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Sustainability and the Bioeconomy

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The 15th International Consortium on Applied Bioeconomy Research Annual Conference (ICABR 2011) explored the linkages between sustainability and the bioeconomy. The conference took place from June 26-29, 2011.

This special issue contains a selection of nine articles presented at the conference and a synthesis of key findings from ICABR 2011. They address questions related to the potential of the new bio-economy in general, as well as biofuels, the adoption of organic and GM agriculture to address issues related to agricultural productivity, product innovation, farmers' experience, and adoption rates of genetically improved crops in Africa and India, and consumer choice of GM crops.

The New Bio-economy

The contribution by David Zilberman and Eunice Kim consists primarily of a historical view of the bioeconomy. The authors point out different fermentation techniques used to drive the "traditional" bio-economy, whereas the new bio-economy emerged out of new discoveries in molecular and cell biology. It allowed the new bio-economy to overcome the barriers of the "traditional" techniques. The new biotechnology discoveries applied to fermentation processes are particularly relevant for the development of efficient bioenergy production integrating agriculture, engineering, and natural science research. As the papers on bioenergy production and sustainability show, we are just at the beginning. Further research is needed to cut costs for making this an economically viable technology. Unfortunately, a number of improvements—in particular in plant breeding—suffer from government interventions due to preventive regulations despite the demonstrated direct benefits for farmers, particularly in developing countries. As the authors point out, experiences from "traditional" biotechnology show this is not unheard of and some important lessons can be learned.

Bioenergy and Sustainability

Support for bioenergy is often driven by sustainability reasons. Many governments regard the contribution of biofuels to greenhouse gas (GHG) emission reductions to be positive. This is often based on the simple calculation that one liter of biofuels replaces one liter of gasoline and if biofuel production and combustion emits less GHGs than gasoline, less GHGs will be emitted. While this—at first sight—appears to provide environmental benefits, this will be less obvious if market dynamics are taken into consideration and if the marginal costs per unit of GHG emission reduction will be above the marginal damage costs.

The article by Dusan Drabik and Harry de Gorter does consider the market dynamics of biofuel policies. The authors present the results of a numerical model that considers the effects of biofuel policies on domestic and foreign gasoline prices and, hence, changes in carbon emissions and the resulting leakage effects. One result is that a domestic biofuel policy in the form of a blend mandate lowers world market prices of gasoline and increases foreign consumption and, hence, foreign GHG emissions, called international leakage. Whether the international leakage can be offset by domestic GHG emission savings depends on the national policies. The authors show that the impact of a blending mandate or a blending mandate in combination with a tax credit on domestic leakage is ambiguous. In a numerical exercise of their theoretical model applied to corn ethanol in the United States, the authors show that corn ethanol does not greatly reduce GHG emission, and the reduction levels are below the minimum emissions savings threshold of 20% set by US policies. The current level of corn biofuel technology in the United States still needs substantial improvements for reducing GHG emissions.

While the authors' model does not allow one to directly calculate the costs of GHG emission reduction per unit saved, Alicia Rosburg and John Miranowski do exactly this. The authors calculate the costs per unit of CO_2-eq emission saving from cellulosic biofuels based on life-cycle assessments. Their result show the costs are between \$141 and \$280 per metric ton CO_2-eq assuming a long-run equilibrium price for crude oil of \$100 per barrel, a price substantially higher than the trading prices at the US and European carbon exchanges. Even under the assumption of a high crude oil price of \$150 per barrel, the price per ton of CO_2-eq emission reduction ranges between \$7 and \$84. Their model does not consider possible leakage effects as shown by Drabik and de Gorter, which would drive the prices up even further.

While the results of the two previous articles are based on current technologies, the article by John Miranowski, Alicia Rosburg, and Jittinan Aukayanagul considers technical change in maize production until 2030 in the United States, spatially differentiated by Federal States. The authors use the results to calculate potential GHG emission savings induced by reduced nitrogen fertilizer use. Their results show possible emission savings can be substantial, ranging from 7.3 to 17.5 mmt CO_2-eq at no additional costs. It remains, however, unclear to what extent these potential emission savings for biofuels from corn due to technical change reduce the price per ton of CO_2-eq emission savings sufficiently.

The costs of emission savings from biofuel production are not only high under the United States setting. Lukas Scholz, Andreas Meyer-Aurich, and Dieter Kirschke assess the potential GHG emission savings and the costs per unit saved for biogas production in Germany. The authors compare different technologies using, as feedstock, either silage maize or silage maize in combination with cattle slurry. Depending on the technology and land-use change, the costs per unit of CO_2-eq emission savings range between €288 and €1,135 per ton of CO_2-eq. Also, in this case the strategy of emission savings via bioenergy production is a very costly strategy under the current level of technology.

All four articles on bioenergy indicate that the promotion of bioenergy at current levels of biofuel production is a very costly strategy to reduce GHG emissions. Nevertheless, improvements in plant breeding offer the potential for reducing these costs and may eventually render the strategy economically viable.

The Political Economy of GM Crops in Africa

Both GM and organic agriculture in Africa have been the subject of intense controversy. The major criticism of organic agriculture is that widespread adoption would lead to diminished yields in comparison to conventional agriculture. Opponents of GM claim that the technology will wreak environmental havoc, worsen food security, and lead to a corporate takeover of agriculture in general. But to what extent does this polarization reflect the perception of Western stakeholders that are subsequently exported to Africa irrespective of the specific agricultural problems and agro-environmental conditions? Ari Novy, Samuel Ledermann, Carl Pray, and Latha Nagarajan of Rutgers University found that African countries' openness to GM agriculture is significantly predicted by colonial legacy, trade links to Europe, and advisory positions. The strongest relationship discovered for organic was its correlation to GM. This is meaningful primarily since it indicates that there is not nearly the kind of competition between the two technologies as the polarized public debate would suggest.

Adoption of Biotechnology Innovation

Are farmers in Africa and India reluctant to embrace innovation in agricultural biotechnology? D.B. Mignouna at the International Institute of Tropical Agriculture (IITA) and his colleagues V.M. Manyong, J. Rusike, K.D.S. Mutabazi, and E.M. Senkondo found that farmers that have adopted imazapyr- (an herbicide) resistant maize (IRM) in Western Kenya have experienced significant increases in household incomes compared to non-adopters. In view of the persistently low adoption rates, they conclude that the promotion of the use of IRM for Striga control is a reasonable policy instrument to raise small-farm income and reduce poverty among maize-farming households in Kenya. The article of Puran Mal, Manjunatha A.V., Siegfried Bauer, and Mirza N. Ahmed investigates the technical efficiency and the environmental impact of Bt cotton in India in view of the contradicting statements about the impact of this GM crop on small-scale farmers. The results indicate that average technical efficiency is higher in Bt cotton farming. In addition, Bt cotton demonstrates a lower Environmental Impact Quotient (EIQ) value than non-Bt cotton, indicating less damage to the environment. The results confirm the findings of numerous prior empirical studies on the impact of Bt cotton in Indian agriculture. Yet, Bt cotton continues to be perceived negatively by some stakeholders in India and Europe, which explains why farmers continue to be worried about government intervention.

Consumers are More Pragmatic

Governments often explain regulatory stringency as a response to negative attitudes and preferences toward

GM foods. The article by Amir Heiman and David Zilberman proposes that consumers have weak attitudes toward GM food that can easily be influenced by framing. Negative framing of the properties of the biotechnology-based product not only affected perception but also increased the weight assigned to health and decreased the weight assigned to taste. The authors further showed that the main effects of knowledge and non-negative perceptions of the contribution of GM products to health increased consumers' willingness to purchase the product. Environmental and moral considerations were found to have little impact on GM selection and gender was insignificant.

In conclusion, the articles in this special issue provide further support for the benefits genetically modified crops generate for farmers as well as the environment. Substantial challenges still remain for bioenergy, but progress in biological sciences and plant breeding and fermentation processes in particular look promising. The sustainability of the bio-economy is, after all, as much a political issue as it is a scientific one.