WATER STRATEGIES FOR THE NEXT CENTURY

Supply Augmentation vs. Demand Management

ISPAN
IRRIGATION SUPPORT PROJECT
FOR ASIA AND THE NEAR EAST

Sponsored by the U.S. Agency for International Development

ISPAN

IRRIGATION SUPPORT PROJECT FOR ASIA AND THE NEAR EAST

ISPAN Technical Support Center
Suite 300
1611 North Kent Street
Arlington, Virginia 22209-2111
U.S.A.
Phone: (703) 247-8730
Fax: (703) 525-9137

INTEGRATED IRRIGATION MANAGEMENT RESOURCES

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Supply Augmentation vs. Demand Management

A debate sponsored by the U.S. Agency
for International Development and ISPAN

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Executive Summary

Executive Summary

In April 1994, a workshop on Future Directions for Implementing Water Policy was sponsored by the Asia and Near East (ANE) Bureau of the U.S. Agency for International Development, with the support of ISPAN. The workshop focused on five major issues related to the sustainable development of water resources. The major topics discussed at the workshop included water user associations, tradable water rights, pricing and cost recovery, wastewater reuse, and industrial waste minimization.

A main area of disagreement emerged during the workshop—demand-side vs. supply-side water management. The discussion focused on the following question:

> *Are demand minimization, efficiency improvement, conservation, and other demand-side measures an adequate focus for international donor interventions or should renewed attention be given to water capture and delivery?*

It became evident during the workshop discussions that this issue was primarily an issue about agricultural water use. Urban water practitioners generally agreed on the need to combine supply-side and demand-side measures in their subsector.

A number of background issues are important in framing the current debate on demand-side vs. supply-side water management, including the following:

Potable water supply and wastewater services remain important areas of concentration for donors following the Water Decade of the 1980s. However, investment in irrigation systems has waned, mainly because of low food prices that limit economic benefits from infrastructure development.

Global food production is probably not an issue at present, but there are emerging country, and possibly regional, problems that will have serious human welfare implications. For example, some irrigation professionals believe that the economic power of major urban areas, combined with their pollution potential, will severely reduce the quantity and quality of water available for food production in some areas.

Even in the domestic/urban water subsector, where services are usually based on combined social and economic criteria, demand-side issues (such as willingness to pay, pricing, and user initiatives) are crucial to sustaining infrastructure and the provision of services.

Cost recovery experience and lessons differ between the urban water supply subsector and other subsectors such as irrigation, sewerage and sanitation, and village water supply. In the

urban water supply subsector, and to some extent for sewerage, it is common for at least the operational costs to be recovered through volumetric water charges. This cost recovery method provides a tool to manage demand. However, where flow measurement is difficult (as in irrigation systems), rates are very low, and/or enforcement is lacking, a reliable mechanism to manage demand through the use of revenue collection usually does not exist.

If revenue collection is difficult, or not politically acceptable, governments and donors dealing with improvement programs frequently attempt to organize water users to take ownership of and responsibility for operating water systems. Some irrigation professionals ask: Why not agree that organizing water users is a basic necessity for any system, fully equal to cost recovery? Some also ask: why should governments expect to recover their, or donors', capital costs from water users?

As a follow-up to the questions raised at the April workshop, ISPAN and USAID sponsored a Special Water Resources Debate on September 26, 1994. The debate, entitled *Water Strategies for the next Century: Supply Augmentation vs. Demand Management,* brought together four well-known, knowledgeable water sector professionals to continue the dialogue on this critical water resources issue.

Dr. David Seckler, Director of the Center for Economic Policy Studies, Winrock International Institute for Agricultural Development, and Dr. Jack Keller, Professor Emeritus of Agricultural and Irrigation Engineering, Utah State University, presented arguments for water supply augmentation. Dr. Peter Rogers, Gordon McKay Professor of Environmental Engineering at Harvard University, and Dr. Ken Frederick, Senior Fellow at Resources for the Future, presented the merits of demand management approaches that may help meet future water demands. The debaters discussed opposing views, but also examined conditions under which various combinations of supply and demand management have merit. The debaters also responded to positions and comments from the audience.

Dr. Guy Le Moigne, Senior Adviser for Water Resources at the World Bank, summarized the results of the debate.

The debate helped focus the attention of international donors and water resources experts on:

- The importance of water to the environment, public health, and economic development
- The gravity of emerging water shortages caused both by growing demand for and pollution of water resources
- Possible approaches to consider when dealing with increasing water demands.

This document provides a verbatim transcript of the debate, comments from the audience, and responses from the panel, plus the summation of Dr. Le Moigne. The transcript was edited by Steven Breth of Winrock International and reviewed by the speakers.

Part 1.

Introduction

Introduction

Official Welcome *John Wilson*

I work with the U.S. Agency for International Development, managing the Irrigation Support Project for Asia and Near East, the ISPAN project, and I'm very pleased to have their assistance in organizing this debate today. It is a pleasure to be here and to open this discussion of water management strategies for the future.

Concern for the sustainable use of water resources is growing worldwide. The concern is well founded. Just think back on recent items in the news: The cholera outbreak in Zaire due to the lack of potable water and sanitation services for the refugees; toxic contamination of water resources by uncontrolled discharges of industrial effluents in the newly independent states; the resurgence of cholera in Latin America; and the continuing disputes over water in the Middle East.

Water shortages and needs are increasing, and the competition for water among urban, industrial, and agricultural sectors, as well as by other resource users, is growing more intense. Over two-thirds of the water withdrawn for use is used for agriculture. Population in the developing world is increasing, leading to growing demands for water resources and, unfortunately, to more pollution, which effectively reduces the availability of water to meet human needs. According to the World Commission on Environment and Development, approximately 80 countries with 40 percent of the world's population already suffer from serious water shortages.

Huge investments in water infrastructure have not met the demands of the developing world. We can think back on major investments in water systems, wastewater disposal, and irrigation systems, but these have not met local needs. In addition, institutional weaknesses have posed serious threats to long-term sustainability in the development of the water sector. And generally the problems stem from infrastructure inadequacies as well as from resource mismanagement.

What should be done? What is the appropriate balance between supply-side and demand-side water management strategies for countries and for donors such as AID? There is a divergence of views among the practitioners working in the water sector. During an AID-sponsored workshop in College Park, Maryland, last April, it became apparent that there were fundamental differences of opinion between the practitioners working in the irrigation and agriculture sector and the practitioners working on urban water infrastructure. We wanted to explore the divergence of views as the basis of the debate that we are happy to be able to sponsor today. We do not expect to declare a winner today, but we do expect that a valuable contribution to the principles of water strategic planning will emerge.

We are delighted that such renowned water professionals as David Seckler, Peter Rogers, Jack Keller, and Ken Frederick have agreed to participate. We are very happy to have Guy Le Moigne from the World Bank to provide a wrap-up synthesis. Now Kathy Alison will explain how we will proceed.

Objectives and Introduction of Debaters *Kathy Alison*

The objectives of this debate are to analyze "the advantages and disadvantages of augmenting existing water supplies through new water capture and delivery systems vs. managing demand for water through appropriate water pricing, conservation, and renovation of existing water capture and delivery systems." As John Wilson said, we've asked a panel of renowned water resources specialists to debate these issues. The debaters will present opposing views, but they will also discuss conditions under which the various ideas have merit.

I want to introduce the water resources experts on the panel. Dr. David Seckler and Dr. Jack Keller will present arguments for supply augmentation.

David is the director of the Center for Economic Policy Studies of Winrock International Institute for Agricultural Development. He is professor emeritus of the department of agricultural and research economics at Colorado State University and senior associate of the International Irrigation Management Institute. Dr. Seckler studied at the University of Denver and earned his Ph.D. from the London School of Economics. His major fields are environmental and natural resource economics, economic development policy and theory, irrigation economics, social philosophy, and private-sector development. Dr. Seckler serves on the international editorial board of *Advances in Agricultural Management and Economics.* He is the author or editor of five books, over 50 articles, and three patents. He has performed overseas consulting assignments in both the private and public sectors in 24 countries. He previously served as director of the International Center for Agricultural and Resource Development at Colorado State University and was founding co-director of the Colorado Institute for Irrigation Management.

Jack Keller is founder and chief executive officer of Keller Bleisner Engineering in Logan, Utah, and professor emeritus of the agricultural and irrigation engineering department of Utah State University. He has personal experience with irrigated agriculture, both as an owner and a manager of large, center-pivot irrigated farms in Colorado and Kansas. Before joining Utah State University in 1960, he was the chief irrigation engineer for W. R. Ames Company, a leading manufacturer of irrigation equipment in the United States. He has served as consultant to several major manufacturing companies. During his tenure at Utah State University, he taught and carried out research in sprinkle and trickle irrigation and served as co-director of the Water Management Synthesis Project funded by USAID to provide socio-technical assistance for transferring irrigation technologies worldwide. Through his public and private activities, Dr. Keller has provided advisory services on irrigation matters in approximately 40 countries and is recognized as an international expert in the field of

irrigation technology transfer and the problems associated with improving irrigated agriculture in developing countries.

On the other side of our debate, we have Dr. Peter Rogers and Dr. Ken Frederick, who will present arguments for demand management.

Peter Rogers has served since 1977 as Gordon McKay professor of environmental engineering and professor of city and regional planning at Harvard University, where he is also a member of the Center for Population Studies. His research areas include improved methods for managing natural resources in the environment, with emphasis on the use of analytical optimizing methods to incorporate both the natural phenomena and engineering controls and the development of meso-scale models of resource management that relate directly to macroeconomic parameters. Dr. Rogers received his Ph.D. from Harvard and has held numerous academic and professional appointments, authored numerous books and papers, and has served on many committees, panels, and working groups. He has served as a consultant on water and energy issues to the government of Pakistan, Bangladesh, Ethiopia, China, and many others. His most recent book, *America's Water: Roles and Responsibilities,* was published in 1993.

And finally, Dr. Ken Frederick is a senior fellow at Resources for the Future. He has been a member of the research staff since 1971 and served as director of the renewable resource division from 1977 to 1988. His recent research and writings have addressed the economic, environmental, and institutional aspects of water resource use and management. He is the author, co-author, or editor of seven books and the author of 50 published papers dealing with water resources and other natural resource issues. Dr. Frederick received his Ph.D. in economics from MIT in 1965 and his BA from Amherst College. He has been an economic advisor in Brazil for USAID and an assistant professor of economics at California Institute of Technology. He is a former member of the Water Science and Technology Board of the National Research Council.

After the debate, we will open the floor for comments and questions. Then Dr. Guy Le Moigne will summarize the results of the debate. Dr. Le Moigne obtained his bachelor's degree in civil engineering from the University of Paris and his master of science and Ph.D. in water resources engineering from Cornell University. He has worked for the U.S. Army Corps of Engineers and on dam design and construction projects in Sudan, the Jordan Valley Authority, and a number of other places. He joined the World Bank in 1970, where he worked first as irrigation engineer, then as water resources development division chief for the Europe, Middle East, and North Africa regions. He rejoined the Bank after a 5-year hiatus in 1983 as an irrigation advisor; and since 1989 he has been the Bank's senior water resources advisor.

We are very pleased to present this debate and hope you find some food for thought. We will start with David Seckler.

Part 2.

Debate

Debate

David Seckler: The chair has given me 10 minutes to make the case for supply augmentation to meet increasing water demands over the future. At first I thought this would be a major problem, because the case is so clear and obvious that we need to increase water supply that I could not imagine spending 10 minutes proving it. But then it occurred to me that perhaps the honorable opposition was not sufficiently familiar with the facts of the case, and that is why they assume the position they do. Therefore, I'll spend the remaining time just listing the basic facts.

Agriculture is by far the largest user of water in the world. On a consumptive-use basis, 80 to 90 percent of all the water consumed. Even though the world is becoming an urban, industrial culture, agriculture will continue to be the biggest consumer of water. This is because even people in cities have to eat, and food production requires water.

Over 80 percent of the increase in food production in Asia since the Green Revolution has been on irrigated land. That is an extremely important figure. The Green Revolution failed on rainfed land; so given the lessons of the past, we can't hope to figure out ways to meet the vast increase in future food demands from rainfed land only. The new biotechnology will help, of course, but no one that I know believes that it's going to make a tremendous difference in production. Even if we wanted to depend on rainfed land as the source of additional supply, we would have to go into Latin American and sub-Saharan Africa. Those are the only places that have large amounts of rainfed land left for development. As we know, that would create grave environmental and ecological consequences in those continents, and it would be enormously expensive to install the infrastructure of roads, storage, etc., in those areas.

Therefore, I conclude that most of the increase in food production in the future is going to have to come from irrigated land, just as it has in the past. And we have to face the fact, which is now becoming very clear, that crop yields on existing irrigated land have been leveling off. We are not getting big yield increases on existing irrigated land. In fact, it is an illusion that yields are increasing around the world. Irrigated area is increasing, and that raises the average yield—so we think overall yields are increasing. When you look at the figures correctly, you find that with the Green Revolution package on irrigated land, yields jumped up within 2 or 3 years, hit a plateau, and never changed. What causes the average yield to increase is more irrigated land, so we're not going to get a big yield increase from existing irrigated land. We'll get some from existing land, but we need to develop more irrigated land.

Now, my colleague, Jack Keller, will explain why we can't develop more irrigated land by conserving water on the existing land and using that to develop additional land. We have to develop more irrigated land by developing additional water supplies. That is the basic fact.

How much more? If you project world population and growth of per capita income to the year 2025, I think you get a very encouraging picture. By 2025, it'll be quite easy to provide enough additional food production to feed, on the average, everybody in the world at quite a high level. It would require an increase of about 14 percent in per capita food production by 2025, which is a perfectly feasible target. That would basically eliminate malnutrition on earth. I estimate that the population of the world between 1995 and 2025, the next 30 years, will grow about 34 percent. The total food needs over that period will grow about 55 percent, so the task is to increase food production on a global basis by 55 percent.

If you look back at the Green Revolution from 1970 to 1995, you find that we increased food production by 79 percent, which is much more than we have to increase it in percentage terms over the next 25 years. But if you look at the magnitude, the need is to increase food production by 780 million tons, and that is almost exactly the same tonnage increase that we achieved from 1970 to 1995. In other words, over the next 25 years we have to create just as many tons of additional food supply as in the last 25 years.

Look at the last 25 years and you see the most rapid development of irrigation in the history of man. This was the era in which we poured tremendous resources into irrigation development. On top of that, this was the era of the Green Revolution, where yields were doubling and tripling almost without doing anything about it. Now, with the Green Revolution topping out and irrigation investment slowing down, it's going to be very difficult to produce that additional 780 million tons of food without changing the trend. We're going to have to invest more in irrigation.

Now, where? It's very clear. The increase in food demand per capita in all the developing countries is somewhere between zero and 14 percent. In the developed world, there's essentially not going to be any increase in food demand because population growth is going down to zero and negative figures. Seventy-three percent of the increase will have to be in the less-developed countries, or we will have to conduct international trade on an unimaginable scale. In the developing countries, by far the worst problem is in sub-Saharan Africa, where food production by 2020 will have to increase two and a half times just to keep per capita food production where it is today, which isn't so great. Latin America needs a 69 percent increase. China, again because of low population growth, only needs a 33 percent increase by 2020 to keep per capita food production where it is, which is fairly high. India needs a 70 percent increase, and the rest of Asia, outside China and India, needs 75 percent.

In order to achieve this next 780 million tons of food, we have to pull out all the stops. We have to do everything we can. We have to develop more irrigation, we have to invest more in agricultural technology and the Green Revolution, we have to put more inputs into agriculture. But the good news is that by around 2020, we will be getting to the top of the hump. I am projecting that by 2035, the world's population growth will be zero, and by 2020, it'll be so slow that we're going to start tapering off to that zero-growth figure. So the basic

point is, let's not give up now. We're 25 years too soon to give up. I think that in 25 years, we may relax and coast all the way through.

Just one other little point to give you an example. The Sardar Sarovar project in India, the Narmada Dam, which has been so controversial, is the biggest water project ever undertaken in India. It would bring in 1.8 million hectares of land. There's no other potential project in India, to my knowledge, of that size. That huge project is only going to increase India's irrigated area by 4 percent, though India has to increase its food production by 70 percent. This shows the magnitude of the increases that we have to be looking at.

These projects have been opposed by the environmental community. I believe that the environmental demands for water will become the second highest demand sector for water, right after agriculture. And I believe that if we don't develop these additional water supplies, we're going to find that the other demands—the agricultural, urban, industrial, and so forth—are going to attack these environmental uses for water to such an extent that within 10 years we will see the environmental community coming around behind development of additional water supplies to take care of wildlife habitats and other environmental needs.

Kathy Alison: Thank you. For the other side, we'll have Peter Rogers.

Peter Rogers: H. L. Mencken said about economists, "For every question, economists have an answer simple, elegant, and wrong." I would modify that based upon my own experience with regard to the water area. It's that they have an answer simple, elegant, and they just don't believe it. And let me give you an example, starting out with part of the Third World, which is called Boston, Massachusetts.

The Massachusetts Water Authority had an economist trained, I'm pleased to say, at MIT, not at Harvard, who, when I pointed out that probably they wouldn't need to invest several billion dollars in extending the water supply in the Boston area because of the potentially large increases in the cost of sewerage (which show up, by the way, on the water bills in Boston), said, "No, water is not price responsive, it's inelastic." Of course it's inelastic. I told him that the price elasticity was -0.3. If you look up your definitions in economic textbooks, that shows that it's inelastic. It doesn't mean to say, however, that when you raise the price of water, nothing's going to happen, and I think that we've seen in Boston some very interesting things over the last few years.

In 1988, for instance, demand for water supply on the input side was 310 million gallons a day, which exceeded our safe yield for the municipal water supply by 10 million gallons a day, and that was, of course, the motivation for buying and building extra facilities. But last year, the demand was 245 million gallons a day, a 20 percent decrease, and it's still going down. That's in the face of increasing income and population growth in the area.

Why did that happen? Well, of course, we have one of the world's largest construction projects. It's called throwing money into Boston Harbor by some of us, which is intended to

build a very large secondary treatment plant in Boston. And the water and sewer bills of the citizens have gone up by a factor of 2.2 in that period. So if you do the simple calculations, you arrive at a price elasticity of -0.3.

My guess in 1988 seems to have been borne out by what has actually happened. Now, that's what happens the world over. You get inadvertent demand management. This has happened, in my experience, in many, many other countries, where you do one thing and something else happens because, in fact, people in Kansas and in Kathmandu respond quite similarly to price increases in commodities that they purchase.

Let's talk a little about demand management and supply augmentation. Demand management is not an option; it must be done in all situations where there is scarcity of resources. And, of course, in the water area, where in the world do we see large amounts of water that's available freely? I don't see any. Maybe you could say in some of the Canadian rivers, maybe some of the Siberian rivers, but even then, when you look carefully at the ecological demands that are being met by those rivers, including things like making sure that the salt balance in the Arctic Ocean is maintained, it's not at all clear that large amounts of water are available. We are doing demand management whether we like it or not. Even if we don't do anything, we're doing demand management.

For example, many countries in the world don't believe that water should be priced. By not pricing, they're actually doing demand management that leads to some very questionable outcomes. For instance, the fact that Saudi Arabia is the world's sixth largest exporter of wheat raises some interesting questions, because even though I've never been to Saudi Arabia, I've seen pictures and it looks like a very dry place. It's actually exporting water (in the wheat that it sells) to Russia, a country that is notoriously wet. So you see, by expanding your supply of water with zero prices on the resource, you end up with something that is not, shall we say, what we thought we were going to get.

So demand management is not an option; it is a necessity. In fact, all international agencies are finally coming around to believing that demand management is a good thing to promote in the world. Look at the recent World Bank policy paper on water, or the UN Conference on Water in Dublin a couple of years ago, or even Agenda 21, which is recommending that demand management be ardently pursued.

What is demand management? It's not just getting the prices right—I think this is part of the misperceptions that many people have. Many of the people in the economics profession have an excessive concern with things like marginal cost pricing. And, of course, nobody in the world does marginal cost pricing in the water sector, and they shouldn't. That would be very foolish. It doesn't mean to say, however, that demand management should ignore pricing, because it's very, very important. But, again, the simple supply-curve analysis will tell you something about how people behave with respect to water. This information, along with some simple assumptions about the behavior of consumers who are purchasing this commodity will lead you to a good sense of what can be done with pricing.

Demand management, by the way, works best when water is considered holistically. David Seckler talked a lot about irrigated agriculture, and irrigated agriculture, I'd like to point out, is not the only activity that human beings engage in. There are lots of other competing uses for water, and in many situations those are by far the most sensible and economical things to do. But if you don't allow pricing adjustments between sectors, then you get, as we have in the United States, radically different prices in different parts of the water economy.

I met the water director from Phoenix, Arizona, who talked about one of his pipelines that brings water into the city, for which he is paying about $100 an acre-foot. It crosses over another aqueduct that is going to an irrigation project somewhere and carries water costing $2 an acre-foot. He said that he often hallucinates about going out at night and making a cross-connection on those canals. He'd like to get some of that $2 water.

Let me give what I call the four P's of demand management. I recently was in China, where everything is four of this or three of that. The four P's of demand management are preachments, prices, politics, and practices. Preachments are very important. That's moral suasion, exhortation, and threats. That deals with the discipline of ethics, I guess. Prices are important—setting resource prices, taxes, and subsidies. Typically, economics deals with that. Politics is extremely important—concern for equity and group representation. That deals with political science and sociology. And then practices—current use and abuse and the technical control practices that people use for water supply and conservation, and that's engineering. I'm pointing those out because it's not just an economic issue. It involves lots of other things.

But pricing is the key to the implementation of demand management, and I'd like to mention what I call the four I's of pricing. (1) Increased price reduces demand. (2) Increased price increases supply. (A lot of people forget, that by increasing the price, marginal projects become affordable. Water losses become large costs, so you worry about unaccounted-for water.) (3) Increased prices facilitate reallocation among sectors. And finally, (4) increased prices lead to improved managerial efficiency. I think the improved managerial efficiency is an important dimension which, again, is overlooked.

Kathy Alison: Jack Keller, ready to carry on the debate?

Jack Keller: That was very interesting, Peter, to hear about your buddies in Boston who have shut down their leaks and are saving all that water. I particularly liked the four P's and the four I's.

Out West, though, we've been through a lot of this talk about water savings, demand management, and improving efficiencies. When people get off on demand management, they're saying, if we just raise the prices of, say, the $20/acre-foot water, farmers will use it well and they won't need so much, and the poor guys in Phoenix who are paying $100 an acre-foot for water will get it cheaper somehow or other. The truth is that after a great deal of debate, even in Arizona, they decided that it was better to let the farmers have some cheap

water so they could at least pay part of the bill for all the water that was around for the cities. The important point is that the so-called inefficiencies in irrigation are really just apparent inefficiencies or what we call paper water vs. real water or dry water vs. wet water.

We've been through the efficiency game on demand management. In fact, I was in irrigation sales about 20 years ago, and one of the things I used to tell customers was, if you get a new sprinkler system or a drip system then you'd have all this extra water to irrigate a bunch of extra land, and it would really pay off because that water is quite valuable even though you don't pay much for it.

That went on for a while, but all of a sudden people realized that what was one guy's loss was the supply for the downstream users. So the state engineers, the guys in the West who monitor and regulate water supplies and water rights, got wise to that. Now when you talk about water with state engineers, you have to talk about your "consumptive use right"—in other words, the amount of water you really did use on your farm in the past—before you can transfer that use to some other person.

In California there was a large study committee, called the Central Valley Water Use Study Committee, which looked at irrigation water use in the Central Valley and considered what could be done to save water. It had 31 members, including people from the universities, USDA, fish and wildlife (both the U.S. and California agencies), the USGS, the Department of Water Resources of California, and the California Water Control Board. They were well aware of this concept of real water—not just paper water, not just apparent savings—and they looked at the three areas where you would suspect getting savings. One was to reduce the water use through crop evapotranspiration, another was to reduce the water use of riparian and native vegetation and direct evaporation from the water surfaces, and the third was to look at the savings that would be available if you could reduce the deep percolation to saline sinks that were within the Valley.

Of the 6.8 million acres of irrigated land in areas where water can be reused and recirculated, such as the East Side of the San Joaquin Valley, they estimated that, even though individual farms may have low efficiencies, the overall efficiency, because of reuse and all, is as high as 98 percent for the entire 6.8 million acres. They concluded that, with extensive conservation practices, the water savings that they might be able to get out of the valley at a cost of about $200 an acre-foot, which is about 17 cents a cubic meter, would amount to about 1.1 percent of the entire irrigation water use in the valley. When you see those kind of figures, you realize that the potential for demand management is minimal, because not much water can be taken out of the system in terms of the irrigated agriculture—at least if we want to maintain present agricultural production, present wildlife habitat, and so on.

There are similar situations in other parts of the world. In Egypt's Nile Valley, the average on-farm irrigation efficiencies are probably in the neighborhood of 40 to 50 percent, maybe 60 in some cases. The delivery efficiency to those farms from the canals is about the same, so the overall project efficiency—a multiplication of those two numbers—is less than 40

percent. Yet the basin—in other words, Egypt's Nile Valley and Delta put together—has an efficiency in the 80 to 85 percent range. That's because of the reuse and recycling of the water. So demand management, by changing the price of water to those farmers, for example, is not going to save water.

The point is that the water the individual farms do not use effectively in that first pass-through returns to the Nile River and is picked up by downstream users. We have a project in which we're looking at the potential for improving the global irrigation efficiency, if you will, in the Nile Valley-Delta system in Egypt. I think that one can improve it by 5 percent, maybe a little more, but I'm not certain that that's a good thing to do. Because of the ecological needs for water in the delta area and in the estuaries for fisheries and so forth, it may be unwise to make it any more efficient than it already is.

Reducing demand is not an option. Rather, I think we need to augment the supplies of water wherever we do have some untapped resources that can be developed sensibly, environmentally, and economically. To close out the option of augmenting supplies is not, in my view, a sensible thing at this time. I would say that we must continue to keep our options open, to develop new water resources and supplies where they are available, and to do everything we can to meet the world's food demands.

Kathy Alison: Thank you. For the final part of the first round, Ken Frederick.

Ken Frederick: I want to spend my time addressing the question, are large-scale water projects necessary or even advisable? Dr. Seckler offers a Faustian bargain. He suggests that either we've got to convert the forests of Africa and Latin America to agriculture or we've got to build large-scale irrigation projects to meet future food demands. I believe that this bargain is based on a number of false assumptions.

First of all, Dr. Seckler is very pessimistic about the prospects of increasing yields from dryland agriculture. But it doesn't seem to me that his pessimism is consistent with either past performance or the analysis of some of the studies that have been done. In one of his publications, he refers to a study by Pierre Crosson at Resources for the Future and Jock Anderson of the World Bank, and he takes their projections of what's likely to happen to increases in food demand, but he does not look at their projections of what's likely to happen to production. Let me mention a couple of these projections.

Historically, for maize, sorghum, barley, and millet—and most of this is in dryland production around the world—yield in developing countries increased by 2 percent a year on average over the previous 20 years. And Crosson and Anderson project that there will be a 120 percent increase in the yields between 1990 and 2030. Looking at the increase in demand for these products, that would suggest that a sizable percentage of the change in demand could be met from yield increases on dryland agriculture.

Our opponents also are very pessimistic about the potential for increasing the yields in the return to water on existing irrigation projects. They assert that there's little opportunity for gains from reducing application rates when you look at it on a system-wide basis. I think that in situations where water is free, you may find that people are applying water in excess of what the plant needs.

But clearly, the economically advisable amount of water to be applied, if you're paying for the water, is going to be less than the amount that is going to maximize the total yield of that crop.

Also, there are important environmental benefits associated with reducing water applications. In the United States, the primary cause of water pollution and other problems associated with irrigated agriculture are related to the high rates of water application. Studies suggest that the best way of reducing the negative environmental impacts would be to reduce the amount of water that's applied. I believe that improved irrigation practices can actually increase water efficiency within a basin. And I'm not sure to what extent the Central Valley of California and the very low potential increases that Jack Keller refers to are applicable in the developing countries.

Another false assumption involves the prospects for cost-effective expansion of irrigation. Large-scale irrigation projects have rarely been economical, even when they ignored the opportunity costs of the land and the water. They are less likely to be economical in the future, because project costs are rising very rapidly, and it's increasingly difficult to ignore the environmental impacts associated with these projects.

Increasing water costs are inevitable for a number of reasons. First of all, the best reservoir sites are developed first. One study in the United States suggested the extent of diminishing returns—reservoir capacity per unit volume of dam declined 35-fold when large reservoir projects constructed before 1930 were compared with those constructed in the 1960s. Also, you get diminishing returns because the water control by storage is subject to diminishing returns. And at some point, evaporation losses associated with increased reservoir storage are going to offset any gains in safe yield that you get from the additional reservoir storage.

Constructing a dam and reservoir does not necessarily increase the overall supply of water. If water is scarce, a new project may just make it possible to reallocate water from in-stream to off-stream uses, and the opportunity costs of storing and diverting water increase over time. Large dams tend to destroy the ecology. They displace people and livelihoods, and they often flood the most productive agricultural lands.

Another false assumption is the idea that large-scale water projects are going to improve the welfare of the people in developing countries. When I studied economics, we learned that you don't improve welfare by investing in projects for which the costs exceed the benefits. In irrigation projects, the cost frequently runs from $10,000 up to $15,000 per hectare. Such projects are not likely to be cost effective. An alternative strategy, if you want to improve the welfare of the people, would be to invest in projects to provide safe drinking water and adequate sanitation. Poor sanitation and unsafe water supplies propagate a number of

debilitating and deadly diseases that affect hundreds of millions of people. Economic prospects are seriously impeded by poor health and the countless hours that people spend carrying water for domestic use.

The last false assumption of our opponents is that they tend to equate self-sufficiency with food security. The ability of the developing countries to feed their people in the year 2020 or 2030 will depend on the wise and efficient use of their financial, human, and natural resources, including water. Hunger and malnutrition are due to poverty and lack of effective demand, not to inability to produce food. The prospects for increasing international shipments of food are much greater than Dr. Seckler implied.

Kathy Alison: We will now have 10 minutes for each side to rebut the other, starting with the Seckler/Keller team.

David Seckler: Peter Rogers told his joke about economists, of which I'm one. I'll tell my joke about engineers. Nathan Rothschild, the British financier in the last century, said, "There are three ways to go bankrupt: Spend your money on horses, on women, or on engineers." He said, "The first two may be most amusing, but the third is by far the most certain." But I have to admit that I disagree probably more with my fellow economists than I do with my engineering friends.

There's one way to solve the world food problem. You don't have to put any irrigation in, you don't have to do anything, you don't have to grow 780 million more tons of food. Just let prices take care of it—let prices rise. That'll solve it: demand management. Let the price of food go up 5, 10 times, you don't have to worry about this at all. All you have to worry about is a few hundred million people starving to death. That's the only problem.

Economists can't seem to get that into their heads, that people have to have food to eat, and poor people spend 80 percent of their income on food. And if you turn the economists loose on this sector, they're just going to let everybody go into the Malthusian solution. Let the market take care of it. Wipe them all out. I think it's such an insane and disgusting position, it almost makes me want to get out of economics.

One thing I was glad to hear is that Peter Rogers doesn't advocate marginal cost pricing in irrigation. That's a tremendous relief, because I always thought he did. He didn't quite tell us what he does advocate, but it must be something like average cost pricing.

The argument of the opposition seems to be that, well, it might be a good thing to develop additional water supplies, but there aren't any. That's a new argument, and I would agree with that in the Middle East. They don't have additional water supplies to develop, so they can't do it. But in India they have it—Narmada is one. We're not saying do it if you can't do it; we're saying, if you can do it, you'd better do it if you're going to feed your people. In China, for example, I'm not convinced, thanks to the success of their population program, that they need big investments in irrigation. I'm totally convinced that India does over the short term. So we have to be sensible about these things. And the main thing we can't do is allow economists to make these kinds of policy choices that affect poor people so much.

Jack Keller: It was suggested that California is somehow unique in its limited possibility for demand management in irrigation. I would like to say that right now I'm involved with water transfers from agricultural use to urban use between the Imperial Irrigation District and the Metropolitan District of Southern California. My job is to quantify the savings that are being made by this $100 million project, which is trying to capture and transfer over 100,000 acre-feet a year. We're having a difficult time coming up with 3 percent savings in the Imperial Irrigation District. However, it is almost the last water user on the Colorado River, and it drains into the Salton Sea. When you're down to the last user with no return flow possibilities and having a hard time finding conservation savings of 3 percent of the water, it's quite an interesting situation that points out the limitations of demand management.

In regard to crop water requirements and the notion that if you backed off and sort of irrigated a little less than the full requirement you could somehow save a lot of water, people who have experience in large-scale farming have tried to do that. It's very difficult because in the West, you have to leach from time to time. There's very little rainfall, and if you underirrigate and have no leaching water, you'll end up with salinization and very low production. So the possibilities of under-irrigation are very limited.

Back to the idea of closing all options and saying, "No more dams," which is, I think, a foolish position to take. It's not that there are a lot of good dams left to be built, but certainly there are some, and there are other things to be developed in terms of water resources. I think all the stops should be pulled in terms of developing the resource for the future use.

Kathy Alison: And finally, for demand management—Peter Rogers and Ken Frederick.

Peter Rogers: I have seen nothing in this debate that would make me change my position. In fact, I feel that the opposition is in some other realm, in some virtual world as opposed to the real world. Maybe Dr. Seckler has not noticed that food prices are declining all over the world. Isn't it interesting that we hear continually about the problems of getting enough income to farmers because the prices are going down? And both David and I are working in Bangladesh, and even in Bangladesh we have food surpluses at the prices that we're talking about—a 20 percent decrease in the price of food in Bangladesh in this past year. This seems to me a very important piece of evidence that we have somehow or other to deal with, despite Lester Brown and all of these gloom-and-doom predictions about the famines that are about to happen. In fact, the agricultural systems in the world have done surprisingly well, and they don't have to do too well to maintain the system in fairly good balance.

Let me comment on efficiency in irrigation. I've heard a lot about wet water and dry water and things like that. Those of you who've spent time in India know that there are really two types of irrigation systems in India. There are those large irrigation canals, which are typically managed by the state governments, and there are small tubewell developments, which are managed by the farmers themselves. The increases in yields in irrigated agriculture don't come from the government canal system; they come from the farmer-operated tubewells. And in my estimation, large potential improvements in irrigation efficiencies are possible in those government canals. When you look at places in North Bihar, you think the goal of irrigation is to evaporate water. I'm a city boy myself, but even I figured out that you

probably ought to be using it to increase your crop yields rather than just dumping it in a way that makes for large-scale waterlogging and flooding. When we're talking about supply augmentation, I think that we can go a long way toward augmenting supply from groundwater, and I myself have advocated that. One has only to look at Bangladesh to see the success of small-farmer irrigated agriculture using tubewells. The success of Bangladesh agriculture is in that area, and its future depends upon its expansion. There's no doubt in my mind that those efforts are worth supporting. I would raise some questions, however, about supporting large projects that involve big canals, large headworks, and regulators, and all of these things that mean bureaucratic involvement in sending water to agriculture.

I'm optimistic about the future availability of water without massive supply augmentation schemes. I don't see many places in the world where we can build big dams and big storage works on the surface; however, I do see parts of the world where there is still a possibility for groundwater development on a smaller scale.

But I'm optimistic about the future for the opposite reason from David Seckler. He sees irrigation as a problem; I see it as a solution. Irrigation is a huge flywheel in the system. In most of the countries that engage in irrigated agriculture, maybe 83 to 85 percent of the total consumptive use of water goes into irrigated agriculture. Small percentage reductions in the water use in agriculture release vast quantities of water for industry and municipal usage. And a lot of the discussion—and I hear this in the Middle East—is that you can't take water away from irrigation because we have to feed ourselves. But I don't think anybody's talking about taking water away from irrigation on a full scale. We're talking about taking 5 percent or 7 percent or something like that. Remember that we're using 10,000 tons of water per hectare to grow a crop. Ten thousand tons is an awful lot of water, which has very high value in other uses. So irrigation is the nice thing that is going to save us all. Because we've got all this water currently used in irrigation, and small amounts can be diverted.

Secondly, I'm optimistic because the current application of the policy tools is so rudimentary in the water sector. David Seckler said he was glad to hear that I wasn't advocating marginal cost pricing. Let me tell you what I am advocating. I'm advocating a positive price for water, not zero, and less than the cost of desalination, but somewhere in that range. Desalination is about $2 a cubic meter right now, so you can figure it out for yourselves. We don't even need to do the calculations for marginal cost. We need to have some reasonable cost that sends the message to the users.

The managerial efficiencies in the water sector are abysmally low, and this is something that the international community, and I think everybody here, is concerned with. We really do need to do some capacity building in terms of the institutions that deal with water.

Of course, I'm very optimistic, ultimately, because we do have a close to infinite supply of water in the oceans, and, while we do have some energy resource limitations and maybe some capital limitations, by and large I have a very optimistic view of the future. The price of food won't go up 50 times or 5 times because we have alternatives that we can substitute, apart from international trade. At those prices, we could start doing what the Saudis are

doing, and we'd be able to afford to buy the wheat that the Saudis are now selling to the Russians.

Ken Frederick: In regard to the question, is there water to be developed? I have no doubt that the engineers can find lots of dams that could be built. The question is, to what extent are they really generating new supplies of water, and what are the opportunity costs of the current water and the land that might be inundated by them?

I would like to reiterate something Peter Rogers said, that expenditures on improved management probably will be the most cost-effective water supply investment that can be made, not only in the developing countries, but probably also in the United States. And I think that, along with improved management, the developing country institutions that are going to make water use more responsive to changes in supply and demand—which come about either as a result of natural changes due to the climate or changing values in these countries—are extremely important. It is interesting that when California had a prolonged drought, the major losses were associated with the environment, not with agriculture. Although a lot of water was diverted from agriculture, the reduction in agricultural production in California during the drought was very small, which suggests that there are lots of ways to save water. Now, granted, they did pump a lot more groundwater during that period, but even with reduced water supplies, it was nowhere near the percentage reduction in agricultural production.

Kathy Alison: Now the floor is open for comments and questions.

Part 3.

Discussion

Discussion

***Janusz Kindler** (World Bank):* Three comments addressed to Peter Rogers.

1. I feel the debate was a bit artificial because it was not one versus the other. What we need is water supply *and* water demand. And I think that Peter will agree with me, because he's very much for integration of demand and supply.

2. I think institutions are terribly important. The separation of water resources management from policy (from the water service, where you don't have to have the government) is very important.

3. There was not much from any of you as to water strategies for the next century. I'm working in the very dry places of the world—Cyprus, the Middle East, Central Asia. The population is booming, and there will be *no* water at a certain point. Therefore, desalination is coming, and it's less than $2 per cubic meter. It's about $1 right now. I feel that when population grows and there is no water, urban water uses grow and desalination is needed. So municipal wastewater reuse becomes terribly important, because this is the only supply stream that is growing. This water goes to agriculture, and so we'll be closing the cycle as much as we can. In this context, storage and transfer will be very important for new water. Therefore, I presume that money will have to be spent not only on women and horses.

Peter Rogers: Of course, we do need some additional supply to get us through the future, and institutions and how we structure them are very important. But institutions don't come along by themselves. The good institutions that manage water, you find, are ones that have effective budgets and revenue. And the way to get revenue is to start charging for the resource. All too often I go to places in the world where I see totally rundown institutions. They have no money, they have no way of doing anything, and they're giving away an extremely valuable resource. Part of the demand-management side, in fact, induces managerial efficiencies by making it possible to do all of the good things. So by getting revenue into the hands of the people who are supplying the water, the institutions will take care of themselves.

You said we didn't say much about the water strategy for the next century. Well, I think that we did. There is still an argument on the table. Both Ken Frederick and I feel that, yes, it's important to keep one's eye on what's going on, but by and large, things are working out reasonably well. In the United States, for instance, we've done remarkably well, despite all sorts of serious problems in the water area. I think that there's a lot to be learned from pushing hard, but we should not panic or say that we have a crisis on our hands. I think that we're going to get through the next century pretty handsomely. I *know* we're going to do that, because we do have all that water to desalinate if it ever gets out of hand.

I'm pleased to hear you say $1 a cubic meter. My data show $2 a cubic meter. But whether it's $1 or $2 a cubic meter, with the current prices in agriculture, you can't afford to use it for irrigated agriculture right now, but you could certainly use it for domestic and municipal supply. In fact, in parts of the United States, it's now almost possible to think about using desalination as opposed to treating wastewater—for instance, completely recycling it instead of putting it back into the ocean. San Diego is considering that.

***Ed Osann** (Bureau of Reclamation):* I have two questions for David Seckler. First, in your description of accomplishments of the Green Revolution and current developments and future projections with regard to agricultural production, where does cotton production fit? Are the numbers you gave us only for food commodities, or was cotton mixed in?

Second, what's wrong with trade? Why should we in this room necessarily assume that individual nations need to boost food production to be totally self-sustaining at some point in the future, when we have farmers in the United States, Canada, Australia, Argentina, and elsewhere who are ready to produce more food for the world market?

David Seckler: The first one is easy. The figures I gave about growth are all on cereals.

What's wrong with trade? Nothing's wrong with trade. I like trade. But I think trade has to be controlled within limits. For example, I like the Indonesian rice policy. They do what they call trend self-sufficiency. That is, they don't try to meet all of their rice demands every year by production. What they try to do is project the trend of rice demand and satisfy it. Then, if in some year or two supply falls below that, they import more. If it goes above, they store a bit for the next year. Food self-sufficiency is not a good idea if you can trade within reasonable bounds. But most big countries, like India or China, cannot, in my opinion, rely on the international food markets for a large percentage of their supply. You remember that Lyndon Johnson held them up politically when they had a bad drought. They never forgot that, and they shouldn't.

I think we're talking big aggregates. For example, sub-Saharan Africa faces a two-and-a-half times increase over present food consumption. Sub-Saharan Africa can't import that much food. We don't know how they'd pay for it in foreign exchange. You need to grow food in many countries, because 50 to 70 percent of your work force is in agriculture. They still need some employment until they move out. There's nothing wrong with trade, but it's a matter of keeping it within reasonable bounds.

In many countries in the Middle East, I think virtually all the additional food is going to have to be imported.

***Dave Groenfeldt** (ARD):* I have a question for both Jack Keller and Ken Frederick about the potential for underirrigating and operating at the steeper side of the production function. We got the suggestion from Ken that we could do it, and the practical point from Jack that we can't do it. But logically, you *can* do it. We have examples of drought situations where

people do something to get by with less water, so I'd appreciate some comments on what can and cannot be done with underirrigating.

Jack Keller: You can do it temporarily in a drought situation, but in the long run you have to overirrigate to get leaching. If you have no deep percolation, which is what will occur if you underirrigate, you really don't get the leaching. There are some tricks you could use to move the nonuniformity around, so that the place that got low irrigation this time will get more the next time; but that's a big management problem because the fields are usually laid out in a way that makes it hard to do, regardless of the type of irrigation system.

I would like to go back to the idea that government projects are inefficient, that they have all this water that's not doing much good or being effectively used, and that all the private tubewells are efficient users. One has to remember that the water that the private tubewells are pumping results from inefficient application from the big government projects that stored the water and spread it around through inefficient delivery systems. So they're really tied together. If private tubewells dependent on dam projects are considered a supply source, developing those supplies is definitely in order.

Ken Frederick: The only point I want to make is that when it comes to water, the term "requirements" is misused. It's misused in relation to urban use as well as to agricultural use. If you give the crop a little less water than what would give the maximum yield, it doesn't necessarily mean that you're going to lose the entire crop. You tend to have a curve of responsiveness.

John Magistro *(AAAS Fellow):* On both sides of the panel, there seems to be an assumption built into your model that there's adequate income and adequate capital for farmers to engage in a strategy of increased supply, either through expanding production or through pricing mechanisms. I would like challenge you on that. My experience from West Africa is that there's a severe scarcity of capital and labor among farmers engaged in irrigation, and I see that becoming an increasing constraint in the future. Could you address the issue of capital scarcity?

David Seckler: Africa has about 5 or 6 million hectares of irrigated land. But the total potential irrigated land in Africa is only 25 million hectares, about half of India's currently irrigated land. So, to answer your question, I believe it should become a major part of donor efforts in Africa to add 20 million hectares of irrigation in Africa as quickly as possible, and to do it, insofar as possible, through pumps or another small-scale means. I believe there's some room for river regulation dams that would cut off some of the flood damage and increase the dry-season flow in the Niger and some of the big rivers. But there's a capital constraint. It has to be a donor-led initiative. Those are the people with the money, and they have to put it into Africa or we're going to have the worst mess on our hands in the next 20 years that you could imagine.

Peter Rogers: In Bangladesh and India, of course, we don't see labor constraints very often. But capital constraint is an interesting one. One has to be very careful with this thing. There isn't a capital shortage. There ought not to be a capital shortage if there are irrigation projects that cost $20,000 per hectare. We must keep a million miles away from those types of projects. And I think that the issue then is small-scale irrigation using tubewells or low-lift pumps, maybe from the rivers. And we're not talking vast amounts of capital. We're talking much more manageable quantities. If you see what's happened in Bangladesh and India, it's growth in certain sectors of the economy that has made a lot of the increase in agriculture available at very modest capital costs.

Ken Frederick: The need for capital points up one of the major advantages of demand management and pricing. It's interesting that in May 1990, delegates from 46 African countries recommended that future investments in water and sanitation be based on effective demand and recovered through user fees as a way both of promoting greater efficiency and making sure that you do have funds to maintain the equipment. This is a strong argument for emphasizing demand management and realistic pricing and, even for some of the very poorest people, making sure that they are at least paying something, so they recognize that there is a cost to the water.

Betsy Cody *(Congressional Research Service):* I want to ask David Seckler about projections for food tonnage. To what degree do your projections take into account substitutes that might be developed or changing consumption patterns in the types of food we eat and how we eat them—meat, grain, that kind of thing?

David Seckler: I want to correct something Ken Frederick said. My projections are not based on the Crosson-Anderson report. In fact, I believe its projections are way too high. My projections are based on 3,200 calories per capita daily average world consumption. That implies that the percentage of meat consumption in the developed world is going to go down, so I'm including some cereal, vegetable, and fruit substitution for meat. That's important, because it takes more cereal to make meat, of course. Ireland, I think, is the world-record eater both of meat and total calories, at around 3,800 calories per day average consumption, and the biggest percentage of that is meat, which really surprised me. So I'm looking for the Irish to slim down a bit. Actually, this 3,200 calories is just about where the English are. So basically, it's kind of a middle-of-the-road projection. I don't think we're all going to be carnivores like the Irish and some of us in the United States, nor are we going to go pure vegetarian. I think the substitutions for meat, like soy-beans, will be accommodated in the kind of a middle-of-the-road projection I've made.

Doug Clark *(Winrock):* I thought the story on Saudi Arabia was an example of how complicated all this is and how, if you take your four P's, you're talking about a positive way of better managing demand. I think the Saudis may have had to go the other way. Their preachment is to be self-sufficient in food. When they apply their economics, I don't know whether it was the water or the pricing. The farmers get four to six times the world market

price, so they went the wrong way on the economics and the pricing. I think behind that are some politics. They have farmers, and they've got to produce something because there is still a rural population in Saudi Arabia. And, like all farmers, they still know how to count. If you give them four to six times the world market price, they'll produce. So I think it's indicative of how complicated all this is, and the only question I have is what influenced them to produce the wheat: the free water or the market price that was four to six times the world price?

Peter Rogers: I have Saudi friends who tell me that in Saudi Arabia, it's much better to own a water well than to own an oil well, because with oil wells, you have to pay to drill and you pay taxes. But if you have a water well, the government will actually drill it and then will pay you huge subsidies on the crops that you grow. So the idea that these are rural poor is probably misplaced. I think these are well-placed individuals who are receiving largesse from the government in a way that is not very smart.

Kathy Alison: Thank you very much for your questions and comments. Guy Le Moigne will now provide a wrap-up.

Part 4.

Synthesis

Synthesis

Guy Le Moigne

Perhaps I can try to summarize two broad aspects. One is the difficulty about agreeing on assumptions, and the other is where there appears to be some consensus as to the recommendations we could draw from these presentations and perhaps agree on.

On the assumptions, I see that it is a major challenge to agree. Forecasting the future is indeed very difficult. To start with, David Seckler mentioned population growth. His projections are way below those of the United Nations, the World Bank, and the population conference in Cairo. All the projections that I've seen at the United Nations and World Bank, even with heroic assumptions for slowing population growth, go from 5 billion in 1990 to 8 billion in 2025. That is much more than 50 percent growth, and it shows that there could be a lot of debate even on the assumptions, although that was not debated much here.

But there was debate about the potential increase in yields on irrigated land, and no consensus was reached. David Seckler presented a view that I often hear expressed in the agriculture department at the World Bank and the CGIAR, but I'm not sure what the future will say, so this is certainly a debate. The potential for increasing yield on drylands was also a subject of debate on which no conclusion was reached.

On the efficiency of water, again, there was a debate. I think there was agreement, even though it was only that we can improve efficiency in water supply and sanitation in Boston. But allow me to mention also Tashkent, where the per capita consumption is 1,000 liters per capita per day, even more than in the United States, so there is probably room for more efficiency there; and Manila, where the unaccounted-for water is 58 percent. So I think that there is room for improvement in agriculture and certainly in water supply and sanitation, and this may help in the future. But Mr. Frederick challenged the overall efficiency of a basin. I think, however, there is greater overall efficiency along the lines presented by Jack Keller in the Nile Basin than is assumed by many people.

The food security vs. food self-sufficiency argument was linked very much to trade, and trade is, again, linked to the capacity to pay. Yesterday in the *Washington Post*, there was an article by Sir Oliver Goldsmith, who said that this country, under the GATT, would actually be exporting high-value products and importing those that require low-cost labor; and that in so doing, even when there is a balance, we would be importing unemployment. So trade is a very complex issue, and that was reflected in the food security vs. trade vs. food self-sufficiency discussion. These are the points where I had difficulty in seeing a consensus.

On the other hand, I saw some points on which perhaps there could be some agreement. Peter Rogers mentioned the four P's. I think these four P's are a very good framework, even though in my view they could apply just as well to supply as to demand management, as was pointed

This indeed is fundamental, whether you apply supply or demand management. Politics is the major issue in water resources management, and many of us forget about it. It can go many ways, but the politics decide.

Pricing was a subject in the debate, and there I think we can all agree on what Peter Rogers said. Even David Seckler mentioned that he was pleased that Peter didn't use opportunity cost or the long-term marginal cost. But Peter said we need reasonable costs that can send messages to users. What is reasonable, of course, can perhaps be argued, but the concept itself is one on which I think we could all agree.

Peter also mentioned capacity building for institutions dealing with water, and I think we can all agree on this, too.

Peter Rogers was challenged on the use of groundwater in India, because the groundwater is recharged by the big canals and the leakage and the overuse of water. I think that's fact. But it still remains that since irrigation water is 80 percent or more of the consumptive use, small potential changes would release a lot of water for urban use. Even the 3 to 5 percent mentioned by one of the speakers can be a significant amount of water that the water-supply-and-sanitation group, once they have applied proper demand management, can use.

I noted also that Peter Rogers mentioned that water must be considered holistically. This is a point about which there was a big debate at the World Bank among economists.

Finally I want to relate a remark about economists and engineers made by one of the senior vice presidents at the World Bank, who came to one of our water resources seminars. As you know, the Bank is certainly a place where the economists really have a say, while engineers are a vanishing breed. He said, "Economists are just as wrong and just as often as wrong as the engineers. However, they often ask interesting questions."