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1. BIOFUELS AND WATER MANAGEMENT: A REPORT ON TWO CONFERENCES

1.1 Introduction

This briefing note has been prepared for the Renewable Energy Foundation by Dr Chris Perry, who advises REF as part of its Technical Advisory Group. Dr Perry trained as an engineer, and worked for the World Bank for over twenty years, primarily on large-scale irrigation projects in the middle east and, primarily, Asia; thereafter, he was head of research and Deputy Director General of the International Water Management Institute. His particular interests are the economic analysis of water systems, productivity of water in irrigation, and the application of remote sensing to analysis of water use. He has published some twenty papers in various journals.

Since 2000, he has worked as an independent consultant, serving on international panels of experts for the World Bank in the Aral Sea basin, and the Mekong, and as a visiting professor at Cranfield University. He also serves on the editorial board of *Irrigation and Drainage*, and has conducted various assignments for DFID, FAO, the Dutch and German governments, and the African Development Bank.

REF supported Dr Perry's attendance at two major conferences in India on biofuels in January and February 2007, and we are publishing his description and discussion as a contribution to a better general understanding of the potential for biofuels.

John Constable
Director of Policy and Research
26 March 2007

2. Biofuel Conferences in India

This note summarises the discussions and presentations at two conferences on biofuels in India:

1. Linkages between Energy and Water Management for Agriculture in Developing Countries, 29-30 January 2007, Hyderabad.
2. 4th International Conference on Biofuels, 1-2 February 2007, New Delhi.

The first was organized by the International Water Management Institute (IWM) and the Food and Agriculture Organisation of the United Nations (FAO), in collaboration with a number of other bodies, and focussed on the interactions between biofuels, energy prices, water demand, food production and poverty. The result was an interesting interaction among a variety of disciplines and viewpoints. The key conclusions for biofuels were:

- Interest in biofuels is driven by a variety of factors (environment, energy self-sufficiency, rural development), and these vary by country.
- Comparative advantage in biofuel production is not well mapped: Brazil has an abundance of land and rainfall, but many other countries would need to allocate land and water to biofuels, with implications for production of other crops.
- Water and energy are co-evolving and have implications for each other. Markets and pricing have important roles in this process.

- Some biofuel crops are as yet poorly documented.
- The current contribution of biofuels as a substitute for petrol and diesel is around 2%, mostly driven by subsidies and tax exemption.
- Brazil is an exception, with 35% penetration in a biofuel market which after some decades of competition is now fully competitive.
- Successful expansion of biofuel production will require cooperation between the agricultural sector, business, and governments. The potential penetration is probably in the 10-15% range.
- Further research on biofuel crops, alternative technologies (cellulosic, especially) is needed.

The second conference was, with important exceptions, was largely an Indian agenda, with the government as the promoter, and the role of biofuels assumed to be desirable and beneficial. Concerns around impacts on other sectors, caveats about limited knowledge, and doubts in relation to productivity were few. The most interesting assessments related to the 'life cycle' analyses of the actual Green House Gas and fossil fuel savings of various technologies.

In the two following sections I discuss each conference separately, laying out those points which seemed to me of greatest interest.

2.1. Linkages between Energy and Water Management for Agriculture in Developing Countries

This conference was organised by the International Water Management Institute (IWMI) and the Food and Agriculture Organization of the United Nations (FAO) in collaboration with the International Water and Resource Economics Consortium (IWREC) and the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). It took place between the 29 and 30th of January 2007 in Hyderabad, India. Further details and abstracts are available online from the IWMI website.[1]

2.1.1. Introduction and Summary

Papers and discussions are summarized below in four parts: first a summary of the factual information presented; second a summary of the scenarios analysed, and the projections and related policy recommendations of the papers presented; third, a summary of the conclusions of the conference; and, finally, future research needs and opportunities.

2.1.2. Facts

In the context of rising energy prices and concerns about global warming, 'carbon neutral' biofuels are seen as a way to limit dependency on oil (and the countries that supply it) while contributing to reduced greenhouse gas emissions. There are two basic types of biofuel, ethanol (based on sugar) which replaces petrol, and biodiesel (based on oilseeds). In total, bioethanol and biodiesel currently account for only 2% of global consumption of 1,200 billion liters of petrol-equivalent. Production of bioethenol is dominated by Brazil (based on sugarcane) and the US (based on maize and soy bean); France, Germany and Italy dominate biodiesel production.

Current biofuel production utilizes about 1% of cropped land and 1% of crop water use. The water consumed in the production of biofuel varies by crop and location. In Brazil, it typically requires 1,850 litres of crop evapotranspiration (ET) to produce 1 litre of biofuel worth US¢31 (assuming an oil price of $50/bbl and given 159 litres per bbl). This gives a gross value of water of US¢ 31/1.85m^3 = US¢17/m^3. To produce 1kg of wheat 1,350 litres of crop ET is required, giving a gross water value of US¢9/m^3 (assuming a wheat price of 120 US$ per tonne).

[1] http://www.iwmi.cgiar.org/EWMA/.

These comparators are extremely crude, ignoring input and processing costs, but indicate clearly that biofuel and food are potential competitors for water.

Because of widely varying resource endowments and factor costs, the oil price per barrel at which biofuels become competitive varies: from $25-30 in Brazil, $50-60 in the US, and $70 in Europe.

Brazil is unique in having a substantial, commercially viable ethanol program that provides some 35% of petrol-based transport fuel demand. This has developed over several decades, beginning as a means of increasing income and employment opportunities in rural areas, and eventually (as technology, business interests and infrastructure developed in parallel with dramatic increases in oil prices) becoming a commercially self-sustaining activity, closely integrated into the processing, distribution and marketing systems. Further reductions in fossil fuel demand are underway through small-scale generation of electricity based on crop residues. Brazil, however, has ample land and water resources (sugarcane is rainfed).

Other areas with good agroclimatic and water availability include sub-saharan Africa (provided available water is developed) and Latin America. Elsewhere the motivation for developing biofuels is either in reaction to climate control (the European model) or, in India, as a means of increasing rural employment and incomes, based on underutilized land and oil-producing trees (Jatropha and Pongamia). Yield data for these crops is scanty, and water sensitivity even more uncertain.

The energy gain ratios for well-documented biofuel crops, dividing the energy content of the biofuel by total energy inputs for farm mechanization, fertilizers and crop processing, vary widely. The ratio for biofuel based on maize is only 1.3-1.6, so that a poor crop may actually use more energy than is produced. Sugar cane in Brazil has a corresponding ratio of about 8, rising to 12 if crop residues are used to generate electricity.

For the future, 'second generation' or cellulosic, technologies that derive energy from crop residues have the clear potential to augment biofuel production, but these technologies are probably 10-20 years away from commercial reality.

Other biofuels such as sweet sorghum (which produces food-grains as well as sugar-rich by-products) are already available, and oil crops such as jatropha had potential for small scale as well as estate-type introduction. The productivity of these crops, particularly their yield response to water, was agreed to be poorly documented and critical to policy decisions.

2.1.3. Scenarios, projections and policies

Several types of scenarios were presented. The global scenarios offered were concerned with the ways in which increased production of biofuels might have an impact on food prices (as competition for land and water intensified). There was agreement that biofuel development would exert upward pressure on food prices (see 2.1.2) exacerbating pressures from increasing energy prices, increases in total food demand, and the demand for more water-intensive foods. The severity of these impacts would depend on the degree to which biofuels are promoted and the parallel improvements in technology.

Separately, the role of markets and pricing (and the implication of insulating the agricultural sector from these forces) were assessed. It was argued that substantial subsidies on power and water were financially unsustainable, and encouraged misuse of resources with very substantial implications for future generations. The water and energy sectors were increasingly co-evolving, while most specialists continued to treat them separately.

The experience of China, where unprecedented levels of economic growth had been underpinned by increasing reliance on appropriate pricing and markets, was likely (together with public investment and R&D) to help the country face the severe pressures on its resource base from rapid urbanization and industrialization.

For India, the situation in the energy, water, and agricultural sectors is difficult and politically fraught. Energy prices to agriculture are highly subsidized, often with a zero marginal

price. Water resources are generally over-committed; groundwater is a significant contributor to overall production and most aquifers are under threat. Agriculture has traditionally been 'managed' by government interventions on prices of both inputs and outputs and attempts to raise the prices of inputs (to allow electricity suppliers to remain solvent, or, more ambitiously to limit overuse of aquifers) were generally resisted.

Some speakers recommended interventions to avoid these difficulties, through dedicated power lines offering limited hours of supply, and focusing development on areas where groundwater is still, for the time being, plentiful.

2.1.4. Conclusions

The potential contribution of biofuels is probably limited to around 20% of the petrol and diesel market compared to 2-3% at present. Use in the US and Europe is driven by concerns about climate change rather than commercial considerations. In Brazil, with plentiful land and water, biofuels provide 35% of transportation energy on a fully commercial basis. Elsewhere, projected prices of conventional fuels may make biofuel production commercially attractive in some countries. However, biofuel production will exacerbate increases in food prices, which are anyway likely after decades of falling trends. At a global scale, impacts are expected to be moderate, but locally, especially in resource-scarce economies, the impacts on food and fodder prices and water demand may be substantial.

Historical 'protection' of the agricultural sector from increasing energy prices has induced unsustainable use of water resources and a poor outlook for future generations. Selective liberalization of markets, as in China, has recently moved vast numbers out of poverty. Biofuels can increase farm incomes if treated as a business activity involving farmers and industries facilitated by supportive government policies. At the local level biofuels can also help communities become self-sufficient and make better use of their resources. Thus, while biofuels offer benefits to many of the poorer sections of society (especially agricultural producers) the increasing numbers of poor, urbanized, consumers would face higher prices. Careful analysis of water consumption and the productivity of various biofuel crops is essential if appropriate locations for cultivation are to be selected.

Biofuels are expected to be energy production *by* the poor, rather than energy production *for* the poor. Further, the poor are increasingly urban as migration from the countryside continues, so that the negative impacts of price increases to consumers will tend to outweigh the positive impacts on producers.

On the relationships between energy prices and sustainable groundwater use, it was agreed that higher energy prices discouraged irrigation and reduced the access of the poor to water. This is a serious issue in India, where 75% of farmers depend to some extent on groundwater, one third of these owning a well, and two thirds buying water from a well-owner. On the other hand, many aquifers are in serious decline (in India and elsewhere) while electricity companies are in serious financial difficulties due to subsidized or free power supplies to the agricultural sector. Alternatives recommended included:

- Revising tariff structures to a higher fixed payment (avoiding the complexities of meter reading and billing)
- Providing separate power supplies to wells, to be run at fixed times for limited hours
- Introducing improved irrigation technologies (drip and sprinkler) which substantially reduced power requirements.

2.1.5. Research needs and opportunities

The underlying themes addressed by the papers presented involved exploring the interactions among six distinct parameters:

- Energy prices
- Competition for water
- Food production
- Biofuel crops
- Poverty
- Climate change

Each of these parameters is linked to each of the others, sometimes in both positive and negative ways. For example higher energy prices will:

- Reduce competition for water in groundwater areas, as the price of irrigation services increase, but increase the competition between hydro-power and irrigation for water stored in multi-purpose reservoirs.
- Cause either i. higher food prices and/or ii. reduced food production.
- Increase the viability of biofuels and hence the income of bio-fuel producers, but increase competition for the water needed to grow these crops and increase the prices of competitor crops including food.
- Increase the incomes of (poor) energy producing farmers but decrease the purchasing power of (poor) food and energy consumers.
- Decrease energy consumption, with positive impacts for climate change as well as increased viability of clean or carbon-neutral energy sources.

It can readily be concluded that the linkages between energy and water management for agriculture is a complex topic requiring careful definition of problems, issues, and analytical frameworks. At one end of the simple/complex spectrum is the lack of basic data on biofuel crops. For example, where they will grow, with what land and water productivity, and how potential incomes compare with those of alternative crops. These issues are fundamental, and without resolving them, the questions at the complex end of the spectrum (for example, what policy environment will best ensure that the outcomes of promoting biofuels are pro-poor) can barely be identified and articulated, let alone analyzed. This basic point should not be forgotten in considering the following broad classification of research ideas.

A significant observation about the perspectives of the conference participants is the variety of driving forces for interest in the biofuels. For the West, the main interest is climate change, with energy security a secondary but important factor, closely followed by the possibility of increasing agricultural value, with positive benefits for rural economies (or a reduction in farm subsidies) is a beneficial side effect.

The developing country perspective (with the exception of Brazil) is quite different. Increasing energy prices are a threat, particularly to the poor, and biofuels can provide extra incomes for rural producers. Climate change is mentioned, but hardly as a priority topic, and energy security is largely a local issue where biofuels allow villages to become independent of expensive conventional fuels.

The differing perspectives of these groups will no doubt influence the composition of the research agenda. On the basis of the discussions at the conference, the research priorities can be grouped under four headings:

Basic information is needed on 1. the agricultural performance of biofuel crops, leading to the identification of the most promising areas (in terms of land and water availability) where they can be grown sustainably, and to 2. a better understanding of the likely competitiveness of biofuels with existing crops in these areas. It is also desirable to identify what future developments are likely (cellulosic processes, bio-saline crops).

Intersectoral analysis is required to address the implication of rising fuel prices and deteriorating power supplies for irrigation, particularly smallholder irrigation. It will be necessary to determine whether groundwater irrigation is compatible with financially sustainable electricity generation, and how biofuels will impact on water demand and food production in various contexts.

Development issues of various kinds present problems. It is highly desirable to find ways of strengthening farmer organizations and linking them to the commercial entities needed to process biofuels. To ensure that carbon neutrality (at a minimum) is achieved we need a better understanding of the full 'life cycle' picture of biofuels including mechanization, fertilizers, processing, and distribution.

Poverty issues include a better understanding of how rising energy prices affect the various categories of the poor, both directly and indirectly, and the extent to which viable biofuel development is a useful pro-poor rural activity.

Each of these categories of research and information gathering, but especially the last three, will be substantially affected by the position taken (either as assumptions or recommendations) regarding the economic environment. If price controls on inputs and outputs of the agricultural sector persist at high levels, then the achievement of essential environmental objectives (preventing land degradation and over-exploitation of water resources) become problematic. While climate change issues that dominate western agendas may not figure prominently on the agenda of the poor and those who speak for them, policies to ensure that water and land will be available and productive for future generations are probably more important to the poor than the wealthy.

2.2. 4th International Conference on Biofuels: Winrock International, India, 1-2 February 2007, New Delhi, India

2.2.1. Session 1: Biofuels: Global and Indian Scenarios—policy perspective

For India, energy security, employment generation, and economic gain are the main drivers for biofuel development (while environmental benefits are noted). The Government of India is supporting programs to expand development and is setting mandatory goals for ethanol use with a 20% target by 2011-12, though imports may be required to meet this.

In Canada, the impetus for biofuels is a clear mix of exploiting economic opportunities for the rural/agricultural sectors together with the achievement of environmental and energy security goals. Incentives are largely based on tax exemptions. Canada has exceptional potential from agricultural and forest residues, and is regarded by some as the Saudi Arabia of biomass. Canada has reviewed all significant reports and studies of biomass to biofuel life cycles, and it seems that the picture is mixed, with many benefits, as well as significant potential issues, and most importantly a large number of areas where little is known (solid waste, land, and water impacts being prominent). Furthermore, life cycle assessments of greenhouse gas impacts of biofuels vary widely in their conclusions, and are all (except for Brazil) US or European based.

For Europe, climate change is the primary driver, followed by energy security and stimulation for agriculture. The EU target of 2% biofuel use by 2005 was only met in Germany and Sweden. A strong lobby for biofuels is essential to success: so far farming lobbies have been most active. Production subsidies and tax exemptions have also been effective, but are very expensive for the exchequer.

2.2.2. Session 2: Biofuels as Drivers for Rural Development (in India) and 2.2.3. Session 3: Special Session on Uttarkhand

The presentations all focussed on the potential for biofuels to provide a stimulus to rural economies: improving wastelands, providing a source of power, and a basis for improved rural livelihoods.

One presentation (which was also made at Hyderabad) stressed the scarcity of agronomic information about the main biofuel crops (Jatropha and Pongamia) promoted in India. While they are drought-tolerant, they require reliable watering every two weeks for good productivity, as well as provision of nutrients (Pongamia, a nitrogen fixing plant, is better in this regard).

2.2.4. Session 4: Challenges and Sustainability issues in mainstreaming biofuels

Presentations from Switzerland and Germany focused on the actual savings of GHGs resulting from biofuel use (lifecycle assessments). These showed that (a) the data are highly variable (partly because there is no universal methodology); (b) the savings vary substantially: palm oil plantations can actually use more primary energy than they produce, and while sugar cane is positive all comparisons are complicated by the effects of local circumstances (land, water, competition with other uses). Ligno-cellulose may be the future (because the technology uses residues rather than the primary crop), but more research is needed.

A number of Indian studies assessed the performance of diesel engines with various types of biofuel. All found this feasible.

2.2.5. Session 5: Recent trends in Production techniques

Various novel approaches to deriving biofuels from a variety of sources were described. In one presentation, concerning a large-scale plant, the point was made that the agronomics and economics of current biodiesel crops are as yet unclear.