regional and national maps of biofuel potentials based on land cover, water availability, soil and crop types given different levels of technology (iii).
- Improve modeling framework through the introduction of nationally relevant data related to land cover, biomass potentials, cropping or socio-economic systems, trade, and ecosystem services (ii).
- Link the analytical framework to a global energy and agricultural market and land use models useful for simulations as well as with land use models (ii).
- Review how current mapping tools could be applied to scenario analysis, and start working on ways to integrate mapping of biomass potential, environmental hot spots and hunger hot spots (ii).
- Estimate the scale and spatial variability of biomass resources and parity prices for bioenergy from different national production systems based on agreed criteria (for example, volume, economic importance, social impacts, environmental considerations, alternative uses, and opportunity costs) (ii).

III. Reference Systems and Socio-economic Considerations

- Prepare a guidance (briefing) document for policy-makers on legal frameworks for bioenergy (iii).
- Supplement survey and inventory work by a needs assessment of bioenergy marketing research from farm gate through each element of the value and supply chain (ii).
- Further define *energy security* in terms of its meaning and in particular its relation to bioenergy potential and food security (ii).
- Design country case studies around food security concerns and bioenergy typologies, including elements of institutional mechanisms and capacity building (ii).
- Develop lessons learned from case studies on relationships between cost, energy ratio and environmental impacts for different liquid biofuels, particularly for areas undergoing rapid biofuel development (iii).
- Based on adaptation of existing methods, identify bioenergy hot spots in terms of vulnerable populations and land use systems (ii).
- Analyse the impacts of expanding bioenergy sectors on subsistence farmers with focus on environmental sustainability, rural livelihoods and social equity (WWF, IFAP, FAO, and WFP) (ii).
- Convene a global workshop on multi-purpose cropping systems to exchange information with a focus on CGIAR and FAO (global) and national experts, particularly from Brazil, China and India (i).
- Complete a study on the possible impacts of bioenergy development on livelihoods and vulnerable people in collaboration with WWF, IFAP, FAO and WFP (ii).
- Analyse bioenergy as an income generating activity for smallholders, in particular for risks such as food insecurity, factors of exclusion, possible marginalization of rural poor (ii).
- Develop guidance on how to bioenergy, food security and environment may impact urban and rural populations differently (iii).
- Define business concepts and develop guidance for small enterprise bioenergy development (iii).
- Research ways that bioenergy development can be used for rural electrification (ii).
- Complete a livelihoods review of transition scenarios from subsistence farming to larger scale or more commercial systems (ii).

- Identify knowledge and data sources for environmental and socioeconomic risk analysis using a field orientation (i).
- Test concrete ways to complement the Integrated Humanitarian Phase Classification (IPC) System for food security analysis with environmental indices (ii).
- Review Early Warning and Emergency Preparedness systems in light of trends that indicate whether or not new food early warning models may be needed due to demand for food crop feedstock for biofuels (ii).
- Assess the implications of bioenergy technology transitions (for example, second generation biofuel) and innovation as related to agriculture and forestry management practices (ii). .

IV. Environment

- Create an information document of the input requirements (for example, water, fertilizer, soil) for major bioenergy crops, reflecting different production systems and taking into account the chain from crop management through biofuel production (iii).
- Assess land cover and land use change potential over time due to demand for food and biomaterials, agricultural and forestry management practice, land allocation (and international trade), technological developments, (bioenergy) policies (ii).
- Link the analytical framework to a global energy and agricultural market and land use models useful for simulations as well as with land use models (ii).
- Design Life Cycle Analysis (LCA) tool kits and e-learning modules to evaluate the environmental footprint of different bioenergy systems (iii).
- Assess the impacts of bioenergy on smallholders and commercial producers from the perspectives of soil fertility, land tenure, water and on-farm diversification of crops, biodiversity and greenhouse gas (GHG) emissions (ii).
- Convene a global workshop on bioenergy land issues as they relate to food security and the environment, including the role of water resources (i).
- Survey the best sources of information on linkages between land use and environment (mapping and/or scale resolution) (Öko-institut, UNEP, and FAO) (i).

V. Climate Change and Biodiversity

- Assess the impacts of bioenergy on smallholders and commercial producers from the perspectives of climate change, soil fertility, land tenure, water and on-farm diversification of crops, biodiversity and GHG emissions (i).
- Assess how bioenergy potential could affect climate change adaptation and mitigate GHG emissions; link this to reference case studies where possible (ii).
- Characterize possible impacts of bioenergy development on food security as they may relate to climate change and biodiversity (ii).
- Map biodiversity hotspots as *no-go* areas for agriculture and biofuel development, identifying *no-go* areas and no-risk areas as quick fixes in the near term (iii).

Next Steps

Experts at the Consultation agreed that the immediate follow-up on the recommendations focus on improved analytical (modeling) and assessment frameworks based on country typologies. Focus on country typologies, such as net energy or net food importer, was considered of high priority to achieve a broad understanding of the country-specific effects of bioenergy development on food security.

An inventory of policy measures including global and regional assessments of different bioenergy potentials and systems in the form of reference case studies. This could form the basis for an open access database on bioenergy information (iBIS) that monitors selected food security, sustainability and energy indicators.

Exploring the activation of FAO Regional and Sub-Regional Offices as bioenergy and food security hubs for reference case studies, projects, and related bioenergy information was seen as a necessary step towards ensuring close linkage with countries and regions.

Accelerating the development of tools to analyse national food security and environmental impacts of bioenergy expanded partnerships to assist countries in assessing their bioenergy potentials such as infrastructure, food insecurity, poverty, environmental challenges or human-induced conflict and identify areas of concern and opportunity (hot spots).

Sustainability certification criteria, ecosystem services, climate change, greenhouse gas issues, biodiversity and potential changes in land use patterns as they impact food security and environmental sustainability were highlighted as important areas for further research and analysis but of somewhat less immediate priority relative to the other topics.

3.0 DISCUSSION HIGHLIGHTS

3.1 Plenary Sessions

Participants in the Consultation represented diverse expertise from various fields, including experts on the environment, natural resources, agriculture, forestry, economic and social development, environment, humanitarian relief, food security, legal frameworks and communications. Insights and observations through the three day Consultation reflected this diversity, with some believing that bioenergy may result in an agricultural renaissance or at least be a source of rural income and development, while others were less positive, noting the need for further study and reference cases. This was particularly the case for developing countries with biomass potential but with perhaps the greatest risk of increased food insecurity due to rapid bioenergy development. Conversely, there are developing countries that may be able to capitalize on the opportunities for rural development due to growth in bioenergy sectors, and certainly this has already been the case for several nations.

A summary of the presentations, discussion and conclusions from the first day of the Consultation is presented in this section.[3] All participants agreed that the Consultation should be considered the first of many conversations on how food security, bioenergy and the environment are linked, and all supported plans under way to convene a second technical consultation. Experts further agreed that developing a common understanding of the risks and opportunities offered through bioenergy calls for extensive multidisciplinary inputs, more research and country specific case studies.

The multiple pathways through which bioenergy development will impact food security and the environment are broad, complex and from the perspective of this Consultation, need to be addressed with respect to those people whose food security and livelihoods are most at risk. The participants agreed that developing a clear and common understanding of land use and availability, and whether or not there is enough land and biomass available to meet food, feed, fibre, fuel and biomaterial demands now and in future was fundamental. Whether or not rural people, typically the poorest and most food insecure populations, will really be able to benefit from bioenergy development in terms of rural incomes and employment, new rural infrastructure resulting from bioenergy industries or ways to diversify agricultural systems and support rural livelihoods, remains a key concern. These concerns and

[3] Moderators for the opening day of the Consultation were André Faaij, Copernicus Institute, University of Utrecht, Francis Johnson, Stockholm Environment Institute, and Terri Raney, FAO. Rapporteurs were Ingmar Juergens, Romina Cavatassi and Jennifer Nyberg, FAO.

others related to local, community and national factors of exclusion, such as land tenure and access to water, other natural resources and agricultural inputs, underpinned discussion of potential impacts on food insecure people, primarily in rural areas.

Real concerns for the urban poor and food insecure were also called for in light of recent and significant increases in international commodity prices, particularly maize and other cereals. Participants agreed that there is a need to more fully understand the near, medium and longer term impact on commodity prices due to rapid bioenergy development, and the potential effects on food insecure people in rural and urban areas. At the global level, participants generally agreed that bioenergy may help reduce GHG emissions, although in-depth discussion of climate change, bioenergy and its relationship to the global energy balance was outside the scope of this first consultation.

Assessing Bioenergy Potentials in the Context of Food Security

The opening sessions of the Consultation provided an opportunity for the participants to review the methods and analytical techniques to assess bioenergy potential and to identify knowledge gaps and challenges. The session began with a preliminary presentation by Ingmar Juergens, FAO, of the primary issues related to rising global demand for agricultural products as sources of energy. Mr Juergens followed with a presentation that highlighted an analytical approach to the bioenergy and food security nexus that clearly demonstrated the complexity of the problem. He concluded that there is a real need to bring together expertise from several areas to build a comprehensive understanding of the impacts of bioenergy on food security. He noted that the key determinants of bioenergy production include energy prices, economic development, land use patterns, efficiency of food production, crop yields and livestock production, all linked to food security. The need to enhance modeling capacity to determine the impact of policy on bioenergy production and hence food security indicators was primary, and he noted that analysis at the country level is required in order to differentiate and specify the various determinants of bioenergy development.

Andre Faaij of the Copernicus Institute, University of Utrecht, followed with a presentation that focused on the outlook of bioenergy potentials, reviewing the simulation of a model to estimate the potential share of biomass in word energy utilization. He noted the many definitions of potential, and how these in turn determine model outcomes and results. A preliminary objective of land use pattern simulations is to determine the amount of available land left for bioenergy production assuming certain levels of growth in agricultural efficiency. He described various scenarios, from worst case to the most optimistic. The optimistic scenario outlines how rapid economic growth and increased agricultural efficiency could lead to a decline in the amount of land necessary to produce food. He noted that this would in turn make more land available for bioenergy production to help meet the estimated 440 EJ of global energy demand.

Mr Faaij further noted that bioenergy could make a significant contribution to global energy needs by 2050, but only if sustained productivity growth in agriculture is achieved. Standards, such as sustainability criteria, will increase production costs, but also result in several benefits. He noted that a policy framework needs to be elaborated and implemented in order to address the issues of standards and certification. The wealth of knowledge on bioenergy potentials needs to be shared and documented, he recommended, as well as work done to reassess biomass potentials including scenarios based on demands for sustainability. He noted the need to recognize more diversity in biomass production and supply systems, for example, considering marginal or dry lands, residues and pastures, and also the need to enhance the linkages between different modeling arenas. He emphasized the need to undertake concrete and specific case studies at national and regional levels, as well as the importance of keeping up to date with the most currently available modeling methodologies and tools (OECD, EU-RURALIS, REFUEL) to assess the effects of bioenergy production. Gustavo Best, as Chair of the Consultation, opened the floor for questions and comments. What follows is a summary of discussion by the Consultation participants based on the presentations of Mr Faaij and Mr Juergens.

Participants noted the need to clearly distinguish between the short-run and long-run effects attributable to bioenergy production. Analysing bioenergy potentials, although clearly important, may be less relevant in the short run than undertaking risk assessment analysis to understand the potential impacts of bioenergy on the environment, commodity prices, land, food security and related issues. The need to integrate issues related to climate change, policy and the role of policy makers in the modeling and analysis of bioenergy potentials was noted. The group noted that some of the short term impact analysis of bioenergy is already under way through the production of commodity market baselines, such as those of FAPRI or FAO-OECD outlook studies.

Key questions emerged during the plenary discussion, among them: What is the likely impact of second generation biofuel on the agriculture sector and food security? What are likely to be the impacts on natural resources, particularly water? How much energy is used to produce a unit of biofuel (depending upon type, setting and context) and how does this relate to the global energy balance? What is likely to happen without further development of a policy framework, for example, are biofuel currently market driven or policy driven? What is likely to be the impact on farmers, particularly in developing countries, and do they need specific support and incentives from government? How will bioenergy development affect rural areas and small farmers? All participants basically agreed that there was a relative lack of empirical evidence at this time to provide answers to many of the above questions.

Participants agreed that one of the more important aspects of any analysis of bioenergy potentials is to clearly identify a reference scenario that would serve as a baseline for future comparative analyses. Global harmonization of rules of conduct for bioenergy production and the environment could be successfully formulated, building on existing regional frameworks. The experts highlighted the need to collect information on energy markets, the environment, policy and stated policy targets for bioenergy in major developing countries, such as India and China. Generally, the group noted several key issues that must remain paramount when analysing bioenergy, as follows: environment (natural resources such as land, water and ecosystem services); policy and legislative frameworks; prices and market uncertainty. Further work is necessary to integrate information and build a knowledge support system for bioenergy. The impact of climate change and sustainability should also be assessed in the context of bioenergy demand, utilization and production.

The participants further recommended that an in-depth study of biofuel production costs and parity prices between commodity and fossil fuel prices be completed, noting how crucial land tenure and land ownership would be for the analysis. This would require a clear understanding of policy issues, particularly related to interventions in the form of national support or subsidies to agricultural or energy sectors. Experts discussed the need to provide information for policy analysis, as well as the potential role of a global institution established to enhance production and trade in bioenergy. The opening session concluded with a strong suggestion to incorporate farmer perspectives into the debate.

Environmental Linkages
Assessment of Bioenergy and Food Security

The second session of the Consultation focused on the environmental linkages related to assessment of bioenergy and food security. The moderator opened the session by asking the group to focus on the following: systems and impacts; food security, vulnerability and resilience; methods and tools, noting how important it was to link discussion of the environmental impacts of bioenergy to food security.

Mr Rainer Krell presented an overview of the linkages among bioenergy, food security and the environment. He noted that bioenergy, food security and the environment are linked through their mutual dependence upon appropriate ecosystem services, made further interdependent as they simultaneously impact the capacity of ecosystems to perform those services. Rural development policies tend to favor industrial scale production, often resulting in negative environmental consequences, such as deforestation, land and soil degradation or water pollution. He presented some observations as to possible ways forward to create an organizing framework for the identification and prioritization of bioenergy systems based on a range of criteria related to environmental, socio-economic and policy objectives. Mr Best, as Chair, then invited discussion and comment from the plenary.

The participants agreed that it made sense to differentiate among main bioenergy crops, particularly as the environmental impacts are varied. Several noted the importance of focusing on the farm level, where potential feedstock crops, such as sugarcane, have different end uses, and pointed out that sugar-based ethanol accounts for only 20 percent of total end use for sugarcane in India. The group noted how important it was to clearly distinguish between different farming systems, rain fed or irrigated, and review crop varieties (species) before making general conclusions about the environment or biomass potentials. They also noted the importance of identifying specific indicators to monitor over time, such as pesticide run-off when considering crops and bioenergy typologies.

Some noted that even if the product (bioenergy or biofuel) can be produced and certified as sustainable, producers may still be inclined to apply practices that are not environmentally positive. Some participants noted that while governments are mandating demand and considering implementing sustainability criteria, once these kinds of criteria are in place, for example, in Europe, the response is immediate and there may be unintended consequences. However, other experts disagreed, noting that certification systems fundamentally cannot work: they stressed that even with certification of palm oil, for example, certified volumes will simply displace other palm oil which may then result in further environmental damage.

At the same time, the participants noted that certification is the only instrument currently being suggested to address environmental issues. The group acknowledged that there will be leakages as a result of certification criteria, and that this must be addressed, however, all also admitted that there was no clear strategy for how this could be accomplished. One suggestion, in addition to the concept of *no-go* areas for bioenergy crops, was that clear signals and incentives for *go*-areas be established, particularly for crops such as jatropha which are generally not expected to compete for resources with food crops. A second idea would be to focus on context-specific settings based on climate and agricultural systems (AEZ approach) instead of regional or national settings.

A key question was what the expected environmental impacts resulting from certified or non-certified biofuels? All agreed that governments play a very important role in certification as well as standard setting, although it was noted that certification through private standard setting works fairly well in high value niche markets, such as fair trade coffee. Conversely, some participants noted that the vast majority of global consumers of vegetable oil, particularly in developing countries, such as India, will not care about certification or issues related to origin of product. Several cautioned that the group should remain focused on an analytical framework, always considering the counterfactuals and not absolute impact.

Some bioenergy crops provide other ecosystem services that must receive some sort of premium to be successful. For example, helping landless farmers access marginal lands implies that some sort of premium must be provided to create appropriate incentives. Some participants generally agreed that analysis and understanding of certification remains weak, but that in the case of palm oil in some countries, the process is industry-, not government-driven. They further noted that if a plantation can be established on marginal lands, then the contribution to global energy balance (GHG) is excellent. In sharp contrast to some previous discussion, several participants noted that consumers do want products that lower GHG emissions.

A focus on supply chain analysis followed in terms of identifying which actors stand to benefit from bioenergy, noting the numerous and complex political and economic issues at hand. An example from India was discussed in terms of farm land versus waste land (considered land not owned by any particularly farmer). Some state governments in India are making these waste lands available to formerly landless people. Several participants countered with observations from the perspective of a palm oil producer, for whom there will always be an incentive to clear natural forest as it is easier and cheaper in establishing a plantation. Producers may not want to deal with degraded and marginal lands unless incentives are larger than clearing natural forest. Thus, the real issue is that the private sector needs to start thinking about how to create incentives for industry to establish plantations on degraded land, signalling the need for a real shift in thinking by the private sector.

All agreed that the issues involved with sustainability and certification were too complex to be addressed from a global perspective, although suggestions were made that one way to start would be to formulate international ecological classifications, and that it would be useful to generate and use the agro-ecological systems approach. There was one simple message – that as more crops are grown, more environmental problems will be created that will need to be addressed. Some disagreed, however, with the statement regarding the simplicity of the message that growing more crops will lead to more environmental problems.

One expert noted that growing more was crucial and that efforts to enhance low productivity food production, for example in Africa, will most likely cause environmental problems. However, these issues must be addressed in terms of food security - with or without the added uncertainty of bioenergy. Several participants noted that bioenergy demand could trigger the type and scale of investment necessary to help rural areas move forward, less concerned with biomass crop type and more concerned with how expected returns (profitability) may pressure land use patterns.

Several experts noted that environmental and biodiversity issues need to be kept at the forefront of further bioenergy development, and that bioenergy sectors need to avoid violating conventions related to climate change and biodiversity. A suggestion was made to start with an inventory of the potential impacts of bioenergy on climate change and biodiversity, isolating biofuel for transport from other forms of bioenergy, reiterating the need to clarify the type of information needed by policy makers.

There are important and different implications for small and large farmers. The group agreed that value and supply chains for bioenergy crops must be analysed to understand existing and potential impacts on livelihoods, returns, transaction costs, barriers to entry and rural development. Participants identified a need to focus on the concept of settings in space and time considering that over the medium to long term new technologies and contexts will emerge and will be important. Clearly, a very dynamic process is under way which may result in unintended consequences, risks and opportunities. The group generally agreed that it was difficult at this time to fully understand the impacts of biofuel on food security given little to no quantitative modelling to date. This would be necessary to develop some guidance as to how different settings can affect food security. There was a general consensus that bioenergy feedstock needs further classification based on end use, long and short run timeframes, geographic location, crop type and energy ratio in order to assess impacts on the environment as they relate to food security.

Implications for Food Security

Impact of an increased biomass use on agricultural markets, prices and food security: a longer term perspective

Mr Josef Schmidhuber opened the afternoon session on food security by presenting his long term perspectives on the impact of increased biomass use on agricultural markets, prices and food security. His main conclusions were that increased bioenergy production will certainly have an impact on agricultural markets: agricultural prices will increase, leading to increased food prices and diminishing surpluses of staple foods (cereals) which may adversely impact availability for humanitarian relief (food aid). He noted that biomass use for bioenergy could put an end to the paradigm of decreasing real prices in agriculture. He mentioned that energy prices are increasingly driving the prices of agricultural commodities, citing the example of the close linkages between crude oil and international sugar prices. He suggested that price volatility will increase, and that this effect will be significant in global sugar markets. Not all commodities will be affected in the same way, although there are signs that similar correlations are emerging in rapeseed and maize commodity markets. Protein prices are likely to decline, but this effect may not remain over the longer term as the commodities (feed) would be redirected to produce energy.

Some countries may have a comparative advantage in growing certain crops. This can be assessed looking at parity prices for various feedstocks. A quantitative approach on a country basis showed that some countries will lose, particularly those that are net importers of both energy and food and agricultural products. These countries will face significant disequilibrium in their trade balance and may not be able to compensate projected imbalances in their terms of trade with exports.

Mr Schmidhuber noted that all four dimensions of food security (see following section for definitions) will be affected. He suggested that utilization will be more closely associated with access over the longer term, while availability of food will decrease due to an expected decline in production and possible restrictions on production incentives. In terms of economic access to food, he noted that consumers are likely to face higher prices, yet this will generate more income for producers by providing more market outlets in rural areas.

Who will benefit? Mr Schmidhuber noted that those with agricultural capacity, land in particular, may benefit more from the economic opportunities attributable to bioenergy. Landless farmers will be left behind, while the impact on rural or urban consumers will be different. He noted that the sugar and ethanol sector in Brazil is interesting given the high flexibility in both the supply and demand side in that sugar mills can switch easily from sugar to ethanol production while consumers can just as easily switch between sugar and ethanol demand, virtually on a day to day basis.

Bioenergy feedstock or biofuel may be imported into the European Union (EU) market in the near future due to limited production capacity, despite current trade barriers. Mr Schmidhuber noted that the private sector seems to be concerned about the rise in feedstock prices and the possible impact of energy crop expansion on food security. One possible impact of bioenergy production on livestock prices may be a rise in meat prices due to increased costs of animal feed (coarse grains, maize).

Incentives for production in the form of subsidies are put in place by governments when establishing mandatory blending ratios and this type of support scheme is costly and difficult to sustain over the long run. It may also be difficult for producers to adjust to a future removal of the subsidy. A key question is whether or not smallholders in rural areas will actually benefit from the rise in agricultural prices. Mr Schmidhuber noted one positive example in Thailand, where smallholders in the sugar industry account for a significant part of national output. This is less clear in the case of Brazil, which has established payment systems and agreements between producers and sugar mills, and fewer small holders. Thus, another socio-economic dimension of bioenergy production is job creation (or loss), particularly in the case of Brazil, where the employment of up to one million people is either directly or indirectly attributable to the sugar and ethanol sectors.

Food Security: Overview, Concepts and Guidance

Ms Jennifer Nyberg presented an overview of food security concepts and the various methodologies used to measure food security. She introduced the definition of food security and its four dimensions (availability, access, stability and utilization).[4] She also presented an overview of the FAO State of Food Insecurity data, noting that 854 million people in the world are chronically undernourished, and a number that has hardly changed in the last 15 years, with 39 countries needing emergency food

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[4] According to FAO, food security exists when all people, at all times, have physical, social and economic access to sufficient amounts of safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life. Discussion of each of the four dimensions as they relate to bioenergy is detailed in the Annex.

assistance in 2006; double the number of 20 years ago. Food aid is often the only resource available to address acute and chronic undernourishment.[5]

Chronic food insecurity is a long term (more than six months) and persistent inability to meet minimum food requirements. Transitory food insecurity is a short term or temporary inability to meet food needs. Household vulnerability to hunger is based on the frequency and intensity of shocks affecting households and the capacity to withstand shocks. Chronic food insecurity reduces household and community capacity to withstand shocks. She noted that food availability could be threatened by biofuel production to the extent that land, water and other productive resources are diverted away from food production. She discussed the concepts of livelihoods and coping strategies, vulnerability analysis and mapping and food security assessment, and identified how these food security concepts could form the basis for identifying a set of indicators that could be integrated into analyses of bioenergy potential and environmental sustainability. Local issues related to potential conflict over access to and control of natural resources is emerging as a key consideration from the environmental perspective.

SELECTED FOOD SECURITY INDICATORS AND POSSIBLE EFFECTS OF BIOENERGY

Potential Positive Effects	Food Security Indicators	Potential Negative Effects
• Diversification of feedstock crops • Infrastructure development and employment (rural) • Competition for land use and other factor inputs • Diversification of domestic energy supply • HZ spell out energy burden reduced for women and children • SAME spell out energy access improved • New technological advances • Climate change mitigation • Revenue from payment for environmental services and monetization of carbon credits	• Proportion of chronically undernourished (<5 stunting) • Adult literacy (+female) • Proportion of HZ income to food (access) • Proportion of own production of food (availability) • Population growth • GDP growth per capita • Agricultural contribution to GDP growth (%) • Proportion of adult population with HIV (%) • Number of food emergencies (stability) • Degree of import or export dependence • Access to water and sanitation facilities	• Decreased access to food due to price increases driven by competition for biomass for energy versus food • Decreased food availability due to replacement of subsistence farm land by energy plantations • Increased environmental pressure due to introduction or expansion of unsustainable bioenergy systems (H_20 pollution, loss of biodiversity, land degradation) • Pressure on prices of other goods and services related to land-use and biomass

What types of food security, livelihoods and vulnerability analysis may be helpful?

Ms Nyberg discussed five major tools used to analyse food security, livelihoods and vulnerability:

Food frequency or dietary diversity: This tool measures the quality of the diet and indirectly indicates the quantity and diversity of food consumed: the lower the score the worse the food consumption pattern may be and the higher the possible food gap. There is no causality; it must be combined with other livelihoods and food security indicators for causes to be analysed.

Coping Strategies Index (CSI): CSI is used to estimate the severity of coping strategies used by households facing food shortages to fill food or income gaps, measured by dietary change, increased short-term food access (borrowing, consuming seed), short-term migration to decrease numbers in the household to feed and rationing (mothers prioritizing children and men, limiting portions for

[5] Countries with more than 20 percent of the population considered undernourished include Angola, Bangladesh, Bolivia, Botswana, Burundi, Cambodia, Cameroon, Central African Republic, Chad, Democratic People's Republic of Korea, Democratic Republic of the Congo, Dominican Republic, Eritrea, Ethiopia, Gambia, Guatemala, Guinea, Haiti, Honduras, India, Kenya, Lao People's Democratic Republic, Liberia, Madagascar, Malawi, Mali, Mongolia, Mozambique, Namibia, Nicaragua, Niger, Pakistan, Panama, Philippines, Rwanda, Senegal, Sierra Leone, Sri Lanka, Sudan, United Republic of Tanzania, Thailand, Togo, Yemen, Zambia and Zimbabwe (FAO SOFI 2005).

themselves), with frequency measured in terms of the number of times per week that the strategies are applied. The higher the index, the higher the severity of coping strategies employed. Monitoring fluctuations in this index can provide a rapid indication of whether food security is improving or deteriorating.

Phases or scales: Phases and scales are combined hard indicators linked to anthropometric or measurable factors, such as caloric intake or height and weight, morbidity and mortality. Soft indicators refer to behaviors that help people cope to obtain income and food and access social capital. One example of a phase-type tool is the FAO Integrated Food Security and Humanitarian Phase Classification, which determines the severity of food insecurity by combining various indicators and comparing to international or context-specific thresholds.

Household Food Economy Approach (HEA): The HEA quantifies the various sources of food, income and essential expenditures among different household wealth groups in order to estimate the gap between resources and requirements. Wealth groups are established through key informant interviews at community level, in-depth for each wealth group, with data converted to kilocalorie equivalents. This establishes a reference year that functions as a baseline, as well as the current year (when/if necessary) to identify changes.

Judgment Based Classification (JBC): The JBC estimates food insecurity by examining various food security indicators and applying the informed judgment of an analyst or needs assessment expert based on experience and triangulation of information.

Livelihoods Approach: The livelihoods approach allows a more precise examination of the capacity of households to manage risks or react to shocks, such as higher food prices, loss of access to natural resources, loss of income or loss of source of livelihood, due to bioenergy development. There is a need for baseline food security data in those developing countries with significant biomass potential, in order to measure the impact of bioenergy production on vulnerability and food security over time. Various tools exist to look at food security, livelihoods and vulnerability, and when analysing food security, it is necessary to look also at the local (or regional) level: national statistics are not sufficient.

Country typologies represent a key starting point for analysing how bioenergy, particularly liquid biofuel, will impact food security over time. Preliminary analysis should be based on typologies or economic groupings of countries, such as developing, Low Income Food Deficit (LIFDCs) and Least Developed countries (LDCs). There will be positive extremes, such as traditional net exporters of food and energy (Indonesia or Malaysia), or negative extremes, such as net food and energy importers (all LDCs and the Near East). Most LDCs are net food importers and net energy importers, and characterized by very low income levels. Thus adverse effects of higher priced energy and agricultural imports relative to national incomes are likely to be particularly strong (Schmidhuber 2006).

Some lessons from hunger reduction efforts are applicable to bioenergy development. According to FAO research, agricultural growth is critical to reducing hunger. Some 70 percent of the poor live in rural areas, where agriculture is the key sector, thus a focus on agriculture is critical. The potential opportunities for rural development from bioenergy systems could play a significant role in supporting food security through increased rural incomes, employment and infrastructure. Hunger negatively affects health and labour productivity, and vulnerable people who are both poor and hungry are in a hunger-poverty trap. Targeted interventions to ensure access to food are necessary, and the needs of vulnerable groups that face significant exclusion factors in terms of economic or social participation at the current time need to be considered in the context of ongoing bioenergy development. Technology can play an important role, but it must favour small-scale farmers and be adapted to local conditions.

Bioenergy sector development may already be having an adverse effect on food aid availability and social equity. Various socially-oriented programmes exist on biofuels, for example, biodiesel in Brazil and biofuels in Thailand, where the governments are aiming to improve the participation of producers in the value chain. This reflects a welfare concern of certain governments and a willingness to increase the share of smallholders along the supply chain. Some of the primary drivers for the development of bioenergy strategies by governments include: reduction of the dependency on fossil fuels (conserve foreign exchange); rural and agricultural development objectives (develop new opportunities for the agricultural sectors; create or save jobs; generate income in rural areas). Land use policies need to be carefully reviewed, and in order to restrict the competition for arable land, it may be interesting to look preferentially at energy crops which can be grown on marginal lands, such as jatropha.

The role of FAO may be to alert countries of the risks and of the potential negative impacts on poverty, food security and the environment of growing energy crops. These impacts could be determined by looking closely at different energy crops and production systems, and at their relative efficiency, profitability and sustainability. Information could also be garnered by monitoring agricultural stocks to analyse available food supplies.

Some of the main concerns of the closing session of Day 1 were: integrating the main impacts of bioenergy production systems, investigating the technical aspects of bioenergy impacts as they relate to feedstock, land use and tenure issues, ensuring sustainability and examining the potential and risks of certification of bioenergy production systems; quantitative and qualitative analysis of trade-offs. The rapporteur focused on the overlapping themes among the discussion topics in regard to food security, focusing on available knowledge and the information gaps. Generally, participants agreed that outcomes should be targeted to beneficiaries at the national level since that was the level at which FAO intervened. The suggestion was made to examine the impacts of international markets on national and regional markets within the context of bioenergy and food security.

3.2 Working Group Discussions

Consultation participants were divided into two working groups, in an attempt to simultaneously address food security as it relates to bioenergy potentials as well as to environmental concerns. Working Group 1 was entitled *Bioenergy Potential and Food Security: a framework for the biophysical, economic and social factors*. The Chair was André Faaij and Rapporteur was Ingmar Juergens. Discussion focused on building scenarios of the food security and bioenergy nexus through modeling impacts, systemic linkages, data and model integration, and identifying major knowledge gaps. Working Group 2 was entitled *Environment and Food Security: potential benefits and/or losses from bioenergy production*, chaired by Francis Johnson with Rapporteur, Jennifer Nyberg.

Guidance was provided through three thematic concept notes, presented as background information and summary lists of key questions to prompt group discussion (see Section 4). The food security concept note was to provide a broad overview of those concepts most relevant to formulating a common understanding of the multiple pathways through which bioenergy developments may affect food security, as well as environmental concerns. Although there are many linkages between traditional biomass and food security, the rapid development of liquid biofuel from food crop feedstock was thought to have the greatest immediate impact on food security. Development of bioenergy sectors is essentially the starting point for assessing food security implications, thus, the consultation placed a very strong emphasis on discussion of bioenergy potentials.

Working Group 1 - Bioenergy Potentials and Food Security

Experts participating in Working Group 1 on bioenergy potentials agreed to try and produce a framework that would support further in-depth analysis. This section discusses the major research questions, observations and preliminary conclusions reached by the group. The group determined that the first step in designing a framework is to provide a definition of bioenergy potentials. A possible definition can be based on one of the following four dimensions: technical, economic, sustainability and implementation. It is also necessary to be very clear about the scale of the analysis: global, national and regional. A set of food security indicators should also be clearly defined, and it is important to think about the dynamics of the analysis by providing a time frame.

Group 1 presented the results of their discussions on Bioenergy Potentials and Food Security to the Plenary. The probable types of bioenergy systems, scenarios and pathways were examined, using a reference case study from South Africa. The drivers for the system were identified as: climate change (mitigating GHG), supply or feedstock, increased market access for small holders and energy security. Under the assumption that there were no limitations in feedstock availability, the different systems and drivers were used to create a matrix to determine linkages and interactions. The flexibility of the framework was discussed and other case studies (scenarios) examined. Several important issues were further discussed, including the dynamics of bioenergy development potential as well as the impact of policies and costs on some of the drivers as well as commodity prices.

The Chair opened the floor for discussions on the proposed framework based on the above criteria. The first observation was related to the importance of including socio-economic and ecologic aspects in the framework. Another proposal was to begin by tracing out the likely impact of bioenergy technologies as a first step. Another proposal was to build a matrix around supply and demand for biomass, and construct a framework on that basis. This was unanimously accepted.

The Chair agreed that the framework should have as a basis the different drivers of supply and demand for biomass. The four dimension of food security were also discussed and their elements listed and identified in relation to biofuel. The discussion, a summary of which follows, turned on the design of the proposed framework: do we need to integrate all these elements in a model, and what kind of data do we need? Some other questions were what type of scenarios should be addressed in the modeling exercise, and whether the analysis should be limited to the global, national or regional level. Participants stressed the need to have available good household data to carry out micro-analysis. The availability and nature of the data should guide the scientist with respect to the level of analysis.

Discussion focused on specific cases, in particular South Africa, where yellow maize for ethanol production is being promoted. On the basis of this example the discussion shifted to drivers of the scenarios and from this emerged a basic framework within which to analyse these drivers. For example, with regard to South Africa, the approach was to assess the economic potential of four different crops/fuels (such as ethanol from yellow maize, biodiesel from soybean and sunflower) and then to decide which to promote. Of the four crops/fuels considered, none was actually profitable. A number of drivers were identified: climate change, disposal of surplus stocks, bio-fuel mandate, better access to market for black, small-scale farmers and energy security. An initial attempt to design a framework to facilitate comparison of various scenarios included variables such as policy goals, ethanol (sugarcane), biodiesel (soybean), biodiesel (maize), current baseline, alternative strategies and market factors. Alternative strategies refer to alternatives for achieving the particular policy goal. By obtaining crop/fuel specific costs one can calculate a price gap to cost the policy and hence evaluate alternatives. Accounting for costs allows for comparability, accountability and transparency with regard to the possible goals/instruments. It was suggested that with regard to scenarios it would probably be useful to include a range of estimates, for example, to cover also as worst-case scenario. The working group session was focused on completing the matrix and generating the key outputs of ways forward and recommendations.

The working group focused on developing an objectives matrix for the evaluation of bioenergy systems performance against policy drivers and major public costs and benefits (labeled Public C/B in the table below), and market drivers and effects (labeled Private C/B). Although discussion focused on South Africa as a hypothetical reference case, the completed boxes in Table X do not represent the actual situation in South Africa, but represent only an example of how to do such a rating. Assumptions made (and labels) to simplify the working group analysis included (X) market and non-market goods and services, plus CC - Climate Change, CPS -Commodity Price Support (for surplus disposal, if any) and MA - Market access of small farmers and EI -Independence from Energy Imports.

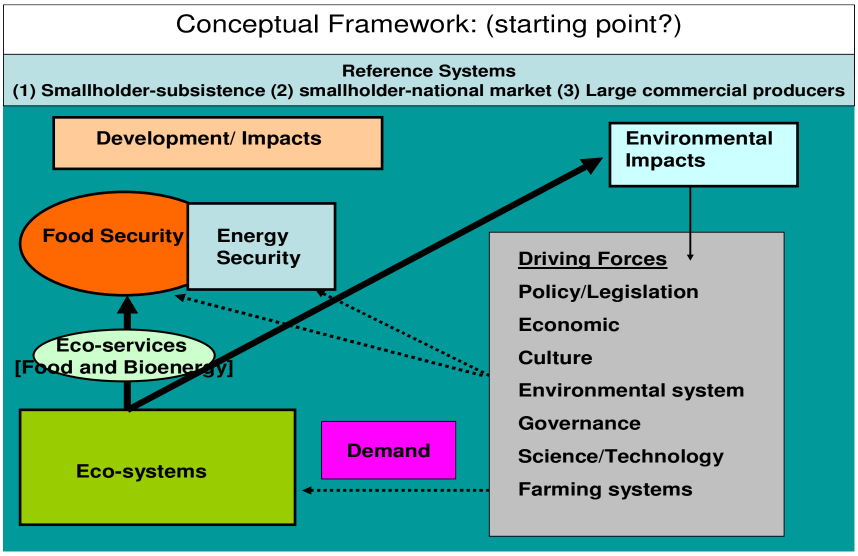
Public C/B	Ethanol				Biodiesel				Alternative		Baseline		Private C/B
Policy Objectives	Sugar		Maize		Soybean		Sunflower		SRC for Ethanol		agr ; LU energy;		Market Drivers
1 CC	€/t t€	+		0		-		--					A – profitability
2 CPS													B – food price
3 MA	-		++		+		+						C – energy price
4 EI													D – input prices
Non-policy													Market Effects
5 Food Security													

The next steps for each group were discussed with Group 1 proceeding to identify which FAO partners had a comparative advantage to take control of which aspects of the framework developed.

Working Group 2 - Food Security, Bioenergy and the Environment

Group 2 discussed the conceptual framework for linking environmental impacts and food security. Using three reference cases (smallholder subsistence, smallholder market, large scale production), several matrices were created based on environmental (biophysical), socio-economic and food security filters as well as their impacts. Each matrix is a progression of the previous, increasing in complexity and variables included. The first matrix weighed the relative and absolute significance of the biophysical filters on the reference systems. Data garnered from this analysis would form the benchmarks. The second matrix included the food security filters (availability, access, stability and utilization) and examined linkages with the biophysical filters and the reference systems. The third matrix included the socio-economic filters which take into account demand and market linkages. Data from this final analysis could be used to formulate policies. The reference framework for food security was also presented with a view to informing plenary of some of the work done in relation to food security indicators.

During the working group session, Monica Zurek (FAO) proposed a conceptual framework for examining the linkages among bioenergy production systems, environmental impacts and food security issues. The framework included a close look at environmental impacts in relation to each cropping system, to identify how these impacts could be assessed and to see how they interfere with food security indicators (partly through the Driving Forces – listed in the table below).



The importance of combining this theoretical approach with reference case studies was emphasized. Participants also stressed the need to look at different population groups, for instance rural and urban consumers. Both may face high prices and limited food availability. On the supply side, different production systems were identified: (i) smallholders producing for local use (subsistence); (ii) smallholders producing for national and/or international markets and (iii) medium and large scale farms producing for national/international markets. A study of the legal framework for bioenergy by the FAO Legal Office demonstrated that among the reasons that governments put in place bioenergy programmes and policies are the desire to reduce dependence on petrol, reduce greenhouse effects and contribute to rural development. Environmental factors can also be drivers for the implementation of bioenergy production systems.

Timeframes are an important element of the analysis within the conceptual framework as proposed. At present, the effect of bioenergy production on food prices can already be observed, and over the medium and longer term, other impacts and risks will appear. Environmental impacts may be observable over the longer term, while some conflicts over resource use are already taking place, particularly related to increased pressure on land. The key environmental issues linked with bioenergy production are often a result of increased pressure on land and land use change. Thus, in order to avoid or mitigate this pressure, the initial focus may need to be on energy crops that can be grown on marginal lands, and on increased utilization of residues and wastes. Such an approach will help minimize the risks of deforestation, offer greater climate change mitigation (based on energy balance of crop production and processing), address water availability and quality, plus account for impacts on biodiversity.

4.0 CONCEPT NOTES

This Section presents three concept notes on food security, bioenergy (biomass) potential and environmental issues, which were provided to participants as background information and guidance for working group discussions. The first concept note on food security and bioenergy was the central theme bridging the separate discussions of biomass potentials and environmental issues, and the concept note provided an overview of the multiple and complex pathways through which rapid bioenergy development and environmental issues may affect food security. The second concept note discussed bioenergy potentials and food security, while the third discussed environmental issues in the context of bioenergy and food security.

4.1 Concept Note 1 - Food Security and Bioenergy[6]

Some 70 percent of the 854 million hungry people in the world live in rural areas and depend on agriculture, and are often concentrated in regions that are particularly vulnerable to environmental degradation and climate change. An estimated 820 million are in developing countries, 25 million in countries in transition and 9 million in industrialized countries. Hunger claims up to 25 000 lives every day, two thirds of them children under the age of five, and is currently the leading threat to global health, killing more people than AIDS, malaria and tuberculosis combined. Although the proportion of undernourished in the world has declined from 20 percent to 17 percent since the mid-1990s, the absolute number of hungry people has remained the same. Global progress towards halving the proportion of hungry people by 2015 remains slow and largely uneven. Only Latin America and the Caribbean, amongst developing regions, have reduced the prevalence of hunger at a rapid enough pace to reach the Millennium Development Goals (MDG) target.

Approximately 30 percent of world grain supplies are currently used to feed livestock (and only indirectly to feed people); thus, the implications of biofuel development on food security will also be linked to changes in dietary patterns. One third of the projected increase in food demand over the next three decades is expected to come from dietary changes as more people are able to afford calorie-intensive meat and dairy products. Population growth in developing countries, roughly double that of industrialized countries, plus rising per capita incomes, economic growth and increased urbanization, are driving the increased demand for animal products, feedstuffs, higher value processed foods and horticultural crops. Production of these items requires relatively large resource inputs, including additional land and water to grow crops for animal feed. Continued increases in global demand for animal products may be an additional source of pressure on available supplies of biomass.

Country typologies key starting point for analysis

Growth rates of agricultural production and consumption in developing countries have outpaced those of industrialized economies in recent years.[7] This has not been the case, however, for most of the Least Developed Countries (LDCs), where agricultural output has not kept pace with population growth and increased domestic demand. Preliminary analysis of the impact of bioenergy on food security should thus highlight differences between developing, least developed, and low-income food deficit countries (LIFDCs). These two latter groups are typically the most food insecure, given high dependence on staple food imports and exports of primary tropical commodities.

LDCs have the highest proportion of chronically undernourished populations, and have become increasingly reliant on imports of basic commodities to ensure food security. For many, this has also resulted in increased exposure to international market price fluctuations, increasing overall food insecurity. Further development of bioenergy systems will increasingly highlight the direct linkages between food security and energy security. These linkages function as an additional source of uncertainty in global production and marketing systems; markets that are already more susceptible to greater variability in pricing and production due in part to trade liberalization and structural adjustments in food and agricultural sectors. Natural disasters and lack of productive input factors, such as fertilizer or water resources, also constrain or result in lost agricultural output, and lowers overall food availability.

The competition for more arable land and water resources directed to biofuel production may lead to higher and less stable food prices, for countries that are both net food importers and exporters. This may be particularly true for low-income, food deficit countries (LIFDCs) that already have a large proportion of undernourished and are net importers of basic foods, and may face serious problems of

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[6] Jennifer Nyberg, Economist, FAO Trade and Markets Division, and Manager, Bioenergy and Food Security Project, and Terri Raney, Senior Economist, FAO Economic and Agricultural Development Analysis Division and Editor, State of Food and Agriculture Report.
[7] OECD-FAO Agricultural Outlook: 2006-2015, OECD-FAO Paris, 2006.

food access within vulnerable populations. Poor households tend to spend a larger proportion of income on food than other items, including energy, and thus, may be particularly challenged by rising food prices, globally and locally.[8]

Linkages between prices, biofuel and food security

Current and expected trends in energy prices may catalyze further growth in bioenergy production and more rapid adoption of bio-based fuels. Biofuel represent an important and growing source of demand for agricultural commodities. Recent FAO research notes that prices for fossil fuels may essentially establish floor and ceiling prices for agricultural commodities used as feedstock.[9] Major producers of biofuel, such as Brazil, the United States, the EU and Canada are either expected to reduce exports of basic feedstock commodities (cereals or oilseeds) and increase biofuel imports. This has serious economic, environmental and food security implications for many developing countries, particularly countries that have large proportions of poor food insecure people living in rural areas.

Agricultural commodity prices have long been influenced by energy prices, because of the importance of fertilizers and machinery as inputs in commodity production processes. The possibility of increased competition for agricultural, water and other natural resources for bioenergy systems instead of food production is already evident. However, given potentially significant markets for bioenergy, competition for resources could induce result in price increases that adversely affect the ability of lower income consumers to purchase food.

Rising commodity prices, while beneficial to producers, will mean higher food prices with the degree of price rise depending on many factors including, as mentioned, energy prices, with negative consequences for poor consumers. Expanded use of agricultural commodities for biofuel production will strengthen this price relationship and could increase the volatility of food prices with negative food security implications. Developing guidelines to analyse how bioenergy can contribute to rural development, as well as formulate policy to ensure that the food security concerns of the rural poor, particularly female smallholders and household heads, is vitally important to ensure that the outcomes of rapid bioenergy development are positive.

There are indications that increased production of biofuel will further link prices of fossil fuels with biofuel feedstock. Prices of sugar and molasses already show high correlations with world oil prices. Increased production of biofuel adds another layer of uncertainty and risk to volatile price relationships by linking food and oil prices; demand can become less elastic (through biofuel consumption mandates), therefore comprising an increasing share of a given crop's market, which gives rise to greater price variability and market volatility. End-users can mitigate energy price volatility where technical options exist for easier fuel-switching, for example, through flex-fuel vehicles, although the extent to which this would benefit poorer populations remains unclear. Increased price volatility may be more detrimental to food security than long-term price trends, to the extent that the poor are usually less able to adjust in the short term. Increased trade in biofuel also has the potential to mitigate some of this price volatility. However, the expected price increases due to greater demand for biofuel crops may induce farmers to increase production and thereby mitigate some of these price effects in the longer term. Appropriate trade policies could potentially minimize tensions between biofuel and food production by allowing trade to flow internationally in response to fluctuations in domestic supply and demand, thus helping to stabilize prices.

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[8] Countries with 20 to 34 percent of the population considered undernourished include Bangladesh, Bolivia, Botswana, Cambodia, Cameroon, Chad, Congo, Dominican Republic, Gambia, Guatemala, Guinea, Honduras, India, Kenya, Laos Peoples Democratic Republic, Malawi, Mali, Mongolia, Namibia, Nicaragua, Niger, Pakistan, Panama, Senegal, Sri Lanka, Sudan, Thailand, Togo. Countries with more than 35 percent of the population considered undernourished include Angola, Burundi, Central African Republic, Chad, Democratic Republic of the Congo Democratic People's Republic of Korea, Eritrea, Ethiopia, Haiti, Liberia, Madagascar, Mozambique, Rwanda, Sierra Leone, United Republic of Tanzania, Tajikistan, Yemen, Zambia and Zimbabwe (FAO SOFI 2006).
[9] Impact of increased biomass use on agricultural markets, prices and food security: a longer-term perspective, Josef Schmidhuber, Senior Economist, FAO, November 2006.

Bioenergy and the four dimensions of food security

According to FAO, food security exists when all people, at all times, have physical, social and economic access to sufficient amounts of safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life. There are four dimensions to food security: availability, access, stability and utilization.[10]

Availability of adequate food supplies refers to the capacity of an agro-ecological system to meet overall demand for food (including animal products, livelihoods and how producers respond to markets). Food availability could be threatened by biofuel production to the extent that land, water, and other productive resources are diverted away from food production. The degree of potential competition between food, feed and fuel use of biomass will hinge on a variety of factors, including agricultural yields and the pace at which next-generation biofuel technologies develop. As second-generation technologies based on lignocellulosic feedstock become commercially viable, this may lessen the possible negative effects of land and resource competition on food availability. The market for biofuel feedstock offers a new and rapidly growing opportunity for agricultural producers and could contribute significantly to higher farm incomes. Modern bioenergy could make energy services available more widely and cheaply in remote rural areas, supporting productivity growth in agriculture or other sectors with positive implications for food availability and access to food.

Access to food refers to the ability of households to economically access food (or livelihoods), defined in terms of enough purchasing power or access to sufficient resources (entitlements). Bioenergy developments will have an impact on those populations vulnerable to food insecurity based on food access issues, to the extent that food prices rise faster than real incomes, reducing purchasing power and in turn, increasing food insecurity.[11] Global food commodity prices are expected to increase in the near to medium-term due to expanded biofuel production. Price increases have already occurred in major biofuel feedstock markets, for example, sugar, corn, rapeseed oil, palm oil, and soybean. In addition to raising feedstock prices, increased demand for energy crops might elevate the prices of basic foods, such as cereals, which comprise the major proportion of daily dietary intake of the poorest and least food secure. Thus, possible income gains to producers due to higher commodity prices may be offset by negative welfare effects on consumers, as their economic access to food is compromised. This appears to be the case for corn in 2006 and early 2007, as rising demand for biofuel production (ethanol) in the United States reduced exports and pressured world grain prices.[12]

Stability refers to the time dimension of food security. Stability of food supplies refers to those situations in which populations are vulnerable to either temporarily or permanently losing access to resources, factor inputs, social capital or livelihoods due to extreme weather events, economic or market failure, civil conflict or environmental degradation, and increasingly, conflict over natural resources. Temporal distinctions between chronic and transitory food insecurity may be important to understand in the context of rapid bioenergy development. Chronic food insecurity is a long term or persistent inability to meet minimum food consumption requirements, lasting for more than six months of the year. Transitory food insecurity is a short term or temporary inability to meet minimum food

[10] FAO, with the financial support of Germany, has recently launched a three-year Bioenergy and Food Security project with the objective to mainstream food security concerns into assessments of bioenergy potentials through targeted analysis and field activities that are designed to support rural development. The elaboration of a methodological framework is currently underway that will integrate tools used to analyse biomass potential with those related to food security. Three national teams will develop country case studies in Asia, Africa and Latin America based upon an assessment of biomass production potential linked to the natural resource base and to external factor inputs, land availability and utilization, the agriculture, energy and environmental policy framework, and the analysis of qualitative and quantitative linkages to food security, social, economic and environmental indicators. The development of policy guidance that focuses on sustainable forms of bioenergy while safeguarding food security remains a primary objective.

[11] Schmidhuber, November 2006.

[12] According to C. Ford Runge and Benjamin Senauer, the enormous volume of corn required by the US ethanol industry is sending shock waves through the food system. The US accounts for some 40 percent of global corn production and over 50 percent of all corn exports. Corn futures rose to over $4.38 a bushel in March 2007, the highest level in ten years. Wheat and rice prices have also surged to decade highs, because even as those grains are increasingly being used as substitutes for corn, farmers are planting more acres with corn and fewer acres with other crops. How Biofuels Could Starve the Poor, Foreign Affairs, May/June 2007.

requirements, usually linked to the hungry (or lean) season, a more limited timeframe with some indication of capacity to recover from shocks.[13] Further growth in biofuel could exert additional pressures on stability of food supplies as price volatility from the petroleum sector is more directly and strongly transmitted to the agricultural sector, increasing the risk of more severe chronic and transitory food insecurity.

Utilization of food refers to peoples' ability to absorb nutrients and is closely linked to health and nutrition factors, such as access to clean water, sanitation and medical services. The food utilization concept is also based on how food is used, such as nutrient loss during preparation, storage or processing, or cultural practices that negatively affect the consumption of enough nutritious food for certain family members, particularly, women and girls. If biofuel feedstock production competes for water supplies, it could make water less readily available for household use, threatening the health status and thus the food security status of affected individuals. On the other hand, if modern bioenergy replaces more polluting sources or expands the availability of energy services, it could make cooking both cheaper and cleaner, with positive implications for food utilization.

Finally, determining the possible positive or negative effects on food security requires an understanding of the concept of **vulnerability**. Vulnerability in relation to food security is determined by the frequency and intensity of shocks affecting households and the capacity of these households to withstand these shocks. Vulnerable households and communities may face acute food crises due to many factors (not just weather-related) and adopt extreme coping strategies to meet food needs. The long-term and cumulative effect of resorting to these types of coping strategies reduces more sustainable access to food as well as access to factor inputs necessary to restore livelihood security and/or own food production. This is clearly the case for many countries in sub-Saharan Africa.

Chronic food insecurity reduces household and community capacity to face human-induced and natural hazard shocks, particularly when faced with an acute food crisis. Repeated shocks, such as higher food prices, loss of income or source of livelihood, or loss of food crops due to extreme weather events, may force households to cope with chronic poverty and seasonal or cyclical food insecurity, depleting household assets and resulting in deteriorating food security.[14]

Environmental concerns related to bioenergy and implications for food security

The relationships between bioenergy and the environment, as related to food security, are complex and interdependent. Environmental and socio-economic benefits and trade-offs, particularly in terms of bioenergy and food security, must be analysed and monitored across space and time. Energy (commodity) crops based on traditional agricultural output are already associated with land and soil degradation, water pollution and input and energy intensive production systems.

Local environmental issues related to resource use and the potential for further degradation of the natural resource base may result in conflict over access and control over natural resources. At the global level, the environmental issues are related to climate change and the potential for bioenergy to mitigate greenhouse gas emissions. This will depend on feedstock used, technological conversion and the impact on the global energy balance. The most direct link between the environment, bioenergy and food security is the impact of climate change on vulnerable, food insecure households, mostly as it relates to the frequency and severity of extreme weather events.

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[13] Identification of methods and tools for emergency assessments to distinguish between chronic and transitory food insecurity, and to evaluate the effects of various types and combinations of shocks on these different livelihood groups, Stephen Devereaux, WFP/ODAN, February 2006, SENAC Project.

[14] The livelihoods approach in food security analysis is helpful given the emphasis on understanding the capacity of a household to manage risks, such as drought or extreme weather, thus livelihood security is a useful concept for the analysis of bioenergy and food security, particularly from the environmental and climate change perspective.

There may be no other region in the world where the relationship between chronic and transitory food insecurity resulting from vulnerability to economic, political and climatic shock is more challenging and urgent than sub-Saharan Africa. A more pronounced vulnerability to shocks of every kind exists in sub-Saharan Africa, with 30 percent of the population chronically food insecure, and subject to diseases of poverty, extreme weather events, remoteness and/or human-induced conflict. Many rural households in sub-Saharan Africa, for example, are dependent on traditional farming systems and rain fed agriculture. Frequent and extreme weather events in sub-Saharan Africa, influenced by seasonal hazards, climate variability linked to climate change, result in weather shocks (droughts and floods) that reduce food production and have negatively impact livelihoods that may have helped vulnerable people access food.

Currently, vulnerability analysis may help define the specific context and nature of risks to food security, although a standardized methodology for analysis and measurement does not exist and standardization may not be possible. There are important sources of traditional knowledge that often play an important role in mitigating shocks, but may be overlooked in current food security assessment methodologies. Examples from the Sahel have shown the importance of considering traditional knowledge of how to cope with drought in analysing natural hazards, as well as efforts to map livelihood zones to help develop early warning systems. Thus, a wide range of quantitative and qualitative information within an integrated livelihoods analysis framework may be necessary to understand bioenergy developments as related to food security and vulnerability.[15]

Policy domains shaping development of bioenergy sectors and food security impacts

At least four distinct policy domains are shaping development of the liquid biofuel sector: energy, environment, agriculture, and trade. Similarly, policies at the national, regional, and global levels are highly relevant and may interact in unexpected ways. Rural development policies have often tended to favour large-scale agriculture and livestock production to foster economic growth at the industrial level, often at the expense of more sustainable mixed farming systems typically employed by poorer people. Dedicating large tracts of land to single crop industrial output often contributes to deforestation, land degradation, contaminated surface and groundwater, and loss of biodiversity.

There are also growing socio-economic and environmental concerns about bioenergy systems based on large-scale monoculture agro-industrial crops. These systems may have a negative effect on food security due to competition for rural resources resulting in increased need for cash-based instruments to access credit, land and productive inputs. Female smallholders are often excluded from accessing the cash and resources necessary to focus on single crop output, and may be excluded from any potential benefits of bioenergy production, although they often play the most significant role in ensuring household food security. Smaller-scale systems can be promoted and/or small-scale farmers can be organized in terms of providing factor inputs and supporting contractual relationships with industrial actors involved in biomass feedstock production processing, product distribution, trade and transport.

Agriculture has become increasingly feminized, particularly in the poorer and more food insecure countries of the world.[16] As the rate of male participation in rural agriculture declines (rural to urban migration, war, illness and death due to HIV/AIDS, particularly in sub-Saharan Africa), women increasingly bear the primary and dominant role in agricultural production. An estimated one-third of all rural households in sub-Saharan Africa are now headed by women, and these households are often forced to make adjustments in cropping patterns and farming systems due to lack of access to land, capital, credit and labour. FAO research indicates that these households also suffer disproportionately

[15] For example, refer to the FAO-FSU Integrated Food Security and Humanitarian Phase Classification Reference Table, FAO, February 2006 or the FAO-ILO Livelihoods Assessment Toolkit, April 2007.

[16] FAO research notes that although women are the principal food producers and providers globally, they remain invisible partners in development. The relative lack of available gender disaggregated data means that the contribution of women to agriculture remains poorly understood and that their specific needs are often missing in development planning.

from environmental degradation, declining crop yields, water and fuel shortages, all of which result in increased vulnerability to chronic and transitory food insecurity.

Agricultural and energy markets are both highly distorted, making it difficult to predict the net effect of reforms in either sector. Although existing agricultural supports clearly depress commodity prices (feedstock), helping make liquid biofuel more competitive vis-à-vis fossil fuels, direct subsidies for biofuel are still required in most cases to overcome the cost advantage enjoyed by petroleum products. Whether such subsidies may be justified in the short term in terms of socio-economic and environmental objectives needs to be evaluated in a rigorous cost-benefit framework.

Ethanol or biodiesel blending requirements mandated on environmental grounds may be inconsistent with trade barriers erected against imports of those products, or even become less effective due to trade barriers. By impeding imports of more efficiently produced biofuel from abroad, the combination of the two policies may divert more land from food production than would have been necessary to meet the blending requirement alone. Similarly, investments based on expected export opportunities that depend on preferential market access or policies that provide subsidies in importing countries, which could be eroded, must be carefully evaluated.[17]

Policymakers need to understand the interactions amongst these various policy domains to ensure that food security considerations are given priority. Integrated policy analysis that considers the effects and interactions of the relevant policy domains at different levels is required, particularly as related to those factors of exclusion, for example, gender, geographic remoteness, poverty (and the associated diseases of poverty), that may constrain political and economic participation.

The potential for world agriculture to be a significant source of feedstock for biofuel may offer development opportunities for countries with sufficient land and water resources as well as policies conducive to trade. At the same time, maintaining national and household level food security remains a major priority for most developing countries. Governments in developing countries have adopted various strategies, including efforts to increase production (often based on national goals to become self-sufficient in food production), market interventions, food or income transfers, distribution of food in-kind and maintenance of national food security reserves. Hunger and food insecurity in developing countries tends to be concentrated in rural areas, thus little sustained progress in food security is possible without paying particular attention to agriculture, factors of exclusion and rural development.

4.2 Concept Note 2 - Bioenergy Potentials and Food Security[18]

Projections indicate that bioenergy produced from biomass could meet up to 25 percent of global energy demand by 2050. As a nearly carbon-neutral source of energy, most bioenergy systems can contribute to climate change mitigation by replacing fossil fuels, and through the carbon sequestration of bioenergy plantations. Since agriculture and forestry are the world's primary sources of biomass, the growing market for bioenergy feedstocks could contribute significantly to higher farm incomes. More than 200 species of plants could be used in bioenergy production, and some plants could help rehabilitate degraded and marginal lands. However, FAO cautions, the shift to bioenergy raises concerns for food security, as land and other productive resources are taken from food production. In addition, intensified biofuel operations could have significant negative impacts on water and soil, natural habitats and biodiversity.

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[17] There are examples of investment and policy support to small-scale, labour-intensive biofuel production systems aimed at providing employment and income for smallholders. For instance, Brazil recently introduced a social biodiesel program, focused on small rural cooperatives, that is targeted specifically at poverty reduction. The Brazilian government is now providing families of labourers with a new market for their oilseed crops with the aim of improving socio-economic conditions.

[18] Ingmar Juergens, Technical Advisor (Bioenergy Officer), Bioenergy and Food Security Project, FAO.

There is an urgent need to assess the feasibility of bioenergy systems based on countries' needs and resource endowments, prevailing policies, and plausible scenarios for the economic, environmental and policy variables. Biofuel policy cannot be successfully managed outside the overall policy and regulatory framework of the agricultural sector, according to a recent IEA report, as this will require coherent, long-term planning for transition and adjustment, which takes into account the complexities of managing change in a market-based world economy.

Today, world agriculture is called upon to play a variety of roles, in which the trade-offs are considerable and often difficult. While guaranteeing food security for the global population and a source of livelihood for billions of people, particularly the poor, it must also provide ecosystem services to the wider environment, serve as a sink for carbon sequestration, and meet future demand for biofuels and various agro-industrial products made from biomass. According to FAO, the actual trade-offs involved in major changes to global agricultural production objectives are difficult to evaluate in terms of overall ecological impact, effects on food security, food prices, agricultural labour prices, terms of trade between countries and regions, and access of the poor to land, and social equity.

How can biomass potential be accessed sustainably?

Understanding how, and at what scale, the potential of biomass resources can be accessed over time and exploited in a sustainable way is a vital element for publicly acceptable and commercially viable long-run bioenergy development. The consultation was to share insights related to global, regional and national biomass resource assessments to sub-national site specific, locally generated estimates of the potential for different biomass production systems to provide bioenergy to markets.

Modeling biomass resources for energy is highly complex and cross-sectoral and represents an exciting emerging area of applied science. It would therefore be unacceptably risky to encourage the development of specific bioenergy projects based solely on the projected outcomes of such models. To resolve this problem, it is envisaged that the models and modeling frameworks to be used to highlight areas with high potential and this be verified through ground-truthing surveys and activities.

What are the key factors to consider when estimating potential?

To date, a variety of analyses has been carried out on the potential role of biomass in the world’s future energy system. Most analyses confirm that biomass can make a major contribution to the global energy supply during this century. Estimates vary between less than 100 EJ/yr up to over 1000 EJ/yr compared to a current (2004) global energy use of 420 EJ, of which over 10 percent is already supplied by bioenergy, although rather inefficiently in the form of traditional usage. However, this contribution is by no means guaranteed. Crucial factors determining biomass availability for energy include ppopulation growth and economic development, food production and other land utilization systems, their productivity and their rate of deployment in developing countries, feasibility of the use of marginal or degraded lands, productivity of forestry systems and maximum sustainable yield levels, increased demand for biomaterials (for example, materials derived from renewable resources), and bioenergy related policies (such as mandates, other support measures).

It is important to note that the potential for developing different bioenergy options in countries and regions across the globe should be constraint by requirements of these systems to be in line with sustainable development objectives (as defined nationally by the producing country or the importing country or eventually, internationally) and in particular food security objectives. For estimates of bioenergy potentials these other objectives could for example be represented in terms of different scenarios for constraints to resource use and requirements for socio-economical or environmental provisions, which will in most cases, represent an additional cost and thus limit the competitiveness and potential of the bioenergy system in question.

How to bridge knowledge gaps?

Several key ways forward could be utilized to identify and bridge knowledge gaps in terms of bioenergy potentials from the production (supply side) as well as end-use (demand) side. A coherent methodological framework for developing increasingly detailed time and space dependent estimates for the biomass resource base (particularly land) needs to be available for estimating bioenergy production. The utility of different definitions of potentials (theoretical, technical, economic and implementation) relative to different stages of development and spatial scales of analysis must be clarified.

A modelling framework around the key determinants of bioenergy potential needs to be established, as well as defining and identifying the data needs and sources necessary to establish information systems, such as the FAO-proposed international Bioenergy Information System (iBIS). Those factors that impede the development of domestic demand for bioenergy in the transportation and heating fuel markets need to be identified. There are trade considerations on the supply side that call for identification of those policy and technical measures that need to be addressed to promote global and regional trade in biofuel, where feasible, and that allow low-cost producers to fully exploit their export potential.

Ways forward to bridge knowledge gaps on the end-use side are straight-forward. Scenarios for bioenergy demand need to be established that incorporate land use and potential changes in land use due to demand for food and biomaterials, land allocation, international trade, technological developments and agricultural and forestry management practice. A comparison between the potential competition for biomass and resources and the likely demands of traditional food and biomaterials sectors is necessary. Easy-to-use tools that quantify potential national bioenergy resource bases and therefore highlight opportunities for biomass use and development over time are also necessary. The national impacts of switching parts of the energy supply to bioenergy need quantification, as well as establishing mechanisms to compare data gathered through monitoring over time to recalibrate and refine model predictions.

Key Approach: Spatially explicit modeling based on Multi-Criteria Analysis

A primary concern relative to the ongoing development of bioenergy sectors is the potential impact on food security, sustainable agriculture and rural development. Current and future development of bioenergy and how this development may positively or negatively affect food security needs to be analysed within a variety of bioenergy systems and food security contexts. Linkages between food security and bioenergy production are defined, in part, by competing demands for productive land. This is a simple and pragmatic approach, but an insufficient one to analyse the complex issues related to food security and underpinning the food versus fuel debate.[19]

Biomass is derived from a multitude of different sources and materials. More than any other form of energy provision, the exploitation of biomass to provide modern energy services requires a simultaneous and complementary evaluation of social, technological, environmental and economic factors in order to avoid conflicts related to food, water, land, human capital or other resources. Spatial modeling based on multi-criteria analysis allows a range of site-specific and non-site-specific variables to be assessed at the same time. Meanwhile, the approach represents new state-of-the-art in science and therefore entails some risk, particularly around resolution (scale) and uncertainty arising from concatenation of multiple assumptions. This modeling approach also incorporates logistical and technological innovation options. By adopting this approach stakeholders would be able to trade-off mature bioenergy options, which may be lower risk but less efficient, against innovative *second generation* bioenergy options that may require larger scale, higher efficiency, logistical complexity and capital requirements but result in lower cost outputs.

4.3 Concept Note 3 - Food Security, Bioenergy and the Environment[20]

One of the key policy domains that will shape further development of bioenergy sectors, particularly liquid biofuel, is related to overall environment impacts. Environmental policies at various national, regional and global levels are very significant, and their interaction may result in unintended

[19] A number of very relevant studies or literature reviews assessing the global bioenergy potential are based on the use of global land use models (Leemans *et al.,* 1996; Fischer and Schrattenholzer, 2001).

[20] Rainer Krell, Climate Change and Bioenergy Unit, Natural Resources Management and Environment Department, FAO

consequences. Rural development policies have often tended to favour large-scale agriculture and livestock production to foster economic growth at the industrial level, often at the expense of mixed farming systems typically employed by poorer people that are much less input-intensive. Dedicating large tracts of land to single industrial crops contributes to deforestation, land degradation, contaminated surface and groundwater, and loss of biodiversity – clearly issues of concern to bioenergy development and food security within the environmental domain. For example, the WWF have estimated that over the next 25 years 250-300 million hectares of tropical forest might be cleared for agricultural development, mostly for oil palm.[21] Thus, serious concerns about the global energy balance of bioenergy systems that depend upon large-scale agro-industrial crops as a source of biomass feedstock continue to grow.

What are the linkages between the environment, bioenergy and food security?

Bioenergy, food security and the environment are linked through their mutual dependence upon appropriate ecosystem services, made further interdependent as they simultaneously impact the capacity of ecosystems to perform those services. Humanity depends upon the goods and services provided by ecosystems, such as food, clean water, climate regulation, and spiritual, socio-cultural and aesthetic fulfillment. Whereas all forms of the ecosystem approach consider people as an integral component of ecosystems, ecosystem approaches applied to food and agriculture tend to place humans more explicitly at the centre of the management strategy and give greater emphasis to goals related directly to human well-being, and on the social and economic advantages that result from their application.[22] Changes as to how ecosystem services are delivered due to development of bioenergy sectors may be positive or negative in how they impact the supply of basic needs for life, health, good social relations, security, and freedom of choice and action.

Many external influences and demands may exert stress on ecosystems or on the performance of agricultural production systems. Ecosystem services as they affect food security will be stressed by population numbers, limited infrastructure and market access, land tenure and increasing degradation problems due to poor management of soils prone to erosion, steep slopes or low rainfall quantities, some of the limitations to agricultural production that have led in many areas to growing numbers of poor people (Lipper, Pingali, Zurek, 2006). Clearly, to sustainably manage ecosystem services, trade-offs between food and energy production that optimize food security need to consider the carrying capacity of the whole system to continue providing ecosystem services over the long term.

What key bioenergy ecosystems are of higher priority?

The Millennium Ecosystem Assessment notes the importance of scale and value in any evaluation of human-environment interactions, to some extent reflected in the classification of ecosystem services as provisional or regulatory. Different scale bioenergy production systems and product chains are rapidly developing or have already developed - from large scale industrial output of liquid biofuel through to local and direct use of biomass without further processing. There are a large number and variety of scales, products and bioenergy typologies that need to be analysed through numerous environmental conditions.

Table 1: Systems Approach to Bioenergy Typology and Production

SOCIO-ECONOMIC SYSTEM		TECHNOLOGICAL SYSTEM		ECOSYSTEM	PRODUCTION SYSTEM	
Social	Economic	Technical	Fuel type	Ecological	Crop	Production

[21] Rain Forest for Biodiesel? Ecological effects of using palm oil as a source of energy, WWF, April 2007

[22] While the ecosystem concept tends to focus on the benefits that biodiversity, ecosystem services and the environment deliver to human well-being, it also links the importance of the conservation and sustainable use of these various elements to the achievement of long-term economic gains. However, there is still little available information on the economic valuation of ecosystem goods and services. For more information on how the approach is applied generally by FAO, please refer to The Ecosystem Approach Applied to Food and Agriculture Status and Needs, Draft Provisional Agenda, Commission on Genetic Resources for Food and Agriculture, Eleventh Regular Session, Rome, 11-15 June 2007.

Rural small holder farmers	Subsistence farming	No processing	Unprocessed biomass and wood fuel	Agro-ecological Zones (AEZ)	Mono crop, species	High intensive
Landless rural poor	Cash cropping	Household scale processing/use	Polluted wood and biomass	Ecosystem type	Multi-crop rotation	GAP
Urban poor	Viable small to medium scale farms	Small business processing/use	Charcoal	Landscape level	Multi-purpose crop	Low input
Community	Rural business	Community scale use	Bio-alcohols (1st generation)	Watershed system	Annual	Certified production systems
Employment	Large scale industrial	Industrial scale processing	Biodiesel	Soil type	Perennial	Traditional
Governance	Fair trade	Most energy efficient process	Biogas	Climatic conditions	Agro-forestry	Collection
	Export	Most environmentally beneficial technology		Water availability	Recycled or residue biomass	Invasive slash and burn, large or small scale

Various combinations could be examined based on a specific analytical questions, for example, socio-economic, ecosystem and production system such as that illustrated, for a desired purpose such as GHG reduction, income generation for smallholders, reduced fossil fuel dependence (including imports), rural development, land reclamation, food security, export enhancement, community electrification, health or household safety.

The selection of various scenarios may also facilitate policy formulation or strategic development decisions relative to sustainability concerns, certification or responsible business practices, such as those developed for the Millennium Ecosystem Assessment.[23] For the purpose of the consultation, a list of various rationales for selecting certain bioenergy production schemes (from Table 1) was prepared. Such a list, once agreed and completed by stakeholders, could be compared with a list of desired outcomes due to development of bioenergy systems. Table 2 attempts to illustrate how this approach could be useful for determining which of the various rationale may be of benefit or harm to food security, the example presented below assumes some benefit towards an improved food security.

Impacts, positive or negative, occur at different scales (for example, local soil, ecosystem, landscape, national, international and global) possibly affecting different geographic locations and apparently unconnected spheres. Expected or significant impacts can possibly be mapped along a vector of increasing complexity, time scale and distance, along which increasingly larger and/or more remote spheres are impacted. Clearly, there is a need to analyse the trade-offs between resources used for short term interventions to improve food security compared to resources necessary to address the longer term impacts on food security, for example, due to degradation of environmental services.

Table 2: Possible Rationale for Selecting Bioenergy System

	Reason for (not) selecting a system	Effect on Food Security
Economic	Large scale investment desired (available)	
	Import substitution (reduce import bills)	
	Profitable business	
	Creating new rural employment	
	Food crop substitution is of no concern	
	Improves resilience of livelihoods to increasing climate variability	
	Better cash crop	
	Rural electrification alternative	
	Low investment requirement	

[23] Four types: Global Orchestration, Order from Strength, Adapting Mosaic and Technogarden, pleaser refer to http://www.maweb.org/documents/document.332.aspx.pdf, accessed April 2007.

	Improve poverty conditions	
Environmental	Reduces GHG emissions	
	No need for environmental or social compliances	
	Irreversible damage/depletion	
	Proven to be beneficial and feasible	
	Flexible multi-use system	
	Conserve local varieties and species	
	Improves environmental production performance	
	Improves and sustains ecosystem services	
	Leads to crop diversification	
Social	Conserves local traditions	
	Reduces physical burden and gender inequality	
	Resulted from multiple stakeholder consultation	
	Recommended after scientific research and assessments	
	Personal preference	
Policy	Compliance with international agreements	
	Compliance with national development goals for increased energy or food self-sufficiency	

Selected studies on standards, sustainability and certification

A comprehensive review of social and environmental issues, called **Sustainability Standards for Bioenergy**, was published by the World Wildlife Fund (WWF) in 2006. [24] The review included legal framework and implementation options for sustainability standards, and concluded that although all reviewed standards should be taken into account for large scale operations and smallholder activities, all standards needed further refinement for application at the regional level. One key recommendation was to list of negative standards, or criteria to be avoided in sustainability. [25]

The **Responsible Commodity Initiative (RCI)** is a diverse team of members from the currently active and pioneering **Commodity Roundtables** on soybean, sugarcane, oil palm, shrimp and salmon aquaculture. The Roundtables also include members of financial institutions that are looking at investment risks and opportunities. The RCI have developed a benchmarking tool that calls for simple, targeted and strategic production standards, as well as measurement of the few key environmental and social indicators that are of highest priority. The overall objectives were to elaborate sustainability standards for a range of commodities that would be manageable at large scale, less expensive to implement than other models, demonstrably more effective at achieving sustainability goals, and generate incentives for continuous improvement in practices, rather than setting minimum requirements which may result in disincentives to continuous improvement. A streamlined set of sustainability criteria was also thought to be of use for the financial industry, in that banks, commodity financiers and shareholder activists could make loans and investments conditional upon the simple formulation of agricultural standards as conditions on loans and investments, similar to the **Equator Principles**, which are a framework for financial institutions to manage environmental and social issues in project financing. The draft tools are available from the Sustainable Food Laboratory.[26]

The **Environmental Sustainability Index (ESI)** is a composite index tracking a diverse set of socioeconomic, environmental and institutional indicators that characterize and influence environmental sustainability at the national scale. An Environmental Performance Index focusing on assessing key environmental policy outcomes using trend analysis and performance targets is under development. The ESI compares 146 countries with measured indices against a total of 76 criteria and

[24] Fritsche U.R., Huenecke K., Hermann A., Schulze F., Wiegmann K., 2006. Sustainability Standards for Bioenergy. WWF Germany, pp.80
[25] Van Dam J., Junginger M., Faaij, A., Juergens I., Best G., Fritsche U.R., 2006. Overview of recent developments in sustainable biomass certification, IEA Bioenergy Task 40, a further review of developments in sustainable biomass certification is under preparation to support IEA Bioenergy Task 40.
[26] Draft tool available at http://www.sustainablefoodlab.org/filemanager/download/416

21 indicators through the following sectors: environmental systems; reducing environmental stress; reducing human vulnerability; social and institutional capacity and global stewardship. [27]

Certification schemes and standards-setting will most likely play an increasingly important role in the longer term development of bioenergy sectors. Efforts to incorporate food security indicators and monitoring criteria should be made in the further elaboration of sustainability standards and certification, given the importance of human development within the ecosystems approach, and the depth and breadth of currently available tools.

5.0 CONCLUSIONS

Few topics have such an important place in the international agenda as bioenergy and how it relates to food security. The shift to bioenergy raises concerns for food security, as land and other productive resources may be taken away from food production, but the potential opportunities to increase rural income and improve rural infrastructure are mirror images of these concerns. Experts noted that the impact on food security is highly context-specific and aggregate analysis must be complemented with system specific regional analyses. Sustainability and certification criteria, role of ecosystem services, climate change, biodiversity and pressures on land use patterns are key areas for further research. Two of the primary concerns of the participants were related to whether or not rural people will really benefit and if there is sufficient land and biomass available to meet future food, feed, fibre, fuel and biomaterial demands. Concerns, policy and legislative framework, commodity prices and market uncertainty.

Some of the key conclusions of the Consultation:

- Bioenergy potential may be as closely linked to increased agricultural efficiency as food security.
- Available food supplies may decline if increased demand for bioenergy feedstock from food crops is not balanced with increased agricultural yields or land use patterns focused on ways to increase planted areas to food.
- Agricultural commodity prices have been influenced by increased demand for feedstock to produce biofuel, particularly sugar, maize and oilseeds, as well as the price of oil.
- Rising commodity prices may benefit producers but may be negative for poor consumers, particularly if increased demand for biofuel pressures food prices and alters land use patterns. Net food and net energy importing countries may face even greater challenges in future.
- New ways to increase food and fuel output are necessary, rotating crops for energy with food crops could improve yields and enhance disease and pest resistance, while providing value addition and diversification for producers.
- Exploring the potential for multi-purpose crops and using agro-ecological zones (AEZ) as entry points for understanding biomass potentials is important.
- Bioenergy could help develop rural infrastructure and increase employment in agricultural sectors, especially in rural areas.
- Biofuel made from non-food crops, for example, such as castor beans or jatropha, provide ways for small farmers to grow cash crops, access new market outlets or farm sources of energy for themselves, their local communities and strengthen linkages to commercial markets.
- Rapid bioenergy development may result in unintended consequences to food security and the environment, and these risks warrant further attention.

The shift to bioenergy raises concerns for food security, as land and other productive resources may compete with food production. The potential impacts on food security are thus highly context-specific and aggregate analysis must be complemented with system specific regional, national and sub-national

[27] For further information, please refer to ESI 2005 indicators at http://sedac.ciesin.columbia.edu/es/esi/ESI2005_policysummary.pdf with the supporting documents and country evaluations available from http://www.yale.edu/esi/ also accessed April 2007.

analyses. Sustainability and certification criteria, the roles of ecosystem services, climate change, biodiversity and pressures on land use patterns are key areas for further research. Experts at the Consultation noted that concerns exist in terms of whether or not rural people will benefit from bioenergy, and if there is sufficient land and biomass available to meet future food, feed, fibre, fuel and biomaterial demands.

A clear need exists for more risk assessments and reference scenarios that incorporate environmental and food security considerations into analysis of bioenergy. These analyses will help policymakers understand the interactions amongst distinct policy domains (energy, environment, agriculture, and trade) to ensure that food security considerations are given priority, as well as understand that policies at the national, regional and global levels may interact in unexpected ways. Trade-offs between food and energy production that optimize food security need to consider the carrying capacity of the whole ecosystem to continue providing sustainable ecosystem services over the long term.

ANNEX 2
CONSULTATION AGENDA

First FAO Technical Consultation on Bioenergy and Food Security
Rome, 16-18 April 2007

Objectives of the Consultation
There are three major objectives of the first FAO Technical Consultation on Bioenergy and Food Security: (i) integrate the most recent research, knowledge and insights on bioenergy and food security; (ii) advise on a medium-term FAO strategy for mainstreaming food security and sustainability concerns in the context of rapid bioenergy development, and (iii) help identify and prioritize actions under the International Bioenergy Platform (IBEP).

Expected Outputs

- Presentations on three key thematic areas – bioenergy, environment and food security – to help summarize the current state of knowledge, focus on major knowledge gaps and outline possible milestones and next steps.
- Review and reflection on the two key questions – *(i) what is the potential for bioenergy?* and *(ii) what are the implications for food security?* – based on expert opinion and concrete case studies.
- Road maps with priority areas for action, assessment and modeling, plus identification of ways to integrate sustainability issues into the bioenergy-food security nexus.
- Clearly identified major themes for further expert study to support the production of a reference publication on bioenergy and food security.
- Identification of facilitators, networks and platforms to support specific immediate and future actions.

Day 1 – Monday, 16 April 2007

8:30 **Registration**
9:00 **Opening Remarks and Objectives for Day 1**
9:30 **Assessing Bioenergy Potentials in the context of Food Security**
- Approaches, models, data, gaps for the assessment of bioenergy potentials
- Socio-economic feasibility along the supply chain
- Priority areas with emphasis on the bioenergy and food security nexus

Moderator - André Faaij and Rapporteur – Ingmar Juergens
11.00 **Coffee Break**
11.30 **Environmental Linkages**
- Approaches, models, data, gaps for the assessment of the environmental dimension of bioenergy and food security
- Integrating environmental analysis with bioenergy and food security
- Priority areas for analysis

Moderator - Francis Johnson and Rapporteur – Romina Cavatassi
13:00 **Lunch**
14.00 **What are the implications for food security?**
- Food security overview and approaches to food security assessment
- Linkages between bioenergy and food security
- Priority areas for analysis

Moderator - Terri Raney and Rapporteur – Jennifer Nyberg
15.30 **Break**
16.00 **Day 1 – Summary and Discussion**
17:00 **Brief presentations by participants**
18.00 **FAO Reception** Aventino Room, 8th Floor

Day 2 – Tuesday, 17 April 2007

8.30 **Opening Session - Objectives for Day 2**

9.00 **Working Groups**

- Working Group 1: Bioenergy Potential and Food Security : a framework for the biophysical, economic and social factors
  Chair - Andre Faaij and Rapporteur – Ingmar Juergens
- Working Group 2: Environment and Food Security: potential benefits and/or losses from bioenergy production
  Chair – Francis Johnson and Rapporteur – Jennifer Nyberg

11.30 **Group Presentations and Plenary Discussion**

12.30 **Lunch**

14.00 **Working Groups**

- Working Group 1: Building scenarios of the food security and bioenergy nexus: modeling impacts, systemic linkages, data and model integration, major gaps
  Chair Andre Faaij and Rapporteur - Ingmar Juergens
- Working Group 2: Bioenergy and the environment: benefits, minimizing risks and damage, certification issues, mainstreaming into bioenergy and food security analysis
  Chair - Francis Johnson and Rapporteur Terri Raney

15: 30 **Coffee break** (at the discretion of each Working Group)

16:30 **Group presentations and Plenary Discussion**

17:30 **Summary – Day 2**

20.00 **Group Dinner**

Day 3 – Wednesday, 18 April 2007

8.30 **Opening Session – Objectives for Day 3**

9.00 **Working Groups – Ways Forward**

- Working Group 1: Bioenergy Potentials and Food Security
  Chair - Andre Faaij and Rapporteur -Ingmar Juergens
- Working Group 2: Bioenergy, Environment and Food Security
  Chair - Francis Johnson and Rapporteur -Jennifer Nyberg

11.00 **Coffee Break**

11.30 **Working Groups – Recommendations for ways forward**
Chair - Jeff Tschirley and Rapporteurs - Jennifer Nyberg and Ingmar Juergens

12.30 **Lunch**

14.00 **Consultation Review**
Chair - Jeff Tschirley and Rapporteurs - Ingmar Juergens and Jennifer Nyberg

15:00 **Plenary Discussion**

15.30 **Closing Remarks**

ANNEX 3
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Rome, 16-18 April 2007

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