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Sustainability and the Bioeconomy: Synthesis of Key Themes from the 15th ICABR Conference

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The International Consortium on Applied Bioeconomy Research (ICABR) held its 15th annual conference near Rome, Italy in June 2011. The theme of the conference was sustainability, and this topic was addressed through numerous presentations from academia, government, and industry. Numerous presentations from developing countries highlighted the adoption benefits of the biotechnologies in these countries.

Key words: biodiversity, bioenergy, poverty reduction, innovation, value chains.

Introduction

Sustainability has long been part of various discussions regarding agriculture but has considerably come to the forefront in the recent years. At the Copenhagen Conference on Climate Change (December 2009), the use of genetically modified (GM) crops for biofuels was suggested as a sustainable option for developing countries, triggering intense discussion and debate. In March 2010, at the Bonn Climate Change Conference, GM crops were again part of the discussion, this time regarding sustainable land use. GM crops and sustainability remained a heated topic at the United Nations Framework Convention on Climate Change in Cancun, Mexico, in December 2010. Clearly, sustainability and its relation to the bioeconomy, biofuels, and biotechnology is increasingly important. The 15th International Consortium on Applied Bioeconomy Research (ICABR) held its annual conference near Rome, Italy (June 26-29, 2011) to examine this issue from four perspectives.[1]

The first key aspect regarding sustainability in agriculture is the contribution of agricultural biotechnology to biodiversity, greenhouse gas (GHG) reduction, and adaption to climate change. Several recent studies have begun to quantify some of these benefits (Brookes & Barfoot, 2006; Carpenter, 2010; Smyth, Gusta, Belcher, Phillips, & Castle, 2011). James (2011) identified that in 2010 the production of transgenic/GM crops reached 148 million hectares. Cumulatively, since 1996, one billion hectares of transgenic/GM crops have been produced. James noted that it took a full 10 years to reach

1. *Further information on the ICABR conferences can be found at http://www.economia.uniroma2.it/icabr-conference/index.php?p=12.*

the 500-million-hectare level, but only five years to go from 500 million hectares to one billion hectares. A total of 29 countries produced transgenic crops in 2010. With the increasingly rapid adoption of GM crops, it is important to get a firm grasp on the contribution of GM crops to environmental and economic sustainability.

The second important aspect of sustainability is the relationship between sustainability and bioenergy. Climate change impacts can be mitigated from innovative developments in bioenergy and biofuels. However, for these innovations to be globally adopted, their sustainability in the developing world has to exceed that of current technologies. Policies and regulations are—and have been—implemented to encourage technological innovations in this area, yet little research exists that can substantiate the impacts, either positive or negative.

The third aspect is the contribution of the bioeconomy to poverty reduction and sustainable development. As James (2011) highlighted, the adoption of GM crops is geographically increasing and it is important to discern if the adoption of sustainable technologies are being impacted by policies and regulations in Organisation for Economic Co-operation and Development (OECD) countries. Factors of consideration here include access to new technologies, market constraints, and impacts from biosafety regulations. To ensure smallholder market participation in the benefits of GM crop adoption, it will be important to understand the institutional innovations and policy interventions that can facilitate this.

The final aspect of sustainability that merits attention is the contribution of the bioeconomy to sustainability in OECD nations. Sustainability in these nations is affected by both public and private R&D investments, innovation policy, and intellectual property rights. The trans-Atlantic divide regard GM crops and resulting products has the potential to have far-reaching global implications, and greater insights are required from both continents as to the role that the bioeconomy is having in relation to sustainability.

The above four aspects of sustainability and the bioeconomy set the agenda for the ICABR conference, which saw four keynote speakers, 59 research paper presentations, and four organized policy roundtable sessions over the three-day conference. The conference provided a global perspective on the bioeconomy and sustainability, as presentations from North and South America, Europe, Africa, and Asia were provided.

Challenges Posed by Climate Change and Agricultural Development

Carlo Carraro (2011) set the stage in the Santaniello Memorial Lecture by providing a challenging outlook on future climate change and possibilities for sustainable development. Limiting the effect of climate change to a 2°C increase in global temperature will be almost impossible. This requires a reduction in the current $C0_2$-eq. concentration in the atmosphere of about 430ppm CO_2-equivalent (CO_2-eq.) to about 390 ppm CO_2-eq. However, 450 ppm CO_2-eq. will be reached within the next six years and, considering global developments, 550 ppm CO_2-eq. will be reached sometime between 2025 and 2040. While temporarily overshooting the target cannot be avoided, this requires technologies with net negative emissions. Most promising are technologies that reduce emission from land use and afforestation and bioenergy production in combination with carbon capture and storage by producing biochar.

In his keynote speech, Hans Binswanger (2011) highlighted the challenges posed by an outlook on the structural transformation of the Indian economy. Livestock products are expected to reach 44% of total household expenditures for consumption by 2040. On average, a total factor productivity growth rate of about 2% is needed to not constrain the economic growth of the whole economy. These developments again challenge the prospects for sustainable development and stress why it will be difficult to reduce GHG emissions in the near future.

Baron Marc von Montagu's keynote speech (2011) discussed how biotechnology can help to address issues posed by an increase in food demand and climate change. Von Montagu also discussed how some of the possible advances and solutions are being delayed by the overregulation of biotechnology in various countries.

Madhu Khanna (2011) showed that biofuel production in the United States has the potential to reduce GHG emissions, but the effects are technology dependent and differ with respect to government policies and to the accounting system applied. While the keynote speeches stressed the challenges for improving sustainability and stressed the importance of the bioeconomy, the presentations did provide further insights on possibilities and limitations.

Agricultural Biotechnology, Biodiversity, GHG Reduction, and Climate Change

GM crops are proving to have significant benefits for the environment. In North America, it is now established that there is a correlation between the adoption of GM crop technology and the increased use of conservation tillage (Ammann, 2005; Brookes & Barfoot, 2006; Dill, CaJacob, & Padgette, 2008; Fawcett & Towery, 2002; Fernandez-Cornejo, Hallahan, Nehring, Weschsler, & Grube, 2010; Smyth et al., 2011). The reduction in tillage, while reducing soil erosion and increasing moisture conservation, benefits the environment through the reduction in GHG emissions and increased carbon sequestration.

However, while the beneficial impacts of GM crops are being quantified, this message is not being communicated to the public. Aerni and Ermen (2011) interviewed 55 stakeholders to gain better insights as to what the views of the stakeholders were regarding GM crops and the ability to mitigate climate change and on the communication barriers. While many interviewees were familiar with the issues of climate change, they were less familiar with the benefits of biotechnology, although supportive of its potential. The survey also found that certain non-governmental organizations (NGOs) opposing biotechnology continue to influence the clarity by which the beneficial impacts of GM crops are communicated to policymakers.

The important role played by NGOs is supported by Capalbo et al. (2011). With the objective of developing a better communication strategy between Brazil, Peru, Colombia, and Costa Rica, a survey of more than 1,400 Brazilians was conducted. Roughly half of the survey respondents were opposed to biotechnology and GM crops, and they indicated that, in part, they relied on NGOs for their information about biotechnology and GM crops. With some NGOs, like Greenpeace and the World Wildlife Federation, denying the agronomic, environmental, and economic contributions of GM crops, it is not surprising that communication about—and broad understanding of—such impacts remain muddled.

Several papers focused on the adoption of GM crops and climate-change mitigation for small landholders in Africa. Historically, the focus has simply been on increasing production; however, there has been a recent shift in attention and the focus is now more concentrated on ensuring that the small landholders are viewed as market actors and are able to participate in market-power relationships (McCarty, 2011). Successful and sustainable land management practices in Africa need to be able to not only reduce the probability of devastating crop losses but to also assist in the restoration of degraded lands and improve agronomic practices (Capaldo, 2011). The importance of sustainable land management systems was also highlighted by Branca (2011), who noted that economic incentives are needed to assist small landholders in overcoming some of the short-term cost barriers. One possibility that shows promise in achieving this is to have international agencies provide financing/credit mechanisms that allow these landholders to surmount the short-term costs.

Modeling the relationship between US corn yields and GHG emission reductions to the year 2030 shows considerable promise (Miranowski, Rosburg, & Aukayanagul, 2011). The use of biotechnology to create new varieties of corn that have increased yield potentials and also increased nitrogen-use efficiencies show that the amount of land in 2030 required to mimic the 2009 corn crop in the United States would include 16-23 million *fewer* acres and 0.6-1.4 million *fewer* metric tons of nitrogen. Stacking the traits of yield increases and nitrogen-use efficiencies for GM corn varieties prove to provide a significant contribution to GHG emission reduction. Modeling African corn yields to the mid-century shows that the drastic predictions of reduced production can be more than offset by the development of drought-tolerant and pest-resistant varieties (Dalton, 2011).

Bioenergy and Sustainability

First-generation bioenergy continues to be a controversial subject of much debate, especially regarding the ability of bioenergy options to be carbon neutral. Much of the earlier research on bioenergy options treated all options as carbon neutral and this is now being called into question; as Sedjo (2011) observed, whether or not a bioenergy option is carbon neutral or not, is very time sensitive. If biomass can decompose in a short time period and then be converted to energy, it can be viewed as carbon neutral. Biomass that does not decompose rapidly will likely not be carbon neutral.

A challenge for bioenergy in terms of carbon neutrality is, often, the higher use of nitrogen fertilizers to increase the yield of energy-based crops. Meyer-Aurich, Olesen, Prochnow, and Brunsch (2011) examined the increased use of fertilizer on food crops, which led to land savings that could, in turn, be used for the production of energy crops and found that while there are some

GHG reductions, the best option was to produce food crops with lower fertilizer application rates.

The production of bioenergy from agricultural resources raises questions regarding GHG mitigation potential and costs. Scholz, Meyer-Aurich, and Dieter Kirschke (2011) examined this issue as it relates to the production of biogas in Germany. The authors assessed six different biogas production options and concluded that, while GHG mitigation has a significant economic cost, it is lower than that of biofuels. In addition, the potential for increased efficiencies in the production of biogas is high, thereby lowering the economic cost of biogas production.

If carbon-leakage effects are included in the analysis, positive GHG emission effects are even more in question. Drabik and de Gorter (2011) showed that while corn-ethanol production under different policy scenarios can reduce CO_2 emissions in the United States through leakage effects, the overall effect is an increase in CO_2 emissions caused by a decline in gasoline prices and the resulting overall increase in gasoline consumption. Even without considering leakage effects in the rest of the world, the authors concluded that corn-based ethanol does not meet the US minimum carbon-savings threshold. Wesseler (2011) reported similar results for biofuel production under EU Directive 2009/28/EC on the promotion of the use of energy from renewable resources. Miranowski and Rosburg (2011) showed similar effects are to be expected from other cellulosic biofuel sources in the United States. The author calculated costs per ton of CO_2-eq. reduced to be in the order of $141 to $282 per metric ton.

Sustainability, and the potential for increased sustainability, is not obvious based on the research presented, and numerous questions still exist. As with any emerging technology, the dissemination of knowledge about the impacts takes time; while some exciting findings were presented and discussed, considerable research is still required within this field.

Poverty Reduction and Sustainable Development

Innovations in agriculture provide numerous benefits in the industrialized nations, but for an innovation to have a global benefit, it must be possible for the benefits of the innovation to be realized in the poorest nations of the world. The quantification of the benefits is challenging; however, over time this has been possible, and the research on the benefits of biotechnology in developing nations continues to increase. One way of demonstrating the potential poverty reduction is to quantify the benefits experienced by small landholders.

One of the more contentious issues regarding GM crops is the commercialization of Bt cotton in India. Informal accounts of the impacts of Bt cotton adoption on Indian smallholders abound on the Internet and in the popular press. Research presented at the conference shed new light on the impacts of Bt cotton in India. Kouser (2011) analyzed data on pesticide applications and related poisonings from 2002-2008 and found that the rate of individual farmer pesticide poisonings dropped by a minimum of 2.4 million cases, and possibly as high as 9 million cases. The savings to the Indian health care system were estimated to range from US$14 to $51 million. Pesticide use decreased by 50%, adding to the reduction in production costs for small landholders.

The first three Bt cotton hybrids were approved in 2002, and by 2008 there were more than 8 million hectares of Bt cotton and 274 different hybrids (Arora & Bansal, 2011). In 2006, the government of the state of Andhra Pradesh intervened in the market by enacting an ordinance that lowered the price of a packet of Bt cotton seed from 1600 Rupees (Rs) to 750 Rs. Other cotton-growing states in India soon followed suit. In analyzing the adoption rate, Arora and Bansal concluded that the market intervention by state governments contributed to the surge in adoption rates post 2006. The introduction and benefits of new Bt cotton technology (Bollgard I) also played a significant role.

Kingiri (2011) examined the role played by knowledge brokers in the African innovation system. Social, institutional, and policy dimensions have a strong influence in innovation systems in Africa and knowledge brokers play a key role in terms of networking and interactive learning between the technology developers and the potential adopters. Kingiri suggests that knowledge brokers could play a useful role in African nations regarding the regulation of GM crops.

The decline in food productivity has a huge impact on poverty, and Mignouna, Mutabazi, Senkondo, and Manyong (2011) examined the adoption of imazapyr-resistant maize in Western Kenya and its impacts. The authors conducted a survey of 600 households, including 169 adopters and 431 non-adopters. This research found that adopters of imazapyr-resistant maize experienced a 27% increase in yield. This degree of increased food productivity will have substantial beneficial impacts on poverty in Western Kenya. Savastano, Anriquez, Alfani, and Paolantonio (2011) reinforced the importance of increased food security by highlighting

the importance of the availability of credit for small landholders to improve access to technological innovation in Kenya and other sub-Saharan African nations.

Bioeconomy Sustainability in Industrialized Nations

The sustainability of the bioeconomy in the developed world is influenced by the regulatory framework that governs the industry. Smyth, Kerr, and Phillips (2011) provided a detailed discussion on the role of science-based institutions and the governance capacity that has been provided post WWII and how science-based regulation has, increasingly, yielded to socio-economic considerations. Indeed, it would appear that we are witnessing the emergence of parallel and, in some cases, competing regulatory frameworks between the Americas (and their science-based approach) and Europe/Africa (and their preference for socio-economic regulatory considerations).

The parallel regulatory perspective was illustrated by de Beer and Smyth (2011) in a discussion about international trade in biofuels and whether this is governed by the agreements of the World Trade Organization or by the Cartagena Protocol on Biosafety. The science-based versus socio-economic-based regulatory approach defines this issue quite clearly, creating the potential for numerous economic and legal conflicts in the future.

Synthesis and Conclusions

The 15th ICABR conference produced a wealth of new information and insights on all themes. Historically, considerable numbers of the research papers have focused on developed countries. However, this year, for the first time, more than half of the papers focused on developing countries. This has continued to increase the knowledge base of the impacts that biotechnologies are having in the developing parts of the globe, as well as the institutional environment in which they operate. From the diverse papers presented at the conference and the discussions that followed, it is possible to draw some general conclusions.

First, the use of GM crops in agriculture has contributed to environmental and economic sustainability in many parts of the world. Despite the accumulated evidence of such benefits, however, the contribution of GM crops to environmental and economic sustainability are not broadly recognized in both developing and developed nations, but especially in Europe and Africa. This is, in part, attributable to the dissenting views of various stakeholder groups that actively participate in the public debate on biotechnology. The ICABR Consortium believes that there is a significant role that social and other scientists must play in informing this public debate.

Second, there is now more durable empirical evidence that GM crops contribute to reducing poverty. Small landholders that adopt GM crops in many countries experience higher yields, improved food security, and health, often via reduced negative health impacts due to chemical poisonings. All these factors make substantial contributions to the economic well-being of small landholders, thereby creating the opportunity to offset some aspects of poverty.

Third, there is increasing recognition that the use of socio-economic considerations in regulatory frameworks slows down the regulatory oversight of new biotechnologies, and, in some cases it can create barriers to commercialization. Moving away from science-based regulation tends to increase the time and cost of approving new biotechnologies, thereby delaying—or in some cases, preventing—their timely approval. The foregone benefits from such regulatory delays are not fully quantified, but they are generally found to be large. The trans-Atlantic gap that exists regarding the commercial use of GM crops continues to widen, with few evident remedies.

Biotechnology, and its application in GM crops and biofuels has, so far, contributed to environmental and economic sustainability in many parts of the world and offers promise regarding the mitigation of climate change. Still, these general findings have not always been efficiently integrated in the public and policy debates about GMOs, and as such the role of the research community in supporting an efficient public discourse that maximizes social welfare is essential.

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