

SESSION III: GREENING THE DEVELOPMENT PARADIGM  
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# DEVELOPMENT IN THE BALANCE: AGRICULTURE AND WATER

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(A draft version of a chapter forthcoming in the book, *Development in the Balance: How Will the World's Poor Cope with Climate Change?*, to be published by the Brookings Institution Press)

## EXECUTIVE SUMMARY:

The poverty implications of climate change with respect to the agriculture and water sectors are threefold. Potential reductions in global food production after 2050 would raise world food prices, creating hardships for many poor households. Low-latitude poor farmers, especially those dependent on rainfed agriculture, may face nearer term reductions in productivity. Water could also become scarcer for both the rural and urban poor. Successful strategies to limit the costs of these impacts should focus on regional development, institutional change, private adaptation, some level of public intervention, and equity frameworks. An underlying theme in all of these strategies is the important lessons we learn from the concepts of private property and market-based organization. The article concludes by emphasizing that regional and institutional development, research, and planning should begin today, but the timing of on-the-ground adaptations will need to be tied to on-the-ground changes.

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The most recent report by the Intergovernmental Panel on Climate Change (IPCC) provides ever more conclusive evidence that climate will continue to gradually warm into the future because of accumulating greenhouse gases. Expected projections of global

temperatures imply continued warming by 2100 of between 2° and 4° C depending on future greenhouse gas emission levels.<sup>1</sup> This paper examines the risk these climate changes suggest for the agriculture and water sectors and what can be done to help reduce the potential harm. The focus of the paper is especially upon the risks to the global poor. There are three key risks to the world's poor from changes to the water and agriculture sector. Global food supplies may go down so that every poor household will face higher food prices. Agriculture in the low latitudes may become less productive dropping the income of many poor rural farmers. Water may become scarcer forcing poor urban dwellers to spend more on essential drinking water and making irrigation water unaffordable to poor farmers.

Changes in global agricultural production will affect every poor household in the world. All of the world's poor spend a disproportionate share of their income on food so they are particularly vulnerable to changes in food prices. Food prices in turn depend on global food supply. A large drop in global food supply will substantially increase food prices. For the first half of the century, it is not likely that climate change will affect global food supply.<sup>2</sup> Reductions in low latitude food production will likely be offset by increases in production in mid to high latitudes. However, climate changes in the second half of the century could start to affect global production especially if warming is on the high end of expectations. As global food supplies fall, food prices will increase, creating hardships for many poor households.

Many of the world's poor are farmers who live in the low latitudes. They are dependent on local agricultural productivity for income. Climate change is likely to have immediate harmful impacts on agricultural productivity in the low latitudes.<sup>3</sup> Reductions in crop productivity are expected to have important economic impacts. For example, African farmers on rainfed farms would lose annual net revenue of \$28/ha per °C.<sup>4</sup> Latin American farmers would lose land value of \$175/ha per °C.<sup>5</sup> Chinese farmers on rainfed farms would lose annual net revenue of \$95/ha per °C.<sup>6</sup> Farmers from India would lose 9 percent of their net revenue/ha per °C. Poor farmers on rainfed farms in the low latitudes are immediately vulnerable to warming. Of course, not every aspect of agriculture is as vulnerable as rainfed crop farming. Irrigated farms are generally not as vulnerable to climate change as rainfed farms<sup>7</sup> and may even benefit from warming.<sup>8</sup> Livestock management is less vulnerable to

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<sup>1</sup> Intergovernmental Panel on Climate Change (IPCC), *The Physical Science Basis* (Cambridge: Cambridge UP, 2007).

<sup>2</sup> IPCC, *Impacts, Adaptation and Vulnerability* (Cambridge: Cambridge UP, 2007).

<sup>3</sup> Ibid.

<sup>4</sup> P. Kurukulasuriya and R. Mendelsohn, "A Ricardian Analysis of The Impact of Climate Change on African Cropland," *African Journal Agriculture and Resource Economics* 2 (2008): 1-23.

<sup>5</sup> N. Seo and R. Mendelsohn, "A Ricardian Analysis of the Impact of Climate Change on South American Farms," *Chilean Journal of Agricultural Research* 68, 1 (2008): 69-79.

<sup>6</sup> J. Wang, R. Mendelsohn, A. Dinar, J. Huang, S. Rozelle and L. Zhang, "Can China Continue Feeding Itself? The Impact of Climate Change on Agriculture," World Bank Policy Research Working Paper 4470 (Washington, 2008).

<sup>7</sup> P. Kurukulasuriya and R. Mendelsohn, "A Ricardian Analysis of The Impact of Climate Change on African Cropland." For Latin American exceptions, see N. Seo and R. Mendelsohn, "A Ricardian Analysis of the Impact of Climate Change on South American Farms."

<sup>8</sup> Wang et al, 2008.

warming than crops. In Africa, although warming causes reductions in crop income, there are offsetting increases in livestock income especially for small farms.<sup>9</sup>

Both rural and urban poor are vulnerable to changes in local water supply. Climate change is likely to alter precipitation patterns.<sup>10</sup> Unfortunately, it is not yet clear how these changes will be distributed across the planet.<sup>11</sup> Even if precipitation does not change, higher temperatures lead to more evaporation and lower (watershed) flows. Possible reductions in water supply coupled with likely increases in water demand will make water scarcer in many countries. Arid countries are particularly at risk but many developing countries rely heavily on their water resources. Poor water management has historically resulted in low returns from available water. As water becomes scarcer, the welfare losses from scarce water grow. Quite often, it is the poor in developing countries who will pay the highest price for water scarcity. For example, the urban poor spend a disproportionate share of their income on drinking water. In addition, many small farmers rely on water for irrigation. Quite often these small farmers are the first to lose their water in water shortages.

## THE SOLUTION

There are five broad sets of solutions for the world's poor:

1. Development can help the poor raise their incomes and move away from the climate sensitive agricultural sector.
2. Institutional changes can be made to allocate resources more efficiently, raising incomes and encouraging efficient adaptation.
3. The poor can help themselves and engage in "private adaptations" to climate change.
4. Governments can invest in "public adaptations."
5. Governments can help with equity issues by compensating poor households and poor regions affected by climate change.

## REGIONAL DEVELOPMENT

Although the source of manmade emissions of greenhouse gases is global economic development, regional economic development is also part of the solution. By improving economic opportunities in low latitude developing countries, poor households who are currently dependent on agriculture for their livelihoods can be given new economic opportunities. New economic opportunities will move farmers out of agriculture into other economic sectors which all tend to be less climate-sensitive than agriculture, especially in the low latitudes. Studies of economic impacts suggest that most economic sectors are not sensitive to climate. Low latitude agriculture is unusually sensitive. Economic advancement will also enrich poor families and allow them to purchase the goods and services they need from outside the region. There is enough food in the world. The only problem is that some

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<sup>9</sup> N. Seo and R. Mendelsohn, "Climate Change Impacts and Adaptations on Animal Husbandry in Africa," *African Journal Agriculture and Resource Economics* 2 (2008): 65-82.

<sup>10</sup> IPCC, *The Physical Science Basis*.

<sup>11</sup> *Ibid.*

people are too poor to buy it. With more income, the former poor will be more independent.

Increasing economic growth rates just slightly can make an enormous difference to income levels in the long run. For example, with an economic growth rate of 2 percent a year, a person currently earning \$1/day would have an annual income of \$2,700 in 100 years. However, if one could increase the economic growth rate to 4 percent a year, that person would earn \$20,000 in 100 years. That person would no longer be poor.

The world has struggled to determine how to actually encourage more rapid economic development.<sup>12</sup> Through bilateral aid and global institutions such as the World Bank or the United Nations Development Program, one approach is to fund individual massive capital investments. Some of these investments are devoted to projects that the private sector would normally make in developed countries. For example, the government can help fund commercial buildings, residential housing, farming equipment, and industrial facilities. Although these investments can stimulate the economy, they are basically substituting for private investment. In practice, government investments of this type tend to be inefficient and ineffective. The public sector is simply not as good as the private sector in determining what economic investments are the most effective. The public sector often has too many objectives and insufficient accountability to effectively compete in the market place.

A second approach is to invest in infrastructure projects that benefit many recipients. Private market forces under invest in infrastructure because investors cannot capture the benefits of their investment since they are often dispersed across many beneficiaries. Projects such as roads, canals, large dams, hospitals, and schools are good examples of infrastructure investments. The government is the natural supplier of infrastructure because presumably the multiple beneficiaries match the government's own interest in supporting society as a whole. Of course, this is slightly naïve as some governments have shown a disproportionate interest in the welfare of only some of their constituents at the cost of others. However, government investments into infrastructure have generally been quite successful in creating wealth and stimulating economic growth.

## INSTITUTIONS

An alternative to investing capital is to create institutions that foster economic development. The most critical of these institutions is private property. One of the great handicaps that developing countries face is that the bulk of their most valuable natural resources are either under public ownership or common property. In both cases, the resources are not efficiently managed and the potential value of these resources is wasted. This leads to underinvestment in the natural capital of biological resources, for example, by over harvesting forests or over grazing grasslands. It also leads to poor management of physical resources such as obtaining low returns from nonrenewable minerals and energy resources as well as water.

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<sup>12</sup> H. Kharas, "The New Reality of Aid," in *Global Development 2.0: Can Philanthropists, the Public, and the Poor Make Poverty History?* eds, Lael Brainard and Derek Chollet (Washington: Brookings Institution Press, 2008).

By changing ownership of these resources into private hands, one can get the incentives of the market place to encourage efficient management of the resource. For example, it is well documented that grazing lands held in common have too many animals. Each farmer considers whether or not to add an animal. Although the next animal may reduce the overall productivity of the grazing land for the village, it is still profitable for the individual farmer. The farmer gets to have one more animal for himself and the reduction in productivity of the grassland is shared by the entire village. Each farmer makes this same choice and the result is too many animals given the available resource. The common ownership leads to private decision makers under investing in the biological capital (the grassland).

Another important example of poor resource management concerns the public ownership of water. Throughout the world, where water is publicly managed, it is often managed inefficiently. The water rarely is allocated to its highest use. Public management of water is plagued by historic precedents, undue influence, poor objectives, and insufficient resources. In almost every water system, it is possible to identify ways that water can be reallocated from low valued to high uses and therefore become more productive. One strategy is to simply improve public management of water. However, the fact that public water management is ineffective in so many places including developed countries, suggests that this is not likely to be successful.

An alternative strategy is to make water a private resource and grant private property rights to water. For example, one could give private property rights to all historic water users. Provided that this allocation was done fairly, no current user of water could be made worse off by this proposal because they would have the right to continue to get the water they have always received. However, what private property rights would allow is that water could be transferred from low valued to high valued uses. People who got low returns from water would find it in their interest to voluntarily sell the water to people who got higher returns. Buying and selling water would establish a market price that would reflect the scarcity of water. This market price would encourage users to look for ways to use water more carefully. Whatever water they saved, they could sell on the market. The market would create self incentives for water to be efficiently allocated and used across myriad users. No government bureaucracy would be needed except to enforce the private property rights of all users. Similar results could be obtained from forests, grasslands, and nonrenewable resources as private owners of these resources look to use them more carefully.

## **PRIVATE ADAPTATION**

A third part of the solution is that the poor must help themselves and adapt to climate change. They must engage in private adaptations that make each household, each farm, and each firm better off. Individual poor households should engage in whatever private adaptations improve their welfare. The complete list of all the choices that make people better off are “efficient adaptations” by definition. Efficient adaptations make the decision maker better off and so it is in the self interest of every household to adapt to climate change. Poor households (as well as every other household) should be encouraged to follow through and adopt efficient adaptations. Programs, even well intentioned programs that remove this incentive are not really helping the poor. For example, social insurance

programs that pay poor people to remain in harms way as the climate changes are actually harmful in the long run. They keep damages high and make poor people dependent.

Some important examples of private adaptation in agriculture include switching from crops to livestock, installing irrigation, and switching crop types or livestock species. These adaptations can help reduce the losses that climate change would otherwise cause and in some cases can even make farmers better off than if climate remained unchanged. For example, when there is sufficient water, agriculture can protect itself from climate change by moving from rainfed to irrigated farming.<sup>13</sup> Farmers can move from crops that grow in cool locations to crops that are more suited to warm locations. For example in Africa, farmers will want to move from maize and groundnut to millet and fruits and vegetables as temperatures warm.<sup>14</sup> In Latin America, farmers can switch from wheat to maize and soybeans to squash and fruits.<sup>15</sup> Similarly, livestock owners can switch from livestock that are more productive in cold locations to livestock suited for warm environments. In Africa, farmers can switch from beef cattle and chickens to goats and sheep as climates warm.<sup>16</sup> In Latin America, farmers can switch from beef cattle and pigs to sheep.<sup>17</sup> Of course, it is important to remember that adaptation is local and must be done to suit local conditions. Farmers should not make the same changes everywhere and at the same time.

It may also be the case that new varieties or new breeds could enhance the opportunities of low latitude farmers to adjust to new climates. Crops and livestock more suited for the new climates likely under global warming would give farmers new opportunities that they do not yet have. For example, Brazil has developed a new soybean variety that is suited to grow in the Mato Grosso. Although this particular application is resulting in rapid deforestation of the Amazon and may not be the best thing for carbon emissions, it is a concrete example of climate adaptation. Such engineering solutions are likely to help in the future.

In the water sector, the key to private adaptation is improved water management. In almost every country in the world, water is not allocated efficiently. That is, the marginal value of water is not the same for every user. Some users place a very low value on water whereas other users place very high values. In general, urban and industrial users place very high values on water whereas some farmers in the same water basins essentially value water as if it had no value at all. This is very inefficient. Moving just a small amount of water out of low valued uses and putting that water in high valued uses would increase the overall value of the water resource dramatically. If climate change reduces the supply of water and increases the demand for water, the problem will become more severe. Improving the efficiency of water allocation is therefore a high priority.

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<sup>13</sup> P. Kurukulasuriya and R. Mendelsohn, "Modeling Endogenous Irrigation: The Impact Of Climate Change On Farmers In Africa," World Bank Policy Research Working Paper 4278 (Washington, 2008); Wang et al, 2008.

<sup>14</sup> P. Kurukulasuriya and R. Mendelsohn, "Crop Switching as an Adaptation Strategy to Climate Change," *African Journal Agriculture and Resource Economics* 2 (2008): 105-126.

<sup>15</sup> N. Seo and R. Mendelsohn, "An Analysis of Crop Choice: Adapting to Climate Change in Latin American Farms," *Ecological Economics* (forthcoming).

<sup>16</sup> N. Seo and R. Mendelsohn, "Climate Change Impacts and Adaptations on Animal Husbandry in Africa."

<sup>17</sup> N. Seo and R. Mendelsohn, "An Analysis of Livestock Choice: Adapting to Climate Change in Latin American Farms," World Bank Policy Research Working Paper 4164 (Washington, 2007).

The suggestion earlier to create private property rights for water was designed to address the current inefficiency of water allocation and use. However, it is also important to understand that private property will also encourage efficient adaptation. As climate changes, it will likely affect both water supply and water demand. The change in water supply will occur if there are fluctuations in precipitation or just more evaporation from higher temperatures. Higher temperatures will also cause some users to have higher water demand as they seek to offset the harmful effects of increased evaporation on crops and other vegetation. Water is likely to become scarcer in many locations. Users should make more sincere efforts to reduce use. Water should also be reallocated from low to high users because of the shift in demand. A water market would create incentives to make all these changes efficiently. In other words, a water market would create the self incentives to adapt efficiently. The adaptations will not necessarily eliminate all damages but they will keep net damages as low as possible. With a water market, the changes will not require modifications in the institution but rather will occur automatically.

### **PUBLIC ADAPTATIONS**

Markets, however, cannot make all the changes required to adapt to climate change. Markets will make changes that benefit individual decision makers such as households or firms. Changes that benefit many decision makers, many households or many firms, are not likely to be made efficiently by markets. These “public adaptations” that have multiple beneficiaries will require government assistance or they will often not be made. For example, it may be attractive that new varieties of crops be created to help farmers in new climates. It is not clear whether private companies will invest in the research and development to create these new choices. It may be desirable that new canals be built to expand irrigation acreage for many farmers. Although the farms may be private, the canals often will require government help. Dams may be needed to hold back increased spring melt under climate change or the runoff from severe storms so that there is reduced flooding and more water available for more productive summer uses. All of these changes require government assistance.

### **EQUITY**

A final part of the solution must address equity. Although the bulk of greenhouse gases are emitted by relatively wealthy countries from the mid to high latitudes, the bulk of the damages will be borne by low latitude countries with most of the world’s poor.<sup>18</sup> The global community needs to consider compensation as part of climate change policy. Compensation can take many forms. The most effective strategy is to help low latitude countries develop more quickly. This will increase income and offset future damages. An alternative approach is to simply send cash to households to spend as they will but this creates a permanent dependence. An even less effective approach is to send specific goods such as food or medicine. Quite often these goods are simply excess supplies in donor countries and may or may not be what is needed in the recipient country. There is a lot of waste in this last approach.

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<sup>18</sup> R. Mendelsohn, A. Dinar and L. Williams, “The Distributional Impact of Climate Change on Rich and Poor Countries,” *Environment and Development Economics* 11 (2006): 1-20.

One important policy that should be avoided is to provide compensation for damages as they occur. It is easy to imagine that the global community or greenhouse gas emitters would consider case by case compensation as one way to help poor low latitude countries with actual damages. This is likely to be completely ineffective because it will be very hard to identify the bulk of climate damages. Most climate damages will occur slowly over time and will not be easily separated from a myriad of other changes. They will be gradual lost opportunities rather than discrete catastrophes. They are not going to be easily identifiable discrete events such as storms or floods. Further, compensation creates an incentive to stay in harms way. That is, compensation removes any incentive for harmed countries or individuals to adapt and reduce damages. The compensation package provides an incentive to increase the harmfulness of climate change.

Development, planning, research, and improving institutions are all activities that can be undertaken immediately. They are generally inexpensive and they provide immediate benefits as well as long lasting returns as climate changes. The benefit to cost ratio is good and there are no complicated questions of timing. They are activities which should begin now.

However, on the ground adaptation investments must be dynamic and match climate as it changes. One must be very careful with adaptation to get the timing right. Done too soon, the costs skyrocket and the impacts can turn from beneficial to harmful. For example, planting a new crop designed for a warmer climate before the climate actually warms may be counterproductive. Done too late, the damages from climate change also climb. A farmer that hangs on to a crop that is no longer producing will suffer many years of low productivity. The world consequently must be patient and let climate change before rushing into expensive adaptation actions. Yet the world must also be ready to act when the time comes and the changes are needed.