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THE ROLE OF AGRICULTURAL TECHNOLOGIES IN CLIMATE CHANGE MITIGATION AND ADAPTATION

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ABSTRACT

Agriculture is a major source of global green-house gas emissions, accounting for about 13% of global anthropogenic emissions, on particular in the areas of methane and nitrous oxide. Without abatement measure, omissions are likely to climb, among others due to population growth and changing food consumption patterns. Climate change will have far reaching consequences for agriculture that will disproportionately affect the poor. Greater risks of crop failures and livestock deaths are already imposing economic losses and undermining food security and they are likely to get for more severe as global warming continues. This paper posits that mitigation and adaptation measures are needed urgently to reduce the adverse impacts of climate change, facilitated by covered international action and strategic national planning. As a major source of GHGS, agriculture has much potential to reduce emissions through reduced deforestation and changes in land use and agricultural practices. Some other possible mitigation measure include a wide range of issues, such as improve farming techniques, minimum soil tillage, using cleaner energy carbon sinks, conservation agriculture etc Innovations for adaptation and mitigation will need to play a key role for mitigating emissions from agriculture. Therefore, spread of technology and innovative approaches, needs to be given the highest attention.

Key words: climate change, carbon, fertilizer adaptation, mitigation.

INTRODUCTION

Climate has obvious and direct effects on agricultural production. The effects of agriculture on GHG emissions are also large. Agriculture is a major part of the global economy and uses substantial fossil fuel for farm inputs and equipment. Animal agriculture also releases substantial GHGS in the form of nitrogen and methane. Further more, and probably more importantly, land clearing and preparation releases carbon from the living biomass that is removed from the land. The 2010 World Development Report draws on analyses of the Intergovernmental Panel on Climate Change (IPCC, 2007) to calculate that agriculture directly accounts for 4 percent of global GHG emission in CO_2 equivalents and indirectly account for an additional percent of emissions when land use and conversion for crops and pasture are included in the calculations (World Bank, 2009A) given that agriculture's share in global GDP is about 4 percent these figures suggest that agriculture is highly GHG intensive . The climate implication of agricultural production and practice have broadened the agricultural agenda over recent years to include responses to climate issues, and the climate change agenda has similarly subsumed agricultural production as both a contributor to climate change and, through adjustment in practices a potential mitigating force (Lybbert and Sumner 2010).

Organized research and innovation have been central to agricultural policy for nearly two centuries, often with the goal of increasing output per unit of land, water, labour or other input. More recently, reducing the negative environmental spillover effects of agriculture has joined improving crop yields and other simple productivity indicators as a research pursuit. With especially rapid population growth in some of the poorest places, with improved diets for the poor an imperative, and with evident local environmental impacts, agricultural innovation has never been more important. Climate issues add to this already challenging agenda. Concerns about mitigating and adapting to climate change are now renewing the impetus for investments in agricultural research and are emerging as additional priorities. In the coming decades, the development and effective diffusion of new agricultural technologies will largely shape how and well farmers mitigate and adapt to climate change. This adaptation and mitigation potential is nowhere more pronounced than in developing countries where agricultural productivity remains low, poverty, vulnerability and food insecurity remain high, and the direct effects of climate change are expected to be especially harsh Lybbert and Sumner, 2010). Creating the necessary agricultural technologies and harnessing than to enable developing countries to adapt their agricultural systems to change climate will require innovations in policy and institutions as well.

CLIMATE CHANGE AND AGRICULTURE

The impacts of climate change on agriculture could be devastating in many areas. Many regions already feels these impacts, which will get progressively more severe as mean temperature rise and the climate becomes more variable [World Bank, 2009B). Scientific evidence about the seriousness of the climate threat to agriculture is now unambiguous, but the exact magnitude is uncertain because of the complex interactions and feed back processes in the ecosystem and the economy. Five main factors will affect agricultural productivity; change in temperature, precipitation, carbon dioxide [co] fertilization, climate variability, and surface water runoff. Initially, rising atmospheric concentrations of carbon benefit crop growth and could offset yield losses from heat and water stress, but this carbon fertilization, may be smaller in practice than previously estimated from experimental data. Under moderate to medium estimates of rising global temperatures (1-3^{o}c) crop climate models predict a small impact on global agricultural production because negative impacts in tropical and mostly developing countries are offset by gains in temperate and largely industrial countries. In tropical countries even moderate warning [IC for wheat and maize and c for rice] can reduce yields significantly because many crops are already at the limit of their heat tolerance (World Bank, 2009B)

For temperature increase above 3^{o}c yield losses are expected to occur every where and be particularly severe in tropical regions. In parts of Africa, Asia, and Central America yield of wheat and maize could decline by around 20 to 40 percent as temperature rise by 3 to 4; even assuming farm-level adjustment to higher average temperatures. With full co_2 fertilization the losses would be about half as large. Rice yield would also decline, though less than wheat and maize yields.

These are conservation estimates because they do not consider crop and livestock losses arising from more intense drought and floods, change in surface water runoff and threshold effects in the response of crop growth to temperature changes. Agriculture in low-lying areas in some developing countries would also be damaged by flooding and salinization caused by sea level rise and salt water intrusions in groundwater aquifers less surface and groundwater sources in some area.

Access to perennial surface water may be particularly vulnerable in semiarid region especially in parts of Africa and in irrigated area dependant on glacial melt. Between 75 and 250 million people are expected to experience increased water stress in Africa. In all affected regions, the poor will be disproportionately vulnerable to its effects because of their dependence on agriculture and their lower capacity to adapt (World Bank, 2009B).

But despite complex special different in climate change forecasts agree that many developing countries climates will become less suitable for the agricultural practices, because place that now tend to be warm and humid will be disadvantaged relative to places that are now cooler (typically in the North). More generally, developing countries are vulnerable to climate change because they depend heavily on agriculture, they tend to be relatively warm already, they lack infrastructure to respond well to increased whereas the stern report (Stern, 2009), projected that a 2^0c increase in average temperatures would reduce world GDP by roughly 1% . The 2010 World Development Report of the world bank (2009 A) focuses on developing countries and estimates that without offsetting innovations climate change will ultimately cause a decrease in annual GDP of 4% in African and 5% in India. At current growth rates, reductions of this magnitude would essentially offset GDP gains due to growth. (Cline, 2007). Moreover, within these already poor region, the largest effects will be on the poor who tend to earn their livelihoods in farming (World bank, 2009).

MITIGATING CLIMATE CHANGE THROUGH AGRICULTURE

Livestock and crop emit co_2, methane, nitrous oxide, and other gasses, making agriculture a major source of GHG emissions. According to the emission inventories that governments submit to the United Nations Framework Convention on Climate Change, agriculture accounts for around 15 percent of global GHG emission from deforestation] in developing countries [agriculture is the leading cause of deforestation], raises its global contribution to 26 and up to 35 percent of GHG emissions. A round 80 percent of total emissions from agriculture, including deforestation, are from developing countries [BIAC, 2009; World Bank, 2009B].

Agriculture contributes about half of the global emission of two of the most potent non-carbon dioxide greenhouse gases-Nitrous oxide and methane. Nitrous oxide emissions from soil [from fertilizer application and manures] and methane from enteric fermentation in livestock production each account for about one third of agriculture’s total non-carbon dioxide emissions and are projected to rise. The rest of non-carbon dioxide emissions are from biomass burring, rice production, and manure management. Agriculture is also a major contributor of reduced carbon sequestration [storage] through land use change [e.g. the loss of soil organic matter in cropland and pastures, and forest conversion to agriculture], although quantitative estimates are uncertain [BIAC, 2009; World Bank, 2009B].

INNOVATION TO ADDRESS CLIMATE CHANGE

in this complex and dynamic scenario, where growing population levels and correspondingly growing demand for food and nutrition must be considered as a crucial aspect, a policy framework that fosters and adequately protects and rewards investment in research , innovation and technology is vital to successfully address the challenges posed by climate change. Innovation, play an essential role in both mitigation of emissions and adaptation to climate change as related to agriculture. Yield-increasing technologies, management practices and approaches can provide a significant contribution to environmental preservation by boosting the productivity of existing land under cultivation, foregoing the need to bring more land into production [i.e. avoid detrimental practices such as deforestation]. Innovation and the spread of innovative technologies require among others open markets, an enabling regulatory framework and the effective protection of intellectual property rights, including strong efforts, and a willingness of governments to adopt effective method for sharing and disseminating knowledge and best practices, for example by reinvigorating moribund agricultural extension provision. The following examples illustrate the importance of innovation for addressing climate change.

CROP PROTECTION

Protecting yields from weeds, pest and disease is crucial to maintaining and potentially increasing agricultural productivity. The production of fruit and vegetable crops, vital for healthier global diets, is especially threatened by pest pressure and other climate change-related effects, such as drought. The responsible use of crop protection products as well as properly-implemented integrated fast management strategies are and will remain important instruments for combating pests and preserving harvests and the global food supply (BIAC, 2009)

PLANT NUTRIENTS/FERTILIZERS

Appropriate and responsible use of fertilizer and sustainable nutrients can make a contribution to helping plants capture more carbon, fostering higher yields and slowing the decline of soil organic matter. The emissions originating from fertilizer use by should be weighed against the net benefits of using fertilizers to increase thus reducing the advent of land-use change and increasing the carbon content in soils. In addition, the industry works with farmer organizations to promote the use of fertilizer best management practices to simultaneously reduce emissions, increase soil organic matter and improve yields.

CARBON SEQUESTRATION

Soil carbon sequestration will be an important mitigation strategy to reduce atmospheric co concentrations. The process of transferring atmospheric co into soil and biotic pools can enhance soil quality, increase agronomic productivity, improve quality of natural waters, and lower rates of anoxia [decrease in the level of oxygen] or hypoxia [dead water in coastal ecosystem. Crops developed from biotechnology have a reduced need for plugging or tillage thus leading to fewer losses of co which is emitted when soil-carbon is oxidized through exposure to air.

SOIL CONSERVATION

Conservation agriculture techniques such as low or no-till agriculture, made possible through the use of herbicides and herbicide-tolerant biotech crops in appropriate and carefully managed cases prevents wind and water erosion and loss of ground moisture, improves soil biodiversity has the potential to increase soil fertility, and reduce carbon emission. In addition, by limiting soil disturbance and promoting a permanent soil cover, conservation agriculture can contribute to limiting emissions from agriculture by increasing soil carbon content and preventing erosion.

EXTENSION

A key element in supporting agriculture's role is capacity building, dissemination of research knowledge and information. Extension programme, were originally conceived as a service to extend research based knowledge to the rural sector in order to improve lives of farmers. However, extension services are being dismantled or are often ineffective particularly in developing countries. Extension help farmers prepare for greater climate variability and uncertainty, create contingency measures to deal with exponentially increasing risk, and alleviate the consequences of climate change by providing advice on how to deal with droughts, food, and so fort. Extension can also help with mitigation of climate change. This assistance may also include providing links to new markets [especially carbon]. Information about new regulatory structures and new government priorities and policies. Innovating and re-instating effective extension services will become more important than ever in a changing climate.

INTENSIFICATION OF AGRICULTURE

While reducing agricultural energy intensity is overall desirable, it is important to keep in mind that for some countries, an intensification of agriculture may be more appropriate and avoid other adverse effects. Many developing country agricultural producers, in particular in Africa, see lower yields due to insufficient inputs, including modern farming equipment and fertilizer. Low productivity and poor soil health, if left unchanged, could lead to increased rates or deforestation, and therefore exacerbate rather than mitigate climate change.

REDUCED WASTE OF AGRICULTURAL PRODUCE

As well as "waste" in the field when yields are reduced by pests, diseases, weeds, climate or weather effects, much agricultural production is lost after harvest during transport or storage or in other parts of the food chain. Investment in technologies that ensure food is not wasted, but can be stored and transported efficiently to the increasingly- urban population of the world, is clearly needed. Investments in developing relatively small scale low cost drying, packing, bottling, canning, etc plants and machineries that can be operated in rural areas where electricity supplies and other infrastructure is not always reliable are needed. This will help ensure that food is not wasted, farmers have reliable market for relatively high value products and small scale business can be set up and run where they will help revitalize rural areas.

NEW TRAITS /VARIETIES OF CROPS

Investment in new crop varieties to increase tolerance to water and heat stress will be essential. For example, the plant biotechnology sector can play a major part in helping to address the negative effects and consequences of climate Change, especial with respect to greenhouse gas reductio0n, Crop adaptation, and the protection of and increase in yield
Innovations in the field of nitrogen efficiency and water efficiency could also constitute important new tools for adaptation and mitigation. GM rice and conola plants, which use nitrogen more efficiency, are already available (Stern, 2007).Increasing agriculture productivity requires technological advance in crop yields. In contrast to developed countries which have seen dramatic yield gains in the past century through investments in agricultural innovation and operate close to the technological frontier, much of developing country agriculture is far from this frontier. The greatest latent productivity potential therefore reside in developing countries

Generally and in sub-saharan Africa in particular, profitable adaptation and farmers' adoption of suitable Varieties and crops could spark substantial yield gains. These Productivity gains could confer a substantial mitigation benefit in the form of foregone land conversion or even reversion of some sensitive lands to grass or forests. Since land use changes, including deforestation and conversion to agricultural production account for 17% of global Co_2 emissions (World Bank, 2009A), productivity gains represent a significant mitigation mechanism in agriculture. New varieties and traits can also lead to less intensive use of other inputs such as fertilizers and the associated equipment (Brookes and Barfoot, 2009)

In addition to increasing productivity generally, several new varieties and traits offer farmers greater flexibility in adapting to Climate change, include traits that confer tolerance to drought And heat, tolerance to salinity (example, due to rising sea levels In coastal areas), and early maturation in order to shorten the growing season and reduce farmers exposure to risk of extreme weather events. These promising new traits and varieties, which are mostly still in development, can emerge from traditional breeding techniques that leverage existing varieties that are well suited to vagaries of the local production environment as well as from more advanced bio- technology techniques such as marker assisted selection and genetic modification(Lybbbert and Summer, 2010).

WATER MANAGEMENT & IRRIGATION

In the midst of increasing urban and environmental demands on water, agriculture must improve water use efficiency generally. Adding climate change to this mix only intensifies the demands on water use in agriculture. With hotter temperatures and changing precipitation patterns, controlling water supplies and improving irrigation access and efficiency will become increasingly important. Climate changes will burden currently irrigated areas and may even outstrip current irrigation capacity due to general water shortages, but farmers with no access to irrigation are clearly most vulnerable to precipitation volatility. Since Africa only irrigates 68 [13.6 million hectares] of it's arable land in contrast, to 20% worldwide [FAO stat, 2007], Africa farmers are in desperate need of techniques, technologies and investments that improve water management efficiency, access to irrigation or to find ways to improve in comes with less secure and more variable water availability. It could be the case that in some marginal areas, agricultural land use agricultural land use will cease and populations will migrate permanently.

OTHER PRODUCTION INPUTS

Improvement in crop yields per unit of land is crucial as an alternative to extensive conversion of grassland and forestland to crops. Therefore practices or technologies with potential to increase the intensity of land use can yield mitigation benefits. This may even include application of additional fertilizer or pesticide inputs, where the 'first round' GHG implication may not look favourable. There are, however amendments such as biochar, a charcoal soil amendment, that may offer both improve soil amendment that may offer both improve soil fertility and serve as a carbon sink (Lehmann, *et al*, 2006). Similarly, herbicides and other inputs that reduce competition from weeds can improve productivity and thereby serve to mitigate GHG emissions associated with bringing additional land under cultivation. Furthermore, since potential crop land in different regions has very different capacities to sequester carbon, shifting crops to the land with least negative carbon implication may have net GHG benefits. This may mean farming dry regions under irrigation which allows use of land that otherwise would not contribute to irrigation (Lybbert and Sumner, 2002).

PRODUCTION MANAGEMENT AND PRACTICES

Production techniques may be as important as production technologies in climate change adaptation and mitigation. One such technique stands out in particular; conservation or reduced tillage agriculture. This technique aims to build up to organic matter in soil and create a healthy soil ecosystem by not tilling the soil before each planting. Seeds are planted using seed drills that insert seed to a precise depth without other wise disturbing the soil structure. By increasing the organic matter in soils, conservation agriculture improves the moisture capacity of the soil and thereby increases water use efficiency. The practice also reduces carbon emissions by reducing tilling, although it also requires more sophisticated pest and disease control because the system is not re-booted at each planting. Any array of other production management practices and technologies could similarly improve farmers' mitigation and adaptation to climate, including equipment and information that enables more precise application of inputs, especially fertilizer. The key challenge is to assure that such practices do not reduce yields so that the demand for additional land offsets the benefits from on field sequestration.

INFORMATION

As farmers and others deal with changes in climate and more variability in weather, history becomes a less reliable guide. Under these conditions there is greater payoff to improvements under to forecasts of weather events and inter-seasonal weather probabilities. For example, warmer ocean temperatures are likely to make el nino events frequent and serve. Farmers with foreknowledge of such events can respond by planting more appropriate crops varieties (say barley rather than maize if dry year is expected. Such improved forecasts would also affect planting event in regions unaffected by the weather events in response to price expectations and opportunities for trade. Furthermore, inter-temporal arbitrage in the form of storage or forward contracting would be used to offset changes in expected harvests. Thus major innovations in response to climate variability will take the form of improved information through global monitoring and forecasting (Hallstrom and Sumner, 2000; Sumner, *et al*…, 1998). Improved micro-climate modeling can also enable more accurate interpolations between actual weather stations and, in effect, crate virtual weather stations for nearly any locations. These improved interpolations could be disseminated via SMS using rapidly spreading cell phone networks. Lastly, better and more timely information can also help to forecast impending 'slow onset' weather events such as drought more effectively and thereby improve response times and adaptation (Mud *et al*; 2009).

INSURANCE

Innovations in microfinance generally and in micro-insurance products specifically may aid farmer's capacity to adapt to climate change (Glauber, 2004). This is especially true in production settings that are exposed to greater variability and more frequent extreme events. Although microfinance has seen wide success as a development intervention, many poor farmers continue to lack low cost access to finance services such as savings and d credit. In the absence of these services, farmer often face serious constraints in their response to both good and bad harvests and in their ability to adopt new technologies. The micro finance movement has significant momentum and will likely continue spreading into poor rural areas. The dramatic expansion of mobile phone networks into rural areas of developing countries and the emergency of sms-based banking services will only speed farmers' integration into financial markets (Dischel, 2002; Hess *et al*, 2002; Stoppa and Hess, 2003).

Innovative insurance mechanisms should be explored to compensate rural communities and smallholders farmers in case of emergency. Africa is particularly vulnerable to climate change because of its high proportion of low input, rainted agriculture, compared with Asia or Latin America (Barrett, etal, 2007). Exposure to rainfall variability also extends to livestock, which mostly depend on range and grasslands that are affected by environmental shocks such as climate change (BIAC, 2009; Lybbert and Sumner, 2010; chaniarate *et a*l 2008]

CONCLUSION

Given the reliance of the poor on agriculture and the sensitivity of agriculture to climate change impeding climate change will almost certainly hit developing countries and vulnerable populations within the tropical regions. The technologies discussed can make important contributions in adapting and mitigating climate change innovations in agriculture have always been important and will even be more what in the contact of climate change.

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