# Coping with Climate Change: A Food Policy Approach

C. Peter Timmer

Contributed paper prepared for presentation at the 57th AARES Annual Conference, Sydney, New South Wales, 5th-8th February, 2013

# Coping with Climate Change: A Food Policy Approach

C. Peter Timmer

## ABSTRACT

The early drafts of *Food Policy Analysis* were stimulated by the attention to high food prices following the world food crisis in 1973-74, and the fears of a repeat in 1979-80. But by the fourth full draft, in 1982, it became apparent that surpluses were returning to world food markets. A volume predicated on a world running out of food would have been out of date before the ink was dry, and a full-scale revamping of the analytical messages was needed. After a nearly complete re-write, the new theme, which has stood the test of thirty years of market fluctuations, was the need for flexibility to cope with market instability. That message is even more relevant now, as we learn to cope with a new source of instability—climate change.

Such flexibility is not a natural feature of domestic policy making, in the food sector or elsewhere, and providing the analytical tools for understanding how to create flexible responses turned out to be a real challenge. The task in this paper is to ask specifically how climate change would alter the basic message of *Food Policy Analysis*. Virtually all of the analysis was focused on national policies and domestic markets, an approach that seems problematical for *preventing* or *mitigating* climate change, but entirely appropriate for *designing adaptation strategies*.

Climate change is imposing itself as a reality via the increased probability of extreme weather events in general, but also on both global and localized food security outcomes in particular. The ecosystem services provided by the climate are essential for all agricultural production. The most important effects of climate change on agriculture are likely to include a net global loss of agricultural land, changing crop suitability, an increase in the frequency of natural disasters, and greater temporal and geographic variance in production. It will also have negative effects on other areas of agriculture broadly interpreted--reducing the carrying capacity of many rangelands and posing threats to fisheries and aquaculture production systems.

Climate change is expected to have highly variable effects on different regions; tropical and equatorial regions will bear the heaviest burdens, with some gains in yields and land availability in temperate regions. Since rural poverty is concentrated in tropical and, in South Asia, coastal areas, climate change is expected to have a disproportionate effect on the already vulnerable. The challenge is to design, analyze and implement in-country "climate-smart agriculture" adaptation projects and programs, which are now part of the food policy agenda, as well as improve the openness to trade in agricultural commodities to even out geographical instability. Designing appropriate policies for bio-fuels also needs to be on the analytical agenda.

# Coping with Climate Change:

# A Food Policy Approach

C. Peter Timmer[1]

It has been 30 years since *Food Policy Analysis* (Timmer, Falcon and Pearson, 1983) was published and more than 35 years since the initial outline for the book was circulated among the authors. It is fair to say that the volume has been very influential in thinking about food policy issues since its publication, and it remains in use as a textbook for a number of university courses.[2] Its academic success is a bit surprising because the audience was not primarily university faculty (for whom it seemed too simplistic in methodology and too anecdotal in presentation). Instead, we targeted the message at practitioners, an ill-defined group of analysts in need of an understanding of how a complicated and interconnected food system actually worked. Training these practitioners has turned out to be the main mission of the book, and one that has continuing resonance.

The early drafts of *Food Policy Analysis* (henceforth FPA) were stimulated by the attention to high food prices following the world food crisis in 1973-74, and the fears of a repeat in 1979-80. But by the fourth full draft, in 1982, it became apparent that surpluses were returning to world food markets. A volume predicated on a world running out of food would have been out of date before the ink was dry, and a full-scale revamping of the analytical messages was needed. After a substantial re-write, the new theme, which has stood the test of thirty years of market fluctuations, was the need for flexibility to cope with market instability. That message is even more relevant now, as we learn to cope with a new source of instability—climate change.

Such flexibility is not a natural feature of domestic policy making, in the food sector or elsewhere, and providing the analytical tools for understanding how to create flexible responses both to high and low price environments turned out to be a real challenge. But the relevance of the approach remains to this day, accounting for the continued usefulness of an analytical guidebook that is three decades old.

---

[1] This paper was prepared for the Australian Agricultural and Resource Economics Society (AARES) meetings in Sydney, February, 2013. Some of the observations on *Food Policy Analysis* appeared in Timmer (2010b). I would like to thank Marshall Burke, Wally Falcon, Casey Friedman, Joanne Gaskell, David Lobell, and Roz Naylor for very helpful comments and suggestions. These colleagues all know far more than I do about climate change, and I am learning a lot from them. However, I remain responsible for the views and shortcomings in this essay.

[2] Although long out of print, the volume remains available on-line at a Stanford University website: http://www.stanford.edu/group/FRI/indonesia/documents/foodpolicy/fronttoc.fm.html

**The Basic Message**

There was no mistaking the ambitiousness of the primary goal of FPA: rapid and sustained poverty reduction. At the time of drafting, there was not even agreement in the development profession that such a goal was feasible. Paul Streeten had published *First Things First: Meeting Basic Human Needs* in 1982, eloquently arguing that rapid growth was not possible and that development strategy needed to focus on providing basic needs to the poor. The focus of FPA on more rapid economic growth, and the policies to enhance efficiency that would bring it about, were controversial for a volume that took poverty seriously.

But FPA argued that growth was not enough. There were four basic food policy objectives, and all four were important:

1. Faster economic growth (the "efficiency" objective),
2. More equal distribution of income from that growth (the "welfare" objective),
3. A guaranteed nutritional floor for the poor (the "safety net" objective), and
4. Secure availability and stable prices in food markets (the "food security" objective).

Clearly, there can be trade-offs (and overlap) among these objectives, and substantial analysis of a country's food system was necessary to understand, if even roughly, the magnitudes of the trade-offs. The central organizing theme of the analysis was the "food price dilemma," an explicit recognition that a single market-clearing food price could not satisfy all four objectives simultaneously—a "pure" market solution would not work. Additional policy instruments were needed, *but they all needed to operate compatibly with market prices*. If readers came away with only one lesson from reading FPA, it was the centrality of food prices—and the signals they sent to farmers, traders, consumers and finance ministers.

The behavior of these decision-making agents dictated market outcomes, but also responded to those market outcomes. The "macro" food system that food policy analysts needed to understand encompassed micro behavior on the farm and in the household, market-level behavior by traders, processors and retailers, and macroeconomic responses by policy makers. The essential message from FPA was that such understanding, in most circumstances, could not come from complicated models that tried to capture econometrically all the behavioral and market relationships. Instead, the understanding needed to come from a simpler "vision" of how the food system operated. This vision was partly created by the framework and analytical discussion in FPA itself, but more importantly, from the data and simple analysis that practitioners were urged to generate.

With more than three decades of hindsight, it is easy to see several themes that received little attention in FPA but which would require extensive treatment today. Gender played a minor role in the analysis, reflecting the dominance of the "unitary household" model of farm and

household decision making at the time (a model that still has considerable relevance, especially in East and Southeast Asia). Further treatment of intra-household decision making, especially with respect to nutrient intake and schooling decisions, is now possible. A "behavioral" perspective would add power to efforts to understand formation of expectations, attitudes toward risk, as well as participation of farmers and households in financial markets. With this behavioral understanding should also come a much more useful political economy framework for understanding policy choices, a topic explicitly left out of FPA (Timmer, 2012). Neither "environment" nor "sustainable" appears in the index (although "petroleum prices" have three entries), much less the problems looming from climate change.[3] All should be incorporated into the analysis now. The task in this paper is to ask specifically how climate change would alter the basic message of FPA.

Virtually all of the analysis was focused on national policies and domestic markets, an approach that seems problematical for preventing or mitigating climate change, but entirely appropriate for designing adaptation strategies (Lobell and Burke, 2010). The international linkages to these markets were stressed and analyzed, but nearly all food policy interventions are designed and implemented by domestic actors. There are no international "food policy makers," unless you count individuals such as Bill Gates or Jim Kim, who have money and speeches to give, but not policy levers to pull. The food crisis of 2008 saw a renewal of this domestic policy focus, despite the arguably larger role now played by global integration of factor and commodity markets. And the prospects for global action on climate change now seem dim.[4]

**The changing global environment**

The international context for domestic food policy decision making has changed substantially since FPA was drafted in the early 1980s. Six basic trends stand out:

1. The last four decades have seen surprisingly rapid economic growth, especially in Asia, with hundreds of millions of people pulled out of poverty. The strong connection between inclusive economic growth, especially in rural areas, and rapid reduction of poverty was simply not apparent in the empirical record in the early 1980s. *The East Asian Miracle* (World Bank, 1993) did not appear for another decade. This rapid growth validated the central theme of FPA, which was the unsustainability of poverty reduction efforts without higher economic productivity of unskilled, especially rural, labor. That theme remains powerfully relevant today.

[3] In the late 1970s and early 1980s there was serious debate over whether the earth was warming or cooling.

[4] As all of my Stanford colleagues pointed out, some countries are large enough that domestic policies have global impact: deforestation in Brazil and Indonesia, use of coal in China, the "Asian Brown Cloud" over India, and use of corn for bio-fuel production in the United States are obvious examples. The absence of "global food policy makers" does not rule out the role of international institutions such as WTO or FAO in influencing global food security.

2. A communications revolution at both the household and international levels has radically reduced transactions costs and increased access to knowledge. Again, the centrality in FPA of markets and price formation to understanding food policy design and implementation received a boost as marketing margins narrowed under improved and more informed competition. Consumers and farmers both benefited from more competitive local food markets. The "supermarket revolution" has merely accelerated these changes (Timmer, 2009b, Reardon and Timmer, 2012).

3. Global financial markets became interested in "emerging economies." The early 1980s were an era of fixed exchange rates, tight controls on the flow of foreign capital, and virtually no financial intermediation beyond state banks. At first, the influx of foreign capital in the 1990s was welcomed as a sign of confidence, but except for foreign direct investment in "real" assets such as factories and real estate, the global financial interest in emerging economies was a two-edged sword. A rapid influx could cause currency appreciation and a loss of competitiveness; its rapid exit when the economy started to decline or foreign investors saw better opportunities elsewhere caused a crisis in local financial markets. Global financial integration came with very poorly understood risks, and 2009 demonstrated them clearly. The growth of foreign investments in land to produce food and/or bio-fuels for export—so-called land-grabs—is controversial, but at least the capital cannot leave the country quickly. The injection of new capital into agriculture in poor countries may not be all bad.

4. The rapid emergence in the 1990s of China and India as global growth engines meant a gradual shift in the drivers of demand for commodities and natural resources. Advanced economies had become more knowledge-driven and less dependent on energy, metals, and other basic commodities—including food commodities—to fuel their economic growth. The price depression for nearly all commodities in the 1980s and 1990s reinforced the view that the future depended on value added from skills and knowledge, not from exploitation of natural resources. But industrialization, especially as practiced by China and India, is a very intensive user of natural resources (and producer of greenhouse gases). By the turn of the millennium it was increasingly clear that the growth path of developing countries was the primary driver of commodity prices, starting with energy prices but quickly extending to food prices. The Malthusian challenge was back, but with two decades of neglected investments in raising agricultural productivity, the challenge is turning out to be hard to meet.

5. High energy prices have turned out to be a "game changer" for agriculture and the food economy. Once oil prices were high enough to justify using sugar, maize, or vegetable oils to produce gasoline or diesel substitutes, agricultural commodity prices became directly linked to oil prices. The concern to reduce emissions of greenhouse gases to mitigate climate change provided ample motivation to US and European legislatures to

mandate the use of domestic food crops to produce liquid fuels. The combination of legislative mandates, which provided essential risk coverage to investors in bio-fuel facilities, and high oil prices, which provided market-based incentives, led to a new set of linkages between agriculture and the energy sector.[5] There had long been a link on the supply side, as energy prices affected fertilizer costs, fuel costs for tractors and trucks, and the economics of global supply chains. The new link was through the demand side. Higher prices for energy translated directly into greater demand for food commodities to convert into liquid fuels.

6. Climate change is imposing itself as a reality on the increased probability of extreme weather events in general, but also on both global and localized food security outcomes in particular. The ecosystem services provided by the climate are a *sine qua non* for all agricultural production—photosynthesis remains the most efficient way to capture solar energy for human use. The most important effects of climate change on agriculture are likely to include a net global loss of agricultural land, changing crop suitability, and an increase in the frequency of natural disasters. It will also have negative effects on other areas of agriculture broadly interpreted; climate change will reduce the carrying capacity of many rangelands and pose threats to fisheries and aquaculture production systems.

   Climate change is expected to have highly variable effects on different regions; tropical and equatorial regions will bear the heaviest burdens, with Sub-Saharan Africa probably facing the greatest challenges, with some gains in yields and land availability in temperate regions.[6] Since rural poverty is concentrated in tropical and, in South Asia, coastal areas, climate change is expected to have a disproportionate effect on the already vulnerable. The growing urbanization of poverty, the result of dysfunctional structural transformations (especially in Africa and India), may change the geographic incidence of the impact of climate change on the poor, but probably not the overall level (Ravallion, Chen and Sangraula, 2007; Badiane, 2011; Binswanger-Mkhize, 2012).

   Agriculture also plays an important role in driving climate change, accounting for 14 percent of global greenhouse gas emissions, and this figure more than doubles when deforestation and other land-use changes are included. Forests, thus, are a crucial global natural resource for climate change mitigation. At the global level, the challenge of climate change for the international architecture in agriculture is to continue pushing towards an overarching global climate deal, while contributing to other schemes that

[5] The link between bio-fuels policies and food prices is complicated and depends on fundamentals in energy and food markets as well as on policies. This complexity has become the topic of intensive research—for examples see de Gorter and Just (2010), de Gorter and Drabik (2012) and Naylor (2012).

[6] Marshall Burke, in a personal communication, has provided a list of why Africa is likely to be more impacted by climate change than other regions, but the most obvious is that "Africa is already hot."

support and provide incentives to the absorption and reduction of emissions at the country level. In-country "climate-smart agriculture" adaptation projects and programs now form part of the food policy agenda. The challenge is to design, analyze and implement these projects and programs.

**What should food policy analysts do now?**

Despite these changes in the international context, the three basic analytical messages from FPA remain intact: the need for "incentive" food prices to stimulate food production and the rural economy, the use of border prices to measure long-run opportunity costs of production and consumption, and the integration of macro and trade policy into the food policy debate (there was a clear recognition that energy prices were part of macro policy, but perhaps not enough was made of how they connected to food prices directly).

1. The need for price incentives to stimulate production was one of the main themes in FPA, and its importance was reflected by the fact that the chapter on food consumption and nutrition came before the production chapter. Why? This material laid out the analytical underpinnings for the targeted consumer subsidies that would be needed to cope with higher food prices. Because of the overriding concern for poverty reduction in FPA, it argued that policy analysts had to design these subsidy programs and be ready to implement them *before* the move to higher prices for farmers was initiated. At the time, the higher prices were seen as a policy choice, one that overcame the historical discrimination against agriculture seen in most countries' rural-urban terms of trade, as compared with border prices.

   The long-run decline in world food prices from the early 1980s to the mid-2000s gradually called this strategy into question. On one hand, the decline was welcome because it raised the real purchasing power of the poor. Since much of the decline was stimulated by the Green Revolution and sharply reduced costs of production for rice and wheat, the decline seemed "sustainable," at least in narrow economic terms. The low prices also speeded up the structural transformation, with rapid exit of small farmers from the agricultural sector. This too was "sustainable" in countries with rapidly growing and labor-intensive export industries, as the labor was absorbed while real wages rose. Of course, countries *without* dynamic macro economies had the benefit of low food prices, but real wages stagnated and poverty rose. The dysfunctional structural transformations in Africa (Badiane, 2011) and India (Binswangeer-Mkhize, 2012) are examples.

   The problem was that low food prices in world markets also sent investment signals to governments, donors and research institutions, encouraging them to walk away from the agricultural sector as a crucial source of productivity growth, food security,

and poverty reduction. Reduced investments in agriculture and rural infrastructure throughout the 1980s and 1990s resulted in falling rates of productivity growth. Eventually, as students of cobweb cycles understand, growth in food production fell behind growth in food consumption, scarcity re-emerged, and market prices spiraled higher. The world food crisis in late 2007 and early 2008 had its roots directly in this earlier neglect of agricultural investments. Markets were sending the wrong signals to public decision makers, even if private decision makers had no recourse except to heed them (Timmer, 1995).

The urgent need to find efficient and effective mechanisms to implement food subsidies for the poor, the main point of the chapter on food consumption and nutrition in FPA, seems sadly relevant three decades later. There are more sophisticated approaches now, using conditional cash transfers, improved information technology for screening, and the realization that broader social safety nets might be just as effective as narrower food subsidies. But the food price dilemma has not gone away.

2. Border prices for tradable commodities are the standard measure of opportunity costs for long-run decisions about production and consumption. Although this was beginning to be accepted in principle in the early 1980s, the prevalence of fixed exchange rates and relatively opaque government-to-government trade deals for important food commodities meant that much of the analysis was devoted to figuring out exactly what the long-run border price actually was. This probably seems like arcane history.

   There were two problems: knowing what exchange rate to apply, and knowing whether short-run price quotations in world markets reflected longer-run opportunity costs. Much of the project appraisal literature from the late 1970s and early 1980s was devoted to determining the "shadow exchange rate" to be used to calculate effective border prices. Much of *Getting Prices Right* (Timmer, 1986), a "price policy" follow-on to FPA, was devoted to understanding the relevant long-run price trends to use for making public sector investments and to manage domestic price policy interventions.

   The first problem has largely been solved, as most countries have adopted reasonably flexible exchange rates that permit the market to indicate the opportunity cost of foreign exchange (although speculative flows of foreign currency make even the market rate somewhat unreliable). Finding the appropriate long-run price signal in the short-run fluctuations still seen in world commodity markets remains elusive. The concern for doing so, clearly articulated in FPA, remains a challenge to food policy analysts (Timmer, 2010a). Coping with food price volatility is going to be an even

more challenging task in the future as climate change is likely to increase the variability of staple food production.

3. Perhaps the most revolutionary argument in FPA was its insistence that food policy analysis needed to incorporate macro economic and trade policy. The argument was not that the policy environment needed for a healthy food system should dictate overall macro and trade policy (although there were certainly some poor agrarian countries where that was likely to be true). The argument was the need for an informed dialogue between food policy analysts and macro policy analysts, with each understanding the stakes on the other side of the table.

   Experience over the past three decades has shown the real benefits of this policy dialogue. First, the need for rapid growth in agricultural productivity, with substantial participation by small farmers where they are a significant part of the production structure, is increasingly recognized by macro policy makers as a key element in the overall development strategy. Finance ministers, with their hands on fiscal policy and public investment allocations, central bankers, with their hands on exchange rates and money supplies, and heads of planning agencies, with their hands on strategic approaches and sectoral resource allocations, understand now their own stakes in a healthy rural economy.

   In return, food and agricultural planners increasingly understand that real wages in rural areas depend fundamentally on real wages in the urban economy. Real food prices for farmers and consumers are conditioned by the rate of inflation and by exchange rates. Investments in rural infrastructure require budget allocations. Trade policy has direct and indirect effects on rural incentives. The need for a "macro food policy" has never been clearer.

**What international regime will be in play?**

The components of this macro food policy will be conditioned, as never before, by the international context in which it is formulated. It is both exciting, and troubling, that this international context—the "global food price regime"—is in a greater state of flux, with more uncertainty, than at any time since FPA was being drafted. Institutionally, the current global food policy regime features somewhat more open food markets (although the extent of openness can easily be overstated, especially during crises) and there is virtually no support for public interventions into price formation in global markets, for example, to stabilize or support commodity prices. Thus the international context is now primarily driven by what happens in these markets as a result of basic supply and demand forces, trade policy, and the new connection between food prices and energy prices (mostly driven by policies in rich countries).

Which global food price regime will drive policy formation in the coming quarter century? Will it be the historical path of structural transformation with falling food prices, leading to a "world without agriculture" (Timmer, 2009a)? Or will continued financial instability, coupled with the impact of climate change, lead to a new and uncertain path of rising real costs for food with a reversal of structural transformation (Timmer and Akkus, 2008)? Management of food policy, and the outlook for sustained poverty reduction, will be radically different depending on which of these global price regimes plays out.

### *A. The historical pathway of structural transformation with falling food prices*

The structural transformation involves four main features:

1. a falling share of agriculture in economic output and employment,
2. a rising share of urban economic activity in industry and modern services,
3. migration of rural workers to urban settings, and
4. a demographic transition in birth and death rates that always leads to a spurt in population growth before a new equilibrium is reached.

These four dimensions of the historical pathway of structural transformation are experienced by all successful developing economies; diversity appears in the various approaches governments have tried to cope with the political pressures generated along that pathway. Finding efficient policy mechanisms that will keep the poor from falling off the pathway altogether has occupied the development profession for decades. There are three key lessons.

First, the structural transformation has been the main pathway out of poverty for all societies, and it depends on rising productivity in *both* the agricultural and non-agricultural sectors (and the two are connected). The stress on productivity growth in both sectors is important, as agricultural labor can be pushed off of farms into even lower productivity service sector jobs, a perverse form of structural transformation that has generated large pockets of urban poverty, especially in Sub-Saharan Africa and India. Both of these cases have been documented in the Stanford Symposium Series on Global Food Policy and Food Security in the 21st Century (Badiane, 2011; Binswanger-Mkhize, 2012).

Second, in the early stages, the process of structural transformation *widens* the gap between labor productivity in the agricultural and non-agricultural sector. This widening puts enormous pressure on rural societies to adjust and modernize. These pressures are then translated into visible and significant policy responses that alter agricultural prices. The agricultural surpluses generated in rich countries because of artificially high prices then cause artificially low prices in world markets and a consequent undervaluation of agriculture in poor countries. This undervaluation over the past several decades, and its attendant reduction in agricultural

investments, is a significant factor explaining the world food crisis in 2007/08 and continuing high food prices.

Third, despite the decline in relative importance of the agricultural sector, leading to the "world without agriculture" in rich societies, the process of economic growth and structural transformation requires major investments in the agricultural sector itself. This seeming paradox has complicated (and obfuscated) planning in developing countries as well as donor agencies seeking to speed economic growth and connect the poor to it.

The historical process of structural transformation might seem like a distant hope for the world's poor, who are mostly caught up in eking out a living day by day. There are many things governments can do to give them more immediate hope, such as keeping staple foods cheap and accessible, helping connect rural laborers to urban jobs, and augmenting educational and health services in rural areas. But for poverty-reducing initiatives to be feasible over long periods of time—to be "sustainable" as current development jargon would have it—the indispensable necessity is a growing economy that successfully integrates the rural with urban sectors, and stimulates higher productivity in both. That is, *the long-run success of poverty reduction hinges directly on a successful structural transformation*. The historical record is very clear on this path.

Coping with the distributional consequences of rapid transformation has turned out to be a major challenge for policymakers over the past half century and the historical record illuminates what works and what does not. Trying to stop the structural transformation simply does not work: and certainly does not work for the poor. Investing in the capacity of the poor to benefit from change, however, does seem to work. Investments in human resources—especially investments in education and health—are the most promising pathways here. Such investment strategies can only be successful if the rest of the economy is doing well, and they typically require significant public sector resources and policy support to enhance rural productivity. These rural investment strategies depend on political processes that are themselves conditioned by the pressures generated by the structural transformation.

A "world without agriculture" would actually make life much easier for development agencies and for politicians in rich countries. "Getting agriculture moving" in poor countries is a complicated, long-run process that requires close, but changing, relationships between the public and private sectors. Donor agencies are not good at this. More problematic, the process of agricultural development requires good economic governance in the countries themselves if it is to work rapidly and efficiently. Aid donors cannot hope to contribute good governance themselves—and may well impede it.

The strong historical tendency toward a widening of income differences between rural and urban economies during the initial stages of the structural transformation is now extending much further into the development process. Consequently, with little prospect of reaching quickly the

turning point, where farm and non-farm productivity and incomes begin to converge, many poor countries are turning to agricultural protection and farm subsidies sooner rather than later in their development process. The tendency of these actions to hurt the poor is then compounded, because there are so many more rural poor in these early stages.

### *B. Climate change, bio-fuels, rising food prices, and the potential to reverse the structural transformation*

Will climate change lead to a reversal of long-run downward trends in real prices of agricultural commodities? This reversal would be driven by demand for bio-fuels and by the impact of climate change on agricultural productivity—but it would also reverse the steady movement to higher income levels of the turning point in convergence of labor productivity in rural and urban areas during the structural transformation. If so, the short-run impact on the poor is almost certain to be negative, but the higher real returns promised to commodity producers, without agricultural protection, could stimulate the broad array of rural investments needed to generate productivity increases in rural areas, raise real wages, and be the long-run pathway out of rural poverty. Climate change might actually make many farmers better off.

**Bio-fuels and food policy**

Bio-fuels are not new. Although coal was known in China in pre-historic times, and was traded in England as early as the 13$^{th}$ century, it was not used widely for industrial purposes until the 17$^{th}$ century. Until then, bio-fuels were virtually the only source of energy for human economic activities, and for many poor people they remain so today. But the widespread use of fossil fuels since the Industrial Revolution has provided a huge subsidy to modern economic activities—because coal and later petroleum were so cheap--a subsidy which seems to be nearing an end.

What will be the role of bio-fuels going forward, and what will be the impact on agriculture? In the extreme, the demand for bio-fuels in rich countries to power their automobiles has the potential to raise the price of basic agricultural commodities to such a level that the entire structural transformation could be reversed. If so, the growing use of bio-fuels has two alternative futures: it could spell impoverishment for much of the world's population because of the resulting high food prices, or it could spell dynamism for rural economies and the eventual end of rural poverty. Which future turns out to be the case depends fundamentally on the location, technology, economics, and politics of bio-fuel production.

The potential devastating effects of bio-fuels are easy to conceptualize (Naylor, 2012). The income elasticity of demand for starchy staples (cereals and root crops for direct human consumption) is less than 0.2 on average, and falling with higher incomes—it is already negative in much of Asia. Adding in the indirect demand from grain-fed livestock products brings the average income elasticity to about 0.5, and this is holding steady in the face of rapid economic

growth in India and China. Potential supply growth seems capable of managing this growth in demand.

But the demand for bio-fuels is almost insatiable in relation to the base of production of staple foods (a point emphasized on page 185 of FPA). The income elasticity of demand for liquid fuels for automobile and truck fleets, not to mention power generation, is greater than one in developing countries. The average for the world is rising as middle class consumers in China, India and beyond seek to graduate from bicycles to motorbikes to automobiles. One simple calculation shows the dimension of the problem: if all the corn produced in the United States were used for ethanol to fuel automobiles, it would replace just 15 percent of current gasoline consumption in the US. Something has to give.

If this were a market-driven process, it is easy to see what will give. High grain prices will make ethanol production uneconomic, driving down the demand (and returns on investments in ethanol processing plants). Greater profitability of grain production will stimulate a supply response, although this may take several years if improved technologies are needed. Grain prices will reach a new equilibrium, with demand from the bio-fuel industry having only a modest impact.

This is not the scenario most analysts see. Instead, political mandates to expand bio-fuel production in many countries will continue to drive investments in processing facilities and the need to keep these profitable in the face of high raw material prices will require large public subsidies. Rich countries will be able to afford these more easily than poor countries, so a combination of inelastic demand for fuel and a willingness to pay large subsidies will keep grain prices very high (Naylor, 2012; de Gorter and Just, 2010).

If this scenario plays out, what are the consequences for economic growth and poverty reductions in developing countries? Not surprisingly, the answer depends on the role of agriculture in individual countries, the pattern of commodity production and the distribution of rural assets, especially land. It is certainly possible to see circumstances where small farmers respond to higher grain prices by increasing output and reaping higher incomes. These incomes might be spent in the local, rural non-farm economy, stimulating investments and raising wages for non-farm workers. In such environments, higher grain prices could stimulate an upward spiral of prosperity.

An alternative scenario seems more likely however, partly because the role of small farmers has been under so much pressure in the past several decades. If only large farmers are able to reap the benefits of higher grain prices, and their profits do not stimulate a dynamic rural economy, a downward spiral can start for the poor. High food prices cut their food intake, children are sent to work instead of school and an intergenerational poverty trap develops. If the poor are numerous enough, the entire economy is threatened, and the structural transformation comes to a halt. The share of agriculture in both employment and GDP starts to rise, and this reversal

condemns future generations to lower living standards. There will be much more "structural" poverty, and countries determined to cope with it will find themselves supporting expensive and long-term safety nets for the poor.

A reversal of the structural transformation as the regular path to economic development and reduced poverty will be a historical event, countering the patterns generated by market forces over the past several centuries. Such an event is likely to have stark political consequences, as populations do not face the sustained prospect of lower living standards with equanimity. It is possible, of course, that new technologies will come on-stream and lower energy costs across the board and thus allow the bio-fuel dilemma to disappear quietly. But it looks like a rocky couple of decades before that happens.

**A food policy response to climate change**

The bio-fuel challenge to food policy analysts stems from efforts to mitigate climate change. Equally challenging will be efforts to adapt agriculture to the dual effects of climate change—higher temperatures and greater variability in rainfall. In their summary to the chapter on "Food Security and Adaptation to Climate Change: What Do We Know?" Burke and Lobell make the following observations:

> The rapid pace of climate change and its anticipated large negative effects on many agricultural systems suggest a broad and pressing need for adaptation. For farming households, the nature of these responses will depend on their recognition that climate is changing and their ability to adjust their behavior in response, perhaps through altering farm management practices or diversifying into off-farm income-generating activities. Such responses must happen in the context of climate variability, which can obscure longer-run climate trends and make more risky the adoption of various adaptation measures. Further contributing to the difficulties is the limited choice set already faced by many food insecure households, which is often the result of high productivity risk, lack of access to insurance and credit, and/or limited connection to functioning input and output markets.
>
> As a result, broader public and private investments will almost certainly be needed to help poor households adapt to climate change. These could include direct investments in the productivity of agriculture, such as the development of improved crop varieties better suited to new climates, investments aimed at improving the physical and market infrastructure that typically underpin functioning economies, or investments that bolster the social safety nets that help poor households maintain their welfare in the face of a livelihood shock. While the optimal composition of investments will vary by country, scientific research can contribute important information concerning where climate change will hit hardest, how agricultural systems are likely to respond, and what particular investments in adaptation could yield high returns [Burke and Lobell, 2010, pp. 151-2].

A particularly insightful example of the kind of food policy analysis that will be needed to cope with climate change grows out of the experience in Indonesia, where weather events, mostly El

Nino-Southern Oscillation (ENSO) dynamics, are particularly well studied.[7] The external dynamics provide a strong case for a *causal* link from El Nino to rice production and local food security, and via trade changes, to global rice prices.

These ENSO effects on Indonesia's national and regional rice production and on world rice prices have been studied extensively by Stanford University scientists and their colleagues (Falcon, et al., 2004; Naylor and Mastrandrea, 2009). Using the August sea surface temperature anomaly (SSTA) to gauge climate variability, their work shows that each degree Celsius change in the August SSTA produces a 1.32 million metric ton effect on rice output and a $21 per metric ton change in the world price for lower quality rice. These relationships offer policymakers a forward looking tool to prepare for threats to local food security, as emphasized in the final report to the National Science Foundation detailing what was learned from a research project on this topic:

> Agricultural production in Indonesia is strongly influenced by the annual cycle of precipitation and the year-to-year variations in the annual cycle of precipitation caused by El Niño-Southern Oscillation (ENSO) dynamics. The combined forces of ENSO and global warming are likely to have dramatic, and currently unforeseen, effects on agriculture production and food security in Indonesia and other tropical countries. This project combined general circulation model (GCM) experiments and empirical downscaling models (EDMs) to assess the influence of global warming on the annual cycle, and on ENSO-induced changes in precipitation and agricultural production in Indonesia. A risk assessment framework was then developed to evaluate how climate-related uncertainty and probable agricultural outcomes derived from the downscaling model can be used in policy decision-making processes. The models focused on rice, the country's primary food staple. …
>
> Over the longer-term, our Bayesian approach could be used to help Indonesian policymakers anticipate ENSO impacts in a warmer world. Given the projections in our study of a significant change in the annual cycle of precipitation in the region, policymakers could use updated climate information for adaptation; that is, they might want to invest in water storage facilities (reservoirs and linked irrigation systems) to take advantage of periods of more intense rainfall and cover longer dry periods. They also might want to invest in drought tolerant crops, or provide incentives for alterations in cropping systems that match both climate conditions and market demand.
>
> In this particular case, the Bayesian null hypothesis would be a change in the annual cycle of precipitation that affects crop production, food availabilities, and incomes throughout the year. The prior would be established on the basis of the observed annual cycle going back in time for decades, and this prior would be updated with new information as the years progressed. The likelihood of the null hypothesis being true could thus increase over time as more information became available on the pattern of rainfall over the course of the year. This analysis is very different from the Bayesian analysis of El Niño events described above for the short term, because a long-run change in the climate's mean state has not yet been fully

[7] It somehow seems appropriate that Indonesia should be a leading example of food policy analysis of climate change impacts because the country also served as the learning and teaching foundation for *Food Policy Analysis*, as is described in the Preface to FPA (see pages ix-x).

established (beyond historical patterns of variability). [Naylor, R., Battisti, D., Vimont, D., and Falcon, W., 2009]

In pulling together their final thoughts on the impact of climate change on food availability, food access and food utilization—the three main factors that determine food security—Lobell and Burke make the following observation:

> …one thing appears almost certainly true in the twenty-first century; if agriculture and food security are to thrive, they will have to do so in a constantly warming world. The level of climate stability that has been experienced since the dawn of agriculture is a thing of the past; the future will be one of constant change. This need not spell disaster for food security, but we would be wise not to underestimate the enormity of the challenge at hand [Lobell and Burke, 2010, p. 1960].

Food policy analysis that understands this challenge and offers insights into how best to cope with it will be a key driver of how successfully society adapts to climate change.

**Reflections on food policy analysis in a rapidly changing world**

The historical evolution of food policy analysis described in this paper raises several questions going forward: *who* will do the analysis and *where* will they be trained; *what* is the appropriate institutional base for food policy analysts; and *why* do this difficult analysis if "politics is in command?"

The human capital investment needed to train skilled food policy analysts is substantial and the educational institutions capable of providing the training are hard to find. A successful food policy analyst needs an unusual blend of technical skills, mostly economic, and a broad vision of how food systems interact and evolve over time. University Ph.D. programs have basically stopped doing this kind of training. Economics programs, for example, increasingly focus on micro economic decision making that needs to be understood through careful experimental design of the data needed for analysis. Some extraordinarily smart students have come out of these programs with field experience in rural settings, and their journal articles are technical gems. But it is rare for these students to be trained in the macro economics of growth and development, much less economic history. Almost none understand climate models or even the basic elements of energy and nutrient flows. Such students have little intuition about how complex food systems function and change. Undergraduates seeking graduate programs to train them as food policy analysts have nowhere to go.

The failure of academic programs to provide coherent training in food policy analysis is partly due to the lack of clear career tracks for such analysts. Just where are the jobs? What institutional base provides the best opportunities for food policy analysts to do good work and be effective advocates for sound policies and programs? The historical record is quite fuzzy, as

successful food policy units have functioned in planning agencies, food logistics agencies, trade and commerce ministries, ministries of health, even ministries of agriculture. But there is no clear set of lessons on which institutional base provides the best incentives for high quality analysis that is effectively plugged into the policy process. Perhaps serendipity and leadership are the key variables in such success.

Finally, there are a set of questions that revolve around the political economy of food policy. When "politics is in command," which seems to be the normal state of affairs for most developing countries (at least in the short run), how do efficiency issues stay on the agenda?

When "markets are in command," which seems to be the main policy advice from the donor community to poor countries, how do distributional and welfare issues stay on the agenda (that is, how do countries develop the capacity to "push back" against donor advice that will drive them out of office)? How can "markets" and "politics" together win democratic elections?

More broadly, how do we educate *policymakers* as well as analysts? In democratic societies it would seem to require educating citizens so that they could be informed voters. Doing so will require a much deeper, behavioral understanding of how both citizens and policymakers make decisions (Timmer, 2012). Research in this arena is just getting underway.

## References


Badiane, Ousmane. 2011. "Agriculture and Structural Transformation in Africa." Stanford Symposium Series on Global Food Policy and Food Security in the 21st Century, (April 7), Stanford University.

Binswanger-Mkhize, Hans P. 2012. "India 1960-2010: Structural Change, the Rural Non-farm Sector, and the Prospects for Agriculture." Stanford Symposium Series on Global Food Policy and Food Security in the 21st Century, (May 10), Stanford University.

Burke, Marshall, and David Lobell. 2010. "Food Security and Adaptation to Climate Change: What Do We Know?" In Lobell, David, and Marshall Burke, eds. 2010. *Climate Change and Food Security: Adapting Agriculture to a Warmer World.* Advances in Global Change Research, Vol. 37, Springer Science+Business Media, B. V. Heidelberg, London and New York, pp. 133-53.

De Gorter, Harry, and Dusan Drabik. 2012. "The Effect of Biofuel Policies on Food Grain Commodity Prices." *Biofuels*. Vol. 3, No. 1, pp. 21-24.

De Gorter, Harry, and David R. Just. 2010. "The Social Costs and Benefits of Biofuels: The Intersection of Environmental, Energy and Agricultural Policy." *Applied Economic Perspectives and Policy*, Vol. 32, No. 1, pp. 4-32.

Falcon, Walter P., Rosamond L. Naylor, Whitney L. Smith, Marshall B. Burke and Ellen B. McCullough. 2004. "Using Climate Models to Improve Indonesian Food Security." *Bulletin of Indonesian Economic Studies.* Vol. 40, no. 3, pp. 357-79.

Lobell, David, and Marshall Burke, eds. 2010. *Climate Change and Food Security: Adapting Agriculture to a Warmer World.* Advances in Global Change Research, Vol. 37, Springer Science+Business Media, B. V. Heidelberg, London and New York.

Naylor, Rosamond. 2012. "Biofuels, Rural Development, and the Changing Nature of Agricultural Demand." Stanford Symposium Series on Global Food Policy and Food Security in the 21st Century, (April 11), Stanford University.

Naylor, R., Battisti, D., Vimont, D., and Falcon, W. 2009. "Final Report, NSF Award ID: 0433679 (Project start date: 10/02/04), *"Agricultural Decision-Making in Indonesia with ENSO Variability: Integrating Climate Science, Risk Assessment, and Policy Analysis."* (Stanford University, July).

Naylor, R. and M. Mastrandrea. 2009. "Coping with climate risks in Indonesian rice agriculture: a policy perspective," in J. A. Filer and A. Haurie (eds.) *Handbook on Uncertainty and Environmental Decision Makin*g: Springer International Series in Operations Research and Management Science.

Ravallion, Martin, Shaohua Chen and Prem Sangraula. 2007. "New Evidence on the Urbanization of Global Poverty." World Bank Policy Research Working Paper 4199, (April). Washington, DC.

Reardon, Thomas, and C. Peter Timmer. 2012. "The Economics of the Food System Revolution." *Annual Review of Resource Economics*. Vol. 4 (September, 2012), pp. 14.1-14.40.

Streeten, Paul. 1982. *First Things First: Meeting Basic Human Needs*. London: Oxford University Press.

Timmer, C. Peter. 1986. *Getting Prices Right: The Scope and Limits of Agricultural Price Policy*. Ithaca: Cornell University Press.

_____. 1995. "Getting Agriculture Moving: Do Markets Provide the Right Signals?" *Food Policy*, vol. 20, no. 5 (October), pp. 455-72.

_____. 2009a. *A World without Agriculture: The Structural Transformation in Historical Perspective.* Wendt Distinguished Lecture. Washington, DC: American Enterprise Institute.

_____. 2009b. "Do Supermarkets Change the Food Policy Agenda?" *World Development*, Special Issue on "Agrifood Industry Transformation and Small Farmers in Developing Countries," guest edited by Thomas Reardon, Christopher B. Barrett, Julio A. Berdegué and Johan F.M. Swinnen, (November). Vol. 37, No. 11, pp. 1812-19.

_____. 2010a. "Reflections on Food Crises Past." *Food Policy*. Vol. 35, no. 1, (Jan), pp. 1-11.

_____. 2010b. "International Best Practice in Food Policy: Reflections on *Food Policy Analysis. Asian Journal of Agriculture and Development,* Vol. 7, No. 1, pp. 1-10.

_____. 2012. "Behavioral Dimensions of Food Security," *Proceedings of the National Academy of Sciences (PNAS),* Agricultural Development and Nutrition Security Special Feature, July 31, Vol. 109, No. 31, pp. 12315-12320.

Timmer, C. Peter, and Selvin Akkus. 2008. "The Structural Transformation as a Pathway out of Poverty: Analytics, Empirics and Politics." *Working Paper 150*. Washington, DC: Center for Global Development.

Timmer, C. Peter, Walter P. Falcon, and Scott R. Pearson. 1983. *Food Policy Analysis*. Baltimore, MD: Johns Hopkins University Press for the World Bank.