**WATER WORKING GROUP, UNIVERSITY OF CALIFORNIA, BERKELEY**

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## *"Technology, incentives and demand"*

I think what I will say will be really complementary to what Peter (*meaning Peter Gleick*) said and I will try to summarize some of the perspectives I have. Even though it's an economist's perspective I believe it has some interdisciplinary worth.

First, I am very glad about the water group -- we had about 2 or 3 years ago a faculty group on water. We tried to suggest something to CALFED. (But) I think the key is to develop a group that would involve faculty and students, and in the long run it will have a unified, or integrated, research program on water and that's something all of us should really strive toward.

Now, what I'd like to do is to think about some of the basic trends that occurred in water resource management and some of the driving forces behind them. I agree with Peter that we have moved from an era of management by supply to a more integrated management system. But I think that there is another element that Peter raised at the end that is really crucial, when I think about it -- and this is that water resource management moved gradually from being an area that was managed by engineers, and is used as part of the pork belly politics, to an area that is managed (in an) interdisciplinary and much more rational manner. Secondly, I think another issue that is very important is the fact that we really have to recognize that we live in a world that is heterogeneous, that there are different patterns of behavior in the U.S., in India, in Israel or China, so aggregation has a lot of flaws. If you have a pattern of development, it may evolve in one country and then migrate to others. There are processes of diffusion that are moving among countries and are very important in the water area.

Now, if I stop to look at some of the basic tendencies in water, the first tendency that is quite clear is the trend of increased scarcity. If you look at water per person, it's declining. We have more people and water resources are more or less constant. (But though) the withdrawal of water is growing, it doesn't catch up with population growth. I think one of the things that is slowly happening is that people are starting to realize that water is not a free good, that water is a scarce resource. Generally, in the past people treated water like air. That people have the right to as much water as they want, when the price of water was zero. Suddenly, people start to realize that water has a price. And that you have to move from a system that is an allocation of water by a queue, maybe first come first served -- and actually the government and society encourage people to take more water -- and then suddenly to (the) allocation of water by market and regulation, and management of water in a way that you manage other scarce resources. I think that is something that is gradually happening now.

Even now I think water, relative to other (economic goods) – people, in many ways, treat it as almost free. But it's not free. It's a scarce resource, let's save it, let's manage it differently, and then there is a supply for everyone. I think that is a crucial element because once something is scarce, then you have markets, you have different institutions and (interest) groups.

Now, I think for the systems in U.S., the story is the power between land and water which is very, very important. If we look at land use in the U.S., the main philosophy in the first 100 years (was) to settle the country. Land was free, (the main) perspective was let's provide incentives for people to settle. So that's the reason that we have homesteading, the reason that we have the situation where the government developed infrastructures for exploiting land. But at the end of the 19$^{th}$ century it (was finished) -- all the country was settled, all the land had owners, and suddenly a move to markets. We are now in this situation with water. If we look at what happened with water we basically exploited one resource after another. When we have processes like this, in the first period there is a big exploitation, the efficiency of use is fixed, then you reach the limit,

then suddenly bingo!! Productivity of resource increased. Now let's look at (land productivity) when there was a spread, an expansion of settlement. (Productivity) stayed constant in the 19th century. What happened in the 20th century? (Yields, productivity) increased about ten-fold. I think the same thing is happening with water. As we have expanded our water resources towards some sort of limit, and we are close to the limit in the U.S., suddenly productivity of water resources is increasing.

Now, people don't… they generally speak about water use in general terms, but 80% of water use is in agriculture. I chose to work in water use in agriculture for two reasons. I'm paid by Dept. of Agricultural Economics but secondly it was that the water industry is important, (but) it's a by product, it's not a significant resource. I think that for most people in their house, they pay little bit, most people (don't) mind to pay a little bit more or less for water. But in agriculture that was (different) -- Once you start realizing that you have scarcity in agriculture, that production cannot grow in agriculture, you suddenly have to start to see changes. What happened in agriculture? There is this theory of induced innovation. People that have scarcity come up with innovation. If you look at some of the big innovations in agriculture they started in desert areas in the U.S. and in Israel. For example, (drip) irrigation started in Israel, some of the most sophisticated forms of automated irrigation started in U.S. and in other areas. Once these technologies are available they move elsewhere.

Now, another thing that happened is that the issues of scarcity, and sudden increase in value, also operate to improve supply. Now, we really didn't have that much scarcity in water so pumping technology wasn't developed in the water sector. Water was the beneficiary of the energy sector. All the pipes and all the other systems that we have in water are a result of technologies that were innovated in the oil sector and moved to water. So, you had a combination of innovations that are operating in agriculture, in areas where high-value crops were produced under scarcity, and a new type of system to pump water, that together moved to a new reality. That is a slow growth in supply, through pumping, and then increase the use of efficiency through technologies.

Now, most people in the world don't operate under scarcity conditions that will justify adoption of modern technologies. But the potential for the adoption and the potential for water use efficiency in agriculture is immense. So, the issues are the issues of developing incentive to adopt these technologies, and that is one problem, and the second thing is to develop the infrastructure that would allow people to modify their existing technologies.
Now, let's speak about incentives. The biggest problem when you speak about incentives is (managing institutional details). If for example tomorrow you move to water marketing it will really depend how you manage it. Do you take the water that belongs to the nation, nationalize it to sell it to farmers? Or you introduce a system of transferable right, that people who have rights for water now can sell it to other people, which is not the case today. This type detail of design will make a big difference -- and if you have a system of transferable right you'll be able to use water in better manner.

Another issue that maybe very important is the use of recycled water. In many areas that are scarce you maybe use water more than once. Maybe you use toilet water again and again. Again, you need a system of incentive a well as a regulatory system to make sure that things work right. So, all in all if I look at water problems I don't think that it's so much a problem of scarcity *per se*, or lack of supplies, but a problem of management and policy. And gradually we are moving to a better policy.

Now, if we look at policy I think that there are three types of patterns that are important. The first pattern, I think, is evolution from what I call weak government to strong government. When we have a weak government like we had in the U.S. in the 18$^{th}$ or 19$^{th}$ century, (which) you have in many developing countries, the government doesn't have its own resources. The government doesn't have the capacity or will to raise taxes, and they want development. What does the government do? They give individuals the right to develop resources. For example, the railroad in the U.S., people got land rights for developing the railroad. Then same thing was true with water resources. In the 19$^{th}$ century there were incentives for people to divert water. The system told

you okay, first come, first use. Most of the water development was done privately. And that's what's happening in many developing countries. When we move to the 20th century the government is able to raise taxes. The government suddenly moved to a system of developing public good projects and then we have the big water projects. If you look at the water projects they started between 1940 and 1970. Their initial design was between 1920 and the 1940s -- a 20 or 30 year lag -- and there was this type of perception that the role of the government is to build infrastructure. The water projects were consistent with the highway systems and a lot of other things.

Two things happened. First, suddenly people realized that there are other priorities for the government. Taxes, there was increased demand for taxes, especially for social problems. Secondly, there was increased environmental awareness that people realized if you build freeways you divert water. There are a lot of environmental side effects. So, suddenly today we have a lot of objections to increased expansion of resources by the government. Now, one thing that happens is that (with this) process you start developing industries that were dependent on these public projects. If we saw, in my view, what happened in the last 20 years, was a process of change of regulation where the industry, to some extent agriculture, but mostly the construction and cement industry, as well as the engineering infrastructure, basically supported a system that was providing them full employment.

Now, for about 10 to 15 years people were fighting to introduce some sort of economic rationale to assess water projects. I think that if you look at the critical moment that Peter (*meaning Peter Gleick*) showed when we switched from linear growth in water use to some steep increased value of water, it was around 1973. Three things happened in 1973. The energy crisis, when economics suddenly make energy expensive and therefore pumping expensive. The establishment of the EPA happened in 1973 and also something that was called enactment of "principles and guidelines". I don't know how many of you know about this document. "Principles and guidelines" is some government document that has a cost benefit to assess water projects. "Principles and guidelines" was introduced

in ’73, Carter tried to use “Principles and guidelines” to block 400 projects in ’76. He failed -- to me that was a moment that he lost his presidency. It seems he really was weak president, he wasn’t able to operate against power groups. Reagan, whatever you say, one of the first things that he basically abolished was this. He was able to cancel these 400 projects and since then “Principles and Guidelines” was quite a powerful tool that would reduce build-up of new projects.

Now with “principles and guidelines” the Army Corp of Engineers and others tried to modify the process to favor new projects, I have some examples. For example, one of the techniques that people invented in environmental economics to assess projects is called contingent valuation. Many of you know it. Basically, you ask people what they think about the value of a project, you sum it and you get the value of environmental amenities. Now, if you use this mechanism to assess a project that will benefit the environment, you get zillions of dollars worth of projects, so this project will be good for you. Now, if you do the same thing to look at cost of environmental projects, again you get large costs for a project. “Principles and Guidelines” use contingent valuation to assess the benefit of new projects but not the cost of new projects. So a lot of projects that have some environmental side effect are over-valued because of the use of this method. But if they have environmental costs, you don’t use this method, so the cost is not apparent, and at least in my judgment there are several (documented events) of cement pouring that was done supposedly for environmental purposes. So, I think that in the future we really need to be a little bit more careful and develop systems that are more balanced and that may even reduce the amount of build up of modifications. But I think that with the Principles and Guidelines, we move toward something that is working much better than in the past, at least there is some element of credibility.

Actually I really think that one of the things that has happened is that today we move away from water development projects to restoration. And some of the agencies like the Army Corp of Engineers, and Bureau of Reclamation now claim themselves to be environmental agencies; this means we have to do something.

So, the point is that we really move toward a system where first, water becomes an economic good with prices, incentives for water become something acceptable. We have technology and industries that think seriously about the increased water use efficiency, in the same way that they thought about increasing the productivity of crops, and slowly we move toward a system of development that ...where the build up of projects becomes less and less acceptable.

Now this is in the U.S., this is California, in other countries of the world it doesn't happen. In other countries of the world there is a lot of old thinking. A lot of people think that in developing countries there is a high rate of water use per person. But my feeling is that almost in every country there are financial constraints. I think that it is very important and it is very good that environmental concerns are moving across nations, and I think that the globalization and transfer of technology is very powerful. So people, for other reasons, may use drip irrigation, automated irrigation, etc. to grow crops in developing countries.

So, my feeling is that I agree with Peter, that we move to a system where water use and water demand will not grow that fast. And I think that actually what we may see in the future, we will still have some water diversion but the main reason to diversion maybe to generate electric power and other reasons. On the other hand, water resources will be diverted to environmental benefit, that's (already) a trend in the U.S.. There will be more recycling of water and I really believe that one thing that will become a very big use of water in agriculture will be aquaculture. If there is one problem that is a severe environmental and economic problem that will continue is the problem of the sea. Aquaculture has a huge economic potential. It is the same thing as that 10,000 years ago we domesticated the cow and goat, or whatever, that led to our civilization. I really start to see that that is something that will happen in the future -- that a significant part of agriculture will be some form of aquaculture because of the benefit (it has) to feed (people), and because of our increased knowledge about the biology of fish. So even though we may see increased use of water to new

alternatives, overall water demand wouldn't grow very much because of the economic and environmental reasons that I have mentioned.

(*Note*: This is a transcribed talk. It has been only minimally edited, so that the speaker's individual "voice" still comes through. Parts of this tape weren't clear because of fade-out, so I have inserted, from memory, the approximate content of the missing pieces. These fill-ins are in parentheses -- Isha Ray.)