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## Chapter 4- Human Dimensions of Water for Food Production

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HUMAN DIMENSIONS OF WATER  
FOR FOOD PRODUCTION

# Human Dimensions of Water for Food Production

## Panel

### **Jason Clay**

Senior Vice President of Market Transformation, World Wildlife Fund

### **Elijah Phiri**

Leader of the Comprehensive Africa Agriculture Development Programme (CAADP) Pillar 1, University of Zambia

### **Lilyan Fulginiti**

Professor of Agricultural Economics, University of Nebraska–Lincoln

### **Richard Perrin**

Jim Roberts Professor of Agricultural Economics, University of Nebraska–Lincoln

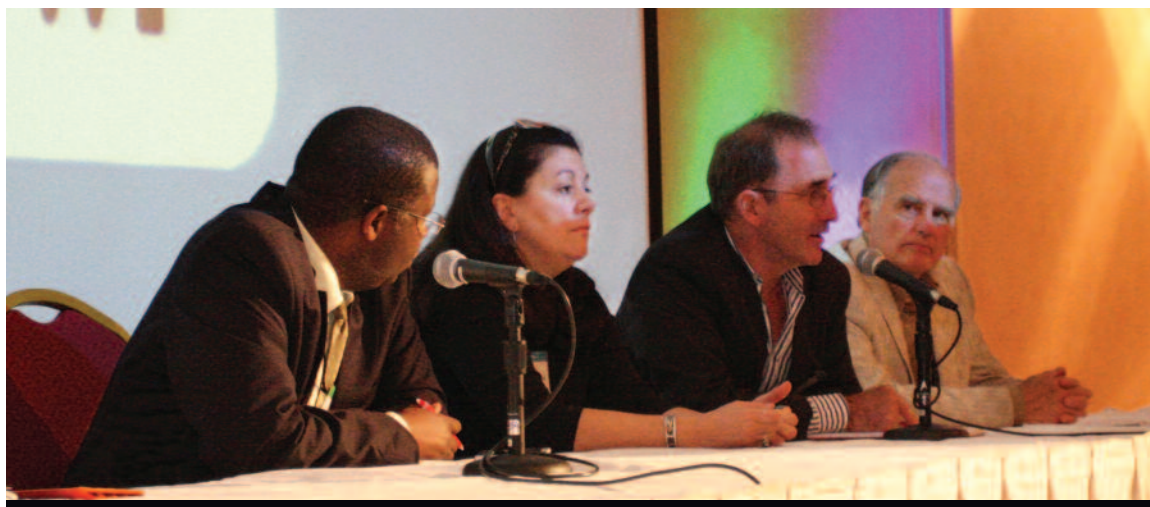
### **Mike Young**

Executive Director, The Environment Institute, University of Adelaide, Australia

### **Raymond Supalla, Moderator**

Professor of Agricultural Economics, University of Nebraska–Lincoln

*The session focused on economic and policy issues surrounding water use for agriculture in developed and developing nations. Topics included food security in developing nations, agricultural water use in Africa, government policies for managing water in Australia, and environmental impacts and sustainability of global water use. Panelists gave overviews of their subject areas and the panel then responded to audience questions.*



From left: Elijah Phiri, Lilyan Fulginiti, Mike Young and Richard Perrin

## Feeding 9 Billion and Maintaining the Planet: Meeting the Challenge of 2050

**Jason Clay, World Wildlife Fund**

*Presented by Marty Matlock, Professor of Ecological Engineering, University of Arkansas*

Environmental concerns, which fall outside normal market powers, require special incentives and consideration in water resource decisions, Marty Matlock said.

Given that the world's population now consumes past the point of sustainability, should sustainability be a market choice for consumers? "This should be pre-competitive," Matlock said. "The consumers should have confidence that everything they buy complies with a certain threshold of humanity, of behavior, of ethics and sustainability."

The market has the power to move materials, goods and services from areas of plenty to those of scarcity. The problem is that the market is not responding to water scarcity, in part because crops are grown where there is no water. For example, in Brazil, areas that once were rainforest now grow 2.4 crops annually for export to China. "They're exporting de facto water to China," Matlock said.

Another example stems from the 1 billion people who lack access to water and the 2.4 billion who don't have basic sanitation. Every day, waterborne diseases kill 5,400 children. "That's the cost of this failure of technology – failure of civilizations," Matlock said. "It's a pretty dramatic cost."

Global climate change will increase water scarcity in already water-stressed areas.

How will financial institutions deal with increased investment risk in farming as floods and droughts increase, leading to critical losses? The problem is not just environmental; it's economic, Matlock said.



Marty Matlock presenting for Jason Clay

Although agriculture no longer accounts for 90 percent of global water use, as it did in 1900, agricultural water use has increased fivefold since then. Competing with other sectors for limited water affects the many other uses that are not monetized, such as biodiversity. The Colorado and Ganges rivers offer examples of dramatic decreases in water discharge due to overallocation. Peak flows have not changed, but critical base flows have dropped considerably over time. "It's hard to have a functional, viable aquatic ecosystem without the aquatic," Matlock said.

Rice, which accounts for 15 percent of human water use, presents another problem. But improvement is possible, Matlock said.

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Anheuser-Busch InBev, for example, achieved 4.7 percent per-unit reductions in rice culture, saving 3.5 billion liters of water in five years.

Water intake is only one issue; equally important is water effluent. From an ecological standpoint, given grossly limited incentive funding, Matlock believes profitable production practices should not be incentivized. “If you already have an incentive for conserving water – reducing soil erosion – then we don’t need to give you more money to do that which you ought to be doing anyway, because the marketplace will weed you out if you don’t perform,” he said. “It’s the things that we don’t incentivize, like preservation of riparian zones, that we should perhaps be incentivizing with our limited resources.”

The Mesoamerican Barrier Reef System offers an example of the interconnectedness of agriculture effluent and environmental harm. Pollutants, particularly sediment and nutrients carried downstream from plantations to the Caribbean Sea, have the equivalent effect of a 10-degree temperature change, bleaching the coral reefs.

Impacts that are acceptable with 6.7 billion people will not be with 9 billion, Matlock concluded. If management happens only to things that are measured, and not everything can be measured, which metrics are important and how can they be incentivized? “We have to shift our thinking from maximizing any one variable or metric to optimizing several key ones.”

### Agricultural Water: Challenges and Opportunities for Africa

**Elijah Phiri**, University of Zambia

Opportunities exist to increase African agricultural productivity, despite many grave challenges, Elijah Phiri said. He described the Comprehensive Africa Agriculture Development Programme (CAADP), an African-led program designed to help countries achieve economic growth through agricultural development.

African countries give little attention to investing in institutions, human capital or required skills, Phiri said. And few have sound strategic policies, or the legal and regulatory framework to manage water resources efficiently. In addition, many countries share river basins, creating a



Elijah Phiri

significant hurdle to effective water management and a potentially serious source of conflict between nations.

To overcome these challenges, CAADP works at the political level to improve policies, capacities and investment. The program is implemented under the African Union program New Partnership for Africa's Development.

“This has come from a collective desire to see a real impact on the development agenda in terms of food security, poverty alleviation. ... There has been a recognition of a requirement for more than just new money but also a radical rethinking of how we do business,” Phiri said.

CAADP provides a framework to enable countries to achieve economic development and the U.N.'s Millennium Development Goals through an agricultural agenda to increase the annual growth rate of agricultural productivity by 6 percent. To achieve that goal, each country has agreed to increase public allocation for agriculture from a typical 3 percent to 10 percent, considered the critical minimum level, Phiri said.

CAADP has identified four major intervention areas, or CAADP pillars, to address agricultural production in Africa. They are:

- Extending the area under sustainable land management and reliable water control systems.
- Improving rural infrastructure and trade-related capacities for market access.
- Increasing food security, reducing hunger and improving responses to food supply emergencies.
- Improving agricultural research and technology dissemination and adoption.

*“There has been a recognition of a requirement for more than just new money, but also a radical rethinking of how we do business.”*

The pillars have a framework to guide member countries in their agricultural development plans and priorities. Each framework provides quality assurance, support in designing investment programs and analytical tools for monitoring and evaluation, stakeholder analysis and institutional capacity assessment, among other key functions.

Each CAADP pillar has a list of policy priorities. The land management and water control pillar, spearheaded in part by the University of Zambia (UNZA), also deals with soil fertility management and rainfed and irrigation water issues. Land policies are challenged by communal land

rights in some areas, which make it difficult to use the land as collateral for investment. Phiri and his UNZA colleagues have created a land policy document at the continent level to overcome such obstacles. Other problems they are addressing include soil and land degradation.

CAADP's process engages stakeholders at many stages during the program development process by creating a common understanding for moving forward, conducting evidence-based analyses, designing and developing programs and alliances, and reassessing priorities and programs.

The process is elaborate with many players involved, Phiri said, but it is widely recognized as a principal framework or reference for agricultural development intervention in Africa. There is greater momentum to act together to increase economic growth through agriculture and a renewed interest in investing in Africa.



# Human Dimensions of Water for Food Production

## Agricultural Productivity in Developing Countries: The World Food Equation and Food Security

Lilyan Fulginiti and Richard Perrin, University of Nebraska–Lincoln

After an age of abundance, feeding people in the future will require 70 percent more food production by 2050, equivalent to about a 1.3 percent annual growth rate, Richard Perrin said. His colleague, Lilyan Fulginiti, presented research about how well various countries and continents are doing to get there.



Lilyan Fulginiti

Productivity often is considered in terms of yield per acre, a single-factor measurement. In contrast, “agricultural productivity” factors inputs into the equation. After subtracting growth rates of inputs from outputs using total factor productivity (TFP) measurements, “there is something left over that is not explained by traditional inputs,” Fulginiti said, “and that’s what we call innovation and efficiency in the use of resources.” TFP growth is an indicator of a country’s ability to innovate and make gains beyond those made by adding more resources, such as water or land.

In the U.S., TFP growth rates are declining, as are actual yields, causing concern. Is the same

slowdown occurring in developing countries as well? Fulginiti asked. To answer that question, she looked at TFP growth rates in Sub-Saharan Africa, South America, Central America and China.

Of the 46 countries examined in Sub-Saharan Africa between 1961 and 2006, both traditional outputs and inputs, such as fertilizer, had increased. Eleven countries, led by Mauritius, South Africa and Nigeria, also have reached or exceeded the 1.3 percent TFP growth rate needed to sustain future food needs, while the growth rate in six countries had contracted. Differences between countries stem from colonial heritage and years since independence, amount of irrigation and the number of drought events.

Overall African TFP growth rates from 1990 to 2006 were 1.09 percent. “Even though it’s not at 1.3, at least the tendency seems to be going the right direction,” Fulginiti said. “It’s not such bad news here ... They are approaching the technologies and the level of efficiency that we have in developed countries.”

In South America, countries are experiencing rapid growth in inputs and production, particularly in the Southern Cone, where Brazil and Argentina account for 85 percent of output. The South American countries achieved TFP growth over 1.3 percent between 1990 and 2006, with the overall average at 2.5 percent. “For South America, we also see very big increases or solid and healthy productivity growth up to now,” Fulginiti said.

The factors affecting rate differences in South American countries included land quality, life expectancy (a proxy used for health and education), public inputs, such as telephone lines and agricultural research, and political rights and civil liberties. Trading density ratio, however, did not affect agricultural productivity.

In Central America and the Caribbean, average TFP growth has increased since 1977, and both regions have reached 1.5 percent since 1990, led by Cuba.

Fulginiti also looked at China to determine if the country's fast growth was due to increasing resource use or was based on innovation. Beginning in the 1990s, China's agricultural production dropped significantly, but following reforms in 1998, has been increasing for the past decade and now averages 2.3 percent. The results suggest that yield productivity

gains have shifted from increasing inputs to a more efficient use of resources.

"It seems that developing countries are not slowing down," Fulginiti concluded. "They might be ... achieving or closing the gap with the developed countries." To continue this positive trend, countries need more resources, new technologies and more investment in agricultural research, she said.

Fulginiti also emphasized the need to focus on policy and trade reform and on investments in women's education, health and infrastructure. She suggested focusing on incentive-compatible policies. "These are incentives not only compatible from a private point of view," Fulginiti said, "but it's an incentive compatible from a social point of view where we do take into account not only private costs, but private social costs and social benefits."

## Managing in a World of Ever Increasing Water Scarcity: Lessons from Australia

**Mike Young**, University of Adelaide, Australia

Australia's water management reforms of the past 20 years have led to significant innovations and allowed for rapid adjustments in times of drought, offering a model for other countries, Mike Young said.

An important building block for reform was redefining water rights. Water is not allocated in Australia based on seniority as in many countries, but on the number of shares held within pools.



Mike Young

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Allocations, made in proportion to the amount of water available for each pool, are metered and made twice a month to more quickly respond to changing conditions.

Trading water shares, transacted through water accounts set up much like bank accounts, also has played a major role in creating incentives for innovating and in allowing for rapid adjustments.

Water shares can be traded quickly and easily to adjust to water scarcity conditions so that, for example, water is used where it is needed most and annual crops can be idled until water conditions improve. The dramatic increase in water trading also has led to improvements in inefficient water irrigation management districts.

Under Australia's system, governments decide allocations and rules, and individual users hold trading rights, removing the need for courts and lawyers and expediting the ability to adjust to water conditions. In addition, irrigation water districts hold entitlements to distribution losses, giving them an incentive to conserve water.

"The revolutions that have occurred since we've done this have been massive in terms of actual improvement in productivity," Young said of the reforms. Rice production, for example, has increased significantly while water use has gone down dramatically.

## Revolutionizing Management Efficiency

A key component in revolutionizing water

management efficiency was to turn the once government-run water supply systems over to farmers. The farmer-owned, share-based systems have lowered costs while doubling the value of

their water assets every four and a half years.

"It's been a very profitable period and a very successful financial experiment," Young said.

Australia learned several important lessons along the way. The country's

severe droughts, for example, demonstrated that changes don't necessarily occur gradually but in steps. A significant drop may signify a new average around which plans should be made.

In addition, when water resources are reduced by half, water available for agricultural use is reduced by three-quarters because river flows must be maintained. "Unless you've got water in your river, you can't take water out," Young said. "The first thing you've got to do is recognize the fixed costs that are in the system. Understanding that is very challenging."

The innovations resulting from reforms have improved water efficiency and yields. Many farmers now use an automated water delivery system and soil probes to measure moisture levels. The resulting water savings have been massive and have allowed farmers to maintain production with very little water, Young said, adding that "it came because we decided to search for innovation and run bottom-up processes rather than top-down planned processes. And that's been really important."

*"The revolutions that have occurred since we've [made reforms] have been massive in terms of actual improvement in productivity."*

Despite the reform's success, Australia made mistakes, such as not accounting for groundwater resources and not allocating enough water to the environment, requiring the government to buy back shares. The country is continuing to experiment with additional reforms.

Young urged other countries to rethink current practices and institutional arrangements. His

advice: Consider a system based on shares, not seniority; define entitlements to savings early to let the system start to evolve; decide who, besides politicians, is going to be responsible for the environment; and allow integration to come from a bottom-up process rather than top-down to facilitate innovations and adjustments to a rapidly changing world.

## Questions and Answers

**Audience question:** *Political stability is required for private investment. What signals should investors look for in Africa to know when to invest?*

Elijah Phiri said he believes that Africa is more conducive for investment now than 20 years or even 10 years ago because of growing acknowledgement that democracy and investment must be part of Africa's development.

**Audience question:** *Does the 1.3 percent growth rate through 2050 reflect total demand from the 1 billion undernourished people becoming market participants in the future?*

Richard Perrin responded that the 1.3 percent growth rate figure comes from the International Food Policy and Research Institute and takes income growth into account in the poorest countries, but he did not know the specific figures. Lilyan Fulginiti added that the 1.3 percent figure keeps the income distribution constant but calculates a rise in everyone's income.

**Audience question:** *In Australia, what happened to farmers who lost service from irrigation districts because their farms were inefficient in terms of water delivery?*

Farmers decide to sell water; it is not forced, Mike Young said. He described a situation in which farmers in Australia's least efficient irrigation system – a place where people were struggling – took control, invented water trading and turned their district around. Many people left but seem to be thriving in other businesses. "It looks very frightening," Young said. "People start leaving, but we find it very, very hard to find concrete examples of people who are worse off that otherwise wouldn't have been in strife anyway."

**Audience question:** *What was present in Australia that was different from U.S. water rights that allowed Australia to create a share-based system?*

Young described three situations: First, long before reform, Australia opted not to follow America's individual seniority ranking,

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but instead established ranking based on seniority pools. Second, in the early stages, Australia guaranteed volumes to those with higher priority. And third, strong political leadership in the early 1990s forced states to make water rights tradable or they were severely fined.

**Moderator Raymond Supalla:** *How should we allocate resources between increasing productivity with existing resources and bringing additional land and water resources into production in an environmentally sustainable way?*

Perrin responded that because water is a public good it must be handled through collective action, not the market. He said he believes the solution is to foster vigorous experimentation from bottom-up choices for community control over resources. Success will require consensus at local levels for regulating, controlling, sharing and monitoring water resources.

Phiri stressed that planning processes must be evidence-based and cooperative. Identifying

best practices provides the facts for planning investments and programs. In addition, obtaining political buy-in and general consensus from all stakeholders, including farmers, is necessary.

Young discussed the importance of institutional design. Australia now understands the importance of planning at different scales rather than trying to manage entire basins from the bottom up so local problems can be resolved without involving the entire basin.

Fulginiti said she believes greater investment in agricultural research is needed. Because agricultural research is a public good, the market fails to provide appropriate incentives to invest, though the rate of return in agricultural research is extremely high. Institutional reform is needed to ensure the necessary investments.

**Audience question:** *How has Australia's trade from inefficient to more efficient producers affected consumptive water use?*

Australia made significant mistakes that severely damaged the environment and cost the government billions to correct, Young conceded. Over-allocations resulted from not understanding how much return flows were needed, and governments and industry were slow to respond. However, much good also occurred, including people leaving environmentally sensitive areas because of low productivity. The government is trying to rectify the environmental problems.

**Audience question:** *Given that only 17 percent of Zambia's arable land is cultivated, what is Elijah Phiri's view of land expansion?*

Zambia, unlike several other African countries, has much land available for cultivation, Phiri said. The issue for Zambia and the rest of the continent is lack of investment in industry and infrastructure to support agricultural production.

**Audience question:** *How does Australia's system deal with trade impacts to third parties?*

Richards described rules and regulations established to pressure irrigation districts, particularly badly managed districts, into becoming efficient and innovative. The environment also was negatively affected and is just now being corrected. Communities feared capital flight, but in fact more jobs were created as people sold water and invested in farm upgrades.

**Audience question:** *In Australia, to what extent has meeting environmental, recreational and similar water uses been a problem? How are they provided for in a market system?*

Massive drought made Australia's environmental plans inappropriate, Richards said. The government suspended the plans, and now a commonwealth holds a water entitlement for the environment. "We're now going into the market, buying back water for the environment because our allocation systems were flawed."

**Panelist Fulginiti:** *Was Australia's prime minister who introduced the reforms re-elected?*

Yes, but subsequently lost, Richards said, adding that water reform has bipartisan support in Australia, although much arguing over details and game playing occurs. Many Australians consider the reforms a disaster, he said, and the country has made many mistakes, "but the final shape of what is starting to emerge, I think all Australians are very proud of."

**Moderator Supalla:** *Final comments?*

Phiri emphasized that Africa has established institutions and policies that make investing safe. For example, in Zambia, investors can back out at any time without restrictions. Eighteen countries involved in CAADP are establishing agricultural priorities and strategies and beginning to develop plans, which will facilitate investing. Investment and support to strengthen capacity are much needed, he added. A network of institutions working together would help tackle the mammoth task.

Fulginiti stressed the need for institutional reforms that include incentives compatible with social benefits and returns, not just private benefits.