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Executive Summary- Water and Food Conference Proceedings

Prem S. Paul

University of Nebraska at Lincoln, ppaul2@unl.edu

Monica Norby

University of Nebraska-Lincoln, mnorby1@unl.edu

Gillian Klucas

University of Nebraska-Lincoln

Ashley Washburn

University of Nebraska-Lincoln, awashburn2@unl.edu

Elizabeth Banset

University of Nebraska-Lincoln, ebanset1@unl.edu

See next page for additional authors

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Authors

Prem S. Paul, Monica Norby, Gillian Klucas, Ashley Washburn, Elizabeth Banset, and Vicki Miller





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“I see the linkage of the water crisis and the future of global poverty, yet I don’t see the general awareness of this issue. Finally, after 25 years of tragically reduced investment in agricultural development, we hear the talk of food security; we see significant increases in the investment that is necessary. Yet I don’t hear the talk of securing water for food,” Jeff Raikes, chief executive officer of the Bill & Melinda Gates Foundation, said in his keynote address at the 2010 Water for Food Conference.



Carrying water in Mali

Hosted by the University of Nebraska with the support of the Robert B. Daugherty Charitable Foundation, the Bill & Melinda Gates Foundation and Monsanto Company, the conference brought together more than 300 scientists and decision-makers from universities, the private sector, governments and nongovernmental organizations around the world to discuss the challenge of growing more food using less water.

Raikes concluded in his keynote address: “If we don’t change, if we don’t innovate across the spectrum of all the levers that we can pull, if we don’t take an integrated, interdisciplinary approach to this challenge, we are not going to be able to feed the world.”

The need to use all available tools – technological, political, societal and institutional – was echoed throughout the conference and reflected in the diversity of topics, perspectives and expertise represented.

Innovating Across the Spectrum

The Gates Foundation is concerned about water-scarce areas, Raikes said, because that is where people are hungriest and global poverty is greatest. Business as usual will not suffice in overcoming water shortages, and although Raikes observed limitations in applying past solutions to the future, he also expressed optimism that we can achieve food security for all people by combining the best practices of today – such as seed technology, market access and soil management – with advances to come, particularly in helping small farmers by developing affordable water storage, pumps and micro-irrigation technologies. Policies, including incentives that provide adequate water resources for farmers, also will be key.

Pedro Sanchez of Columbia University’s Earth Institute demonstrated that tripling Africa’s rainfed cereal crop production from 1 ton to 3 tons per hectare is not only possible, but achievable. It can be accomplished without increasing water use by reducing losses from evapotranspiration at higher plant densities of 3 tons per acre. “This is what I would like to call the Green Revolution bonus,” Sanchez said. “As you go from 1 to 3 tons per hectare, you can get a lot more water.” Successes in Malawi and the Earth Institute’s Millennium Villages project have shown that distributing fertilizer and seed increases production dramatically. These successes have led to the Global Food Security

Trust Fund, a global fund for smallholder agriculture. “I’d like to redefine the goal of the Green Revolution as going from 1 to 3 tons per hectare,” Sanchez said. Sanchez also described efforts to create a digital soil map of the world to better manage local needs by, for example, pinpointing areas requiring additional nutrients or erosion control and identifying regions with a higher probability of drought stress.

David Molden of the International Water Management Institute (IWMI) urged

prioritizing water access for the poor, ecosystem enhancement and improved water governance. He reinforced Sanchez’s point that the greatest opportunity lies in low-yield agriculture; increasing yields from 1 ton to 2 tons per cubic meter of water increases water productivity 74 percent. “This is the area for the biggest potential. ... This is also the area where there’s high poverty. If we can go and narrow in on that focus, we get two big wins all at the same time.” Rather than focusing on the distinction between rainfed and irrigated agriculture, Molden encouraged looking at appropriate available solutions in a given location as well as considering large-scale innovative solutions. He offered six problem sets for the future: 1) upgrade rainfed systems with better water and soil management; 2) revitalize under-performing irrigation systems; 3) learn to manage groundwater sustainably; 4) reuse urban wastewater safely; 5) transform water governance and management; and 6) improve information systems.

“I see the linkage of the water crisis and the future of global poverty, yet I don’t see the general awareness of this issue.”

Irrigation must play a large role in a future Green Revolution for Africa, said Ken Cassman of the University of Nebraska–Lincoln (UNL). The 1960s Green Revolutions in Asia and Nebraska relied primarily on irrigation, which allowed

both areas to successfully and dramatically increase productivity, Cassman said. “If [Sub-Saharan African] agriculture is much more like the harsher rainfed environments of the western Corn Belt, can rainfed agriculture do it alone?” he asked. Sub-Saharan Africa has sufficient water resources to

support irrigation, which in turn provides stable yields and generates income to support investment in associated industries and infrastructure.

Although irrigation maximizes yields, greatest net income occurs below maximum yields after factoring in additional water costs, said Richard Cuenca of the National Science Foundation (NSF). What incentives, he asked, can be used to encourage growers to consider other objectives besides reaching maximum production? Cuenca also cautioned that climate change will undoubtedly affect future food production, although models disagree by how much. An International Food Policy Research Institute study predicted that by 2050, food production of major rainfed and irrigated cereal crops will decline 13 to 42 percent, eliminating progress made in lowering child malnutrition rates.

John Briscoe of Harvard University noted the many changes and advances occurring worldwide.

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The West's investment in agricultural research and water infrastructure projects has dwindled. Some middle-income countries, such as Brazil, are having great success financing their own projects, and China is financing most dam projects in developing countries. In addition, model public-private partnerships are occurring in irrigation, drainage and water supply systems. New technologies, such as genetically modified organisms, are proving revolutionary in many developed and middle-income countries. Sub-Saharan African countries must adopt them as well, Briscoe urged. "We're going to need public leadership and private innovation," he said. "The world doesn't begin and end in the United States anymore. ... The world is out there in China, India, Africa, Brazil. These are places with enormous intellectual capability, where they're able to actually innovate often much faster than we are."

Country Case Studies

Visitors from several countries shared innovative research and reforms happening in their countries, offering insights and challenges for the future. Shiqi Peng of China's Ministry of Agriculture described China's experiences implementing an irrigation strategy designed to save water. China struggles with geographic and temporal imbalances in water resources. Despite irrigation improvements, inappropriate management continues to cause problems. The government's strategy includes infrastructure construction, water management improvements, modern irrigation equipment and rainfed technology to take advantage of rainfall on irrigated land. As a result, irrigated land has expanded, and grain production and water use efficiency have improved without increasing agricultural water use.



Chinese farmer in wheat field

However, future demands to increase agricultural production, particularly of cash crops, will further stress China's agricultural system. "We have a long way to go," Peng said, but by working with other countries, China hopes to continue improving water management and promoting sustainable agricultural development.

India also has successfully begun reforming irrigation management, said U.N. Panjiar, secretary of India's Ministry of Water Resources. Like many places, India faces significant water supply shortages from additional food demands and deteriorating infrastructure. Two major problems have plagued India's irrigation system: poor use of irrigation facilities due to incomplete projects and inefficient irrigation practices, and inequity in water distribution. To tackle these issues, India has instituted a participatory irrigation-management system through water-users associations. The sense of ownership among farmers ensures sustainability and has resulted in increased water use efficiency and distribution equity, and improved conditions for farmers.

Nguyen Hieu Trung of Can Tho University also recommended including a bottom-up approach to food security in Vietnam's Mekong Delta. Study results demonstrate that rice and fish farmers adjust their practices to cope with current weather variability, but they may not be equipped to deal with future climate change. Adaptive strategies must include top-down and bottom-up approaches, including instituting appropriate policies to enhance farmers' adaptability and giving farmers a choice of technological packages.

Elijah Phiri of the University of Zambia described the Comprehensive Africa Agriculture Development Programme (CAADP) designed to help countries achieve economic growth through agricultural development. Implemented under the African Union, CAADP works at the political

level to improve policies, capacities and investment. It provides a framework to guide countries as they develop their agricultural development plans and priorities in several key areas, including research, market infrastructure and reliable water systems. This framework is driven by a collective desire to make a significant impact on the development agenda in terms of food security and poverty alleviation, Phiri said. "There has been a recognition of a requirement for more than just new money, but also a radical rethinking of how we do business."

In Australia, radical rethinking of water management has led to a sophisticated system of tradable water rights, based not on seniority but on shares held within pools, which has achieved impressive results, said Mike Young of the University of Adelaide. A key step was



Agricultural fields along a river in Australia

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turning water supply systems over to farmers. Now farmers make more money from selling water when prices are high and water is scarce than from growing low-value crops. This system has resulted in water moving from low-value to high-value uses, dramatic improvements in previously inefficient water-irrigation management districts and farmer-generated innovations that have increased yields and water use efficiency. “The revolutions that have occurred since we’ve [made reforms] have been massive in terms of actual improvement in productivity,” Young said.



Terraced fields in Nepal

In contrast, Afghanistan’s many years of conflict and environmental devastation have severely decreased the country’s water supply and agriculture, John (Jack) F. Shroder of the University of Nebraska at Omaha said. In addition to man-made causes, such as overgrazing and deforestation, powerful winds and mud flows during the monsoon season contribute to environmental problems. Shroder’s work on Himalayan glaciers, which are critically important storehouses of water, has shown the surprising data that some glaciers are growing, although many more are shrinking. As the permafrost warms, rockslides occur, threatening Pakistan,

Afghanistan and other countries with destructive and powerful flooding, particularly during the monsoon. “Change is coming in the Himalayas and Hindu Kush, just like it always has,” he said. “Drought in some places, too much water in others, and the change probably won’t be quite what we expect anyway.”

Technological Advances

Research continues to produce new technologies and tools to increase agricultural yields while using less water. The conference featured numerous researchers in industry, universities and global organizations working in crop breeding, molecular genetics, computer science and systems modeling, irrigation engineering and other disciplines.

Monsanto Company is committed to doubling U.S. crop production by 2030 while reducing inputs per unit of output, said Robert T. Fraley, the company’s executive vice president and chief technology officer. He cited efforts to advance agronomic practices and breed new varieties, including Roundup Ready® and YieldGard® technologies. Within a few years, the company plans to release a new bioengineered drought-tolerant corn in the U.S. “Clearly, the area that needs this technology the most is Africa,” Fraley said. “I believe that there’s both the opportunity and the need to bring technology that can have tremendous benefit there.” Monsanto has partnered with the International Maize and Wheat Improvement Center (CIMMYT) and others to bring biotechnology to Africa, in an effort funded by the Gates Foundation.

CIMMYT’s Gary Atlin agrees that public-private partnerships, such as those with Monsanto, will

provide improved transgenic varieties for African smallholders, an undertaking that is too expensive for public institutions to do alone. CIMMYT and the International Rice Research Institute also have had tremendous success breeding drought-tolerant corn and rice in rainfed Africa and Asia under managed-stress conditions, which he encourages others to do. New genetic tools will enable even greater advances in breeding. “We need to make sure that farmers in drought-prone environments, the poorest farmers in rainfed regions of the world, are among the first to benefit,” Atlin said.

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Richard Richards of Australia’s Commonwealth Scientific and Industrial Research Organisation has released several improved wheat varieties using a trait-based approach. He found it most effective to select each trait under favorable conditions and by phenotype, not genetic markers. He emphasized the need to develop benchmarks for water use efficiency by dispensing with concepts like drought tolerance that are not easily measurable and may be unrelated to productivity.

Roberto Tuberosa of the University of Bologna presented data on research in mapping and cloning quantitative trait loci (QTLs) to increase yields in wheat and maize. He has found QTLs important for drought resistance in *Triticum* wheat and root architecture in corn using forward genetics. “The reason I like the QTL approach is that pretty much we ask the plant what is important,” Tuberosa said. “We do not go in with a preconceived hypothesis.”

A high-resolution water assessment model Marty Matlock is developing at the University of Arkansas could be used to determine how much water corn uses globally and to evaluate the balance between rainwater stored as soil moisture and water from surface or groundwater sources. With a framework for assessing these characteristics, the model can analyze various scenarios, such as climate change and water demand by region.

Matlock also presented for Jason Clay of the World Wildlife Fund, who was ill.

Environmental concerns, such as effluent, fall outside normal market powers and require special incentives and considerations in water resource decisions. “It’s the things that we don’t incentivize, like preservation of riparian zones, that we should perhaps be incentivizing with our limited resources,” Matlock said.

Suat Irmak of UNL described research projects investigating ways to improve agricultural practices that minimize water loss, such as improving evapotranspiration models, developing more efficient center pivot irrigation and studying crop water stress physiology. Irmak emphasized the need to get research results to the farmer, which he is doing through the Nebraska Agricultural Water Management Demonstration Network. Popular with farmers, the network established by Irmak and his colleagues is improving management practices and increasing water use efficiency.

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Advances in irrigation technology and management, such as weather station networks, pressurized irrigation and water use predictions, have been critical to increasing yields and reducing water loss, said Steven R. Evett of the U.S. Department of Agriculture's Agricultural Research Service. He illustrated irrigation benefits with examples from his work in Jordan and Uzbekistan. New technologies, such as mapping yield potential and reusing water, provide opportunities for even greater water use efficiency, he said.

M. Can Vuran of UNL encouraged interdisciplinary research to devise new agricultural solutions. Vuran, a computer scientist, is developing underground wireless sensor networks that may provide real-time information about soil and crop conditions to

above-ground devices, enabling farmers to make immediate, informed decisions about irrigation, improving water use efficiency and yields.

Despite these and other tremendous innovations taking place in universities and other public institutions, the challenge of integrating research into the real world leaves many of these innovations stuck in the laboratory, said Sally Mackenzie of UNL. She described many innovations, particularly in molecular and developmental biology, that have the potential to transform agriculture but are slow to reach commercialization because of the U.S. regulatory process. UNL's Center for Plant Science Innovation hopes to move research into the field by broadening in-house capabilities in crop transformation, facilitating interdisciplinary research and training students to meet these challenges.



Low-pressure sprinkler waters coffee plants in Brazil.

Economic Tools

Richard Perrin and Lilyan Fulginiti, both of UNL, expressed optimism that developing countries are increasing agricultural production to levels required to feed a growing population. Economists predict 1.3 percent annual growth is needed to meet global food requirements in 2050. Using total factor productivity measurements, the economists found that growth rates in the last two decades reached 1.09 percent in Sub-Saharan Africa, 1.5 percent in Central America and 2.5 percent in South America and China. “It seems that developing countries are not slowing down,” Fulginiti said. “They might be ... achieving or closing the gap with the developed countries.” To continue this positive trend, countries need more resources, technologies and investment in agricultural research.

Giulio Boccaletti of McKinsey & Company outlined the results of a McKinsey report that projected a 40 percent water gap between future demands and current capacity, with some areas facing gaps up to 75 percent. He described the water-availability cost curve, an economic tool that determines the cost and potential of various solutions to close the gap, tailored to each country. The tool can be used to identify combinations of solutions and factors in different scenarios, such as climate change and accelerated economic growth. The analysis demonstrates that closing the water gap is possible. He said the problem is not a lack of technology or money, but the need for effective policies, incentives and institutions. “This actually starts framing the choices that policymakers have in thinking about the issue,” Boccaletti said.

Support from Government and Public Sector

Richard Cuenca described several national and international projects supported by the NSF, including the Long-Term Ecological Research sites, the African Long-Term Research Network, northern Kenya’s Mpala Research Centre and the Basic Research to Enable Agricultural Development (BREAD) program in partnership with the Bill & Melinda Gates Foundation. BREAD addresses constraints faced by smallholder farmers in the developing world.

UNESCO-IHE Institute for Water Education supports poor farmers with practical technologies by building capacity through education and research, said the institute’s Krishna C. Prasad. He urged differentiating between developing and emerging countries in considering solutions because their experiences differ substantially; emerging countries, for example, face large urban migration and growing urbanization. IHE emphasizes institutional reform by establishing partnerships, encouraging stakeholder participation and developing innovative educational activities to fill capacity gaps.

Another UNESCO agency, the International Center for Integrated Water Resources Management (ICIWaRM), is the first Category 2 Water Center in the U.S., said the center’s William S. (Will) Logan. It focuses on practical science and technology, including engineering and policy, and partners with universities, organizations and other U.N. agencies in the U.S. and worldwide. The benefits of joining ICIWaRM include an extensive pre-existing network, but it might also somewhat limit freedom of action compared to university centers, Logan said.

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A View from Producers

Four producers – two from Nebraska, one from Oregon and one from Argentina – spoke in a panel discussion about their experiences running large farms. The panel focused on changes in farming over the past century and the concerns and opportunities panelists see for using water more efficiently.

Martin Pasman described the growth of his family's farm in Argentina since 1825. Today, the Pasmans raise cattle, corn, wheat, potatoes and Monsanto seed on 20,000 acres, much of it center pivot irrigated. Early adopters of Roundup Ready® soybeans, Pasman's family considers no-till farming the cornerstone of their production technology because of the water and labor savings no-till provides.

On his western Nebraska farm that receives about 19 inches of rain annually, Keith Olsen has gone from plowing his rainfed wheat fields and watching rain and wind erode the soil, to growing drought-tolerant corn using no-till and now genetically modified organisms. Olsen is experimenting with new soil management techniques, such as using a stripper head and skip-row planting. He urges fellow farmers to brace for future droughts.

Another western Nebraska farmer, Roric R. Paulman, a self-described early adopter, grows primarily dry beans and popcorn on more than 7,000 acres, much of it irrigated. He is developing a model for measuring consumptive water use to better understand the effects of his water conservation efforts, which will become increasingly important as local utilities limit when and how much water farmers can pump.

"I don't think we talk enough about consumptive use," Paulman said. "Now, 300 bushels of corn, that's great, but in that same respect, I'm going to be asked in my area to reduce my consumption. So can I grow a crop to full capability?"

Because Aaron Madison's family farm in eastern Oregon receives just 7 inches of rain a year, the family is intensely interested in water conservation. The Madisons irrigate 7,200 acres of their 17,500-acre farm and plant a variety of crops, including a wheat-fallow rotation. The rest is native rangeland for raising cattle. Through Oregon's innovative Aquifer Storage and Recovery program, the Madisons take water from the nearby Columbia River during high-flow months and store it in a depleted aquifer below the farm until needed.

During the panel discussion that followed, Pasman discussed the changes in Argentina's tax and trade policy that allowed the country to take advantage of innovations. As a result, production has nearly tripled. He said he would support further policy changes to reduce duty-export taxes on soybeans. Olsen said he's optimistic that technological advances will help farmers survive future droughts, but he is concerned that too few young people are entering agronomy. He is also concerned that too many government regulations will hurt agriculture's future. Madison is encouraged by new technological advances, such as variable-rate water and electricity applications. He also described a water conservation project in which Madison Farms collects flooded creek water on its property to store in the aquifer for later use. Every panelist addressed the need to move research from the lab to farmers, both in the

U.S. and elsewhere. An increasing and ongoing exchange of information is vital to tackling the challenge of expanding agriculture with limited water.



Producers Aaron Madison and Keith Olsen answer questions.

Key Issues for the Future

The conference concluded with a panel discussion on key issues for the future and recommendations for the new Water for Food Institute. Ken Cassman of UNL urged the institute to embrace irrigated agriculture as a significant player in a Green Revolution in Sub-Saharan Africa and to focus on issues important to Nebraska and the rest of the world, such as answering the question of whether high-yield, irrigated agriculture is sustainable.

Nebraska farmer Eugene Glock emphasized the importance of compiling and disseminating information and cautioned against the institute becoming a lobbying agency. He wants it to provide information that helps policymakers make wise decisions.

David Molden of IWMI said the institute can fill the “people gap” by encouraging and training young people in agricultural fields. He also

encouraged the institute to reach outside the U.S., listen to international concerns and help solve global problems.

Peter Rogers of Harvard University reminded participants that global climate change will have tremendous impact on water for food issues and encouraged giving it greater attention. He also emphasized the need to foster accurate and understandable scientific communication through working with journalists and educating faculty who are unfamiliar with agriculture. He also pointed out the important lesson from Australia regarding the need for institutional reform before introducing economic reforms. “I think the important thing there is that the institutions for water management and regulation are absolutely fundamental, if we’re ever to take advantage of the powerful economic tools we have,” Rogers said.

The panelists also encouraged engaging young faculty from a range of disciplines, disseminating information to farmers and reaching out to smallholder farmers worldwide. They discussed the necessary role of private companies, because of the more limited resources of public institutions, but Molden urged the audience to remember that the private sector is not limited to big, international companies, but also includes other countries’ small-scale private enterprises that stimulate local economies. Cassman concluded the discussion by reminding the audience of the important role scientists play in influencing policymakers. Cassman said he believes the institute has a key role in helping those who care about water for food make their case to the world.