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Research article

Global assessment of technological innovation for climate change adaptation and mitigation in developing world

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ABSTRACT

Concerns about mitigating and adapting to climate change resulted in renewing the incentive for agricultural research investments and developing further innovation priorities around the world particularly in developing countries. In the near future, development of new agricultural measures and proper diffusion of technologies will greatly influence the ability of farmers in adaptation and mitigation to climate change. Using bibliometric approaches through output of academic journal publications and patent-based data, we assess the impact of research and development (R&D) for new and existing technologies within the context of climate change mitigation and adaptation. We show that many developing countries invest limited resources for R&D in relevant technologies that have great potential for mitigation and adaption in agricultural production. We also discuss constraints including weak infrastructure, limited research capacity, lack of credit facilities and technology transfer that may hinder the application of innovation in tackling the challenges of climate change. A range of policy measures is also suggested to overcome identified constraints and to ensure that potentials of innovation for climate change mitigation and adaptation are realized.

1. Introduction

Climate change has obvious and direct effects on agricultural production. Intergovernmental Panel on Climate Change (IPCC) in its fourth assessment report cited that agricultural production in many African countries would considerably be influenced by climate change (Mbilinyi et al., 2013).

Accordingly, concerns about the possible impacts of climatic variability on agriculture have considerably changed research interests over the last decade (Aydinalp and Cresser, 2008). Concerns about mitigating and adapting to climate change resulted in renewing the incentive for agricultural research investments and developing further innovation priorities. In the near future, development of new agricultural measures and proper diffusion of technologies will greatly form the ability of farmers in adaptation and mitigation of climate change. This adaptation and mitigation capacity is more obvious in developing countries with low level of agricultural productivity; in which poverty, vulnerability and food insecurity is large; and the direct impacts of climate change are going to be particularly severe (Lybbert and Sumner, 2012). The adoption of improved technology based on best agricultural management practices and technological innovation will increase the crop production and reduce GHG emissions. For example, Lal (2011) emphasized the need to respond to climate change through carbon sequestration based on the existing and new technologies. New technological innovations that suit or adapt to warming climate present an opportunity to build resilience to the impact of climate change in the future, especially due to the substantial challenges that climate variability imposes on agricultural production in developing countries. Indeed, while most agricultural technologies have direct linkages with climate change, there are emerging technologies that are relevant to agriculture practices in developing countries with great potential to offer a substantial mitigation and adaptation benefits (Khan and Hanjra, 2009). Nevertheless, constructing the essential agricultural technologies and supplying them to developing countries in order to be able to adjust their

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agricultural systems to the changing climate will further need institutional and policy innovations. In this regard, policies and institutions are crucial at various scales. Obstacles to creating, diffusion and utilizing related technologies can show up at multiple levels – from the starting point and innovation steps to the technologies transfer and the accessibility of agricultural innovations by small-scale farmers in developing world.

In other words, innovation is not just about new outcomes and processes introduced to the world (absolute innovation), but also includes those that are new to a specific company or country (diffusion). Further to absolute innovation, diffusion of innovative technologies throughout countries is considered as an important part in tackling the challenges of climate change mitigation. The dissemination of available technologies might be sped up through providing practical support policies which benefit from normal capital substitution. The position of emerging markets may be suitable so that the adverse impacts of existing technologies that hinder the diffusion of innovative alternatives would be avoided. Available infrastructure may not support the innovations, but deployment of existing technologies in emerging markets would need utilizing suitable financial resources and dealing with other general barriers to adoption of new technology. In order to be able to transfer into a low-carbon economy, there should be the possibility of development of new technologies and implementation of available measures on a larger scale. To achieve this, new technologies as well as new solutions for managing economic practices will be required. Such substantial changes will ask for developing a policy and institutional framework that supports innovation and also diffusion of available technologies. If this needs to be fulfilled, first, it is important to create the right impetus and structures to enhance large-scale, global change.

Bosetti et al. (2009) emphasized that any cost-efficient policy framework to tackle climate change should accelerate useful research and development (R&D), innovation and diffusion of technologies developed for reducing GHG emissions. Different approaches have been developed in different disciplines to protect human environments from the adverse extensive effects of climate change and natural hazards such as a modeling management tool for agro-watershed management. Likewise, nowadays, there is a wide variety of innovations and new advanced technologies utilized in different sectors to reduce GHG emissions. For example, Papageorgiou et al. (2009) evaluated the emission impacts of three technologies including Mass Burn Incineration with energy recovery, Mechanical Biological Treatment via bio-drying and Mechanical Heat Treatment that could be used for the treatment of Municipal Solid Waste in order to recover energy from it. Among all the existing innovative techniques in different fields and sectors, the need to sequester carbon in agricultural practices is one of fundamental ways to respond positively to the challenges of climate change in developing countries while changing lifestyle through the adoption of integrated soil management practices (Lal, 2011). Moreover, in the context of climate change adaptation and mitigation, biotechnology stands out as a promising set of tools that can positively be utilized for decreasing vulnerability of human and natural systems to climate change impacts by enhancing crops adaptability, food security, and productivity as well as contribution to the greenhouse gas reductions (Godliving and Mtui, 2011; Adenle, 2011). Information and communication technologies (ICTs) is also expected to be an effective tool in communication of technologies related to the climate change mitigation that are definitely with low carbon effects in order to mitigate GHG emissions. Agriculture has the potential to adversely affect the environment through land conversion from wetlands and forests. Yet, GHG emissions from land use change are substantial in developing countries, and so are emissions from energy systems, industrial motors, transportation, and manufacturing, among others. Considering the existing worldwide reality of climate change and its harsh impact, the trend of GHG emissions in developing countries needs to be inversed, and ICTs have been demonstrated to provide such advantages (Niyibizi and Komakech, 2013). Moreover, the traditional energy system is another main contributor to GHG emissions and consequently, to climate change while renewable energy produce no or assist in GHG emission reductions. Further to this advantage, renewable energy technologies (RETs) create several socio-economic benefits in many rural areas and may perform as a safe option for adaptation to climate change. Renewable energies increase agricultural productivity by producing energy for postharvest processing and irrigation pumping. These productivity enhancements can decrease the needs for converting forests to croplands while necessarily keep or raise productivity.

This paper emphasizes the possible role of innovative agricultural measures and technologies in climate change adaptation and mitigation and aims to develop policy and institutional changes that are needed to promote the innovation and diffusion of these practices and technologies in developing countries. We describe some technologies that seem particularly promising in mitigating or adapting to climate change including integrated soil management practices, biotechnology, information and communication, and renewable energy technologies and use these as a basic for identifying the policies and institutions required for supporting the development and diffusion of existing technologies in order to provide some guidelines for technological advances in the future.

2. Methodology

In this paper we use triangulation, academic journal publications and patent-based data relating to these four technologies to indicate the degree to which capacity exists in developing countries. Bibliometric approaches have widely been employed to assess the impact of R&D and public policies in the field of innovation studies especially for both existing and emerging technologies (Johnstone and Hascic, 2013; Meyer and Persson, 1998). Accordingly, this paper begins with discussion on several technologies that may be useful to climate change adaptation and mitigation in developing countries. Keeping in mind these technologies, Section 3 explores the main constraints of technology development, transfer and use that create a platform for our discussion in the section of policy implementations that could facilitate climate change mitigation and adaptation in developing world. The final section provides policy recommendations to increase R&D investment for agriculture technologies toward tackling climate change.

3. Agricultural technologies for climate change mitigation and adaptation

3.1. Integrated soil management practices (ISMP)

The use of ISMP strategy will require practices such as zero to conservation tillage, minimal application of fertilizer, nutrient management, crop residue incorporation, manure, mulch, compost, cover crops and appropriate supplementary irrigation (Follett, 2001; Lal, 2008; Machado and Silva, 2001). The ISMP interventions require integrated utilization of mineral and organic fertilizers and comprise their wise manipulation to gain sustainable as well as productive agricultural systems. The main claim of the ISMP paradigm is that no single determinant of sustainable soil management can meet solely the necessities of sustainable soil management (Mugwe et al., 2009). There is considerable evidence demonstrating the important contributions of ISMP in reducing