

Discussion Paper for Round Table 3

Research and innovation for smallholder farmers in the context of climate change

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The opinions expressed in this paper are those of the authors and do not necessarily reflect official views or policies of the International Fund for Agricultural Development, except as explicitly stated.

ACRONYMS

ARD	Agricultural Research for Development
CDM	Clean Development Mechanism
CGIAR	Consultative Group on International Agricultural Research
CIAT	International Centre Centre for Tropical Agriculture
CIMMYT	International Maize and Wheat Improvement Centre
CIRAD	Centre International en recherch� agronomique pour le d�veloppement
CIRAD	Centre International en Recherche Agronomique pour le D�veloppement
GFAR	Global Forum for Agricultural Research
GHG	Greenhouse gas
GMO	Genetically modified organism
IAASTD	International Assessment of Agricultural Knowledge, Science and Technology for Development
ICARDA	International Centre for Agricultural Research in the Dry Areas
ICRAF	The International Centre for Research in Agroforestry
IFPRI	International Food Price Research Institute
IPCC	Intergovernmental Panel on Climate Change
IPR	Intellectual Property rRights
IRRI	International Rice Research Institute
IWMI	International Water Management Institute
NAPA	National Adaptation Programmes of Action
NARS	National Agricultural Research System
NEPAD	New Partnership for Africa's Development
PES	Payment for ecosystem services
PRESA	Pro Poor Rewards for Environmental Services in Africa
R&D	Research and Development
RUPES	Rewarding the Upland Poor in Asia for the Environmental Services They Provide
UNFCCC	United Nations Framework Convention on Climate Change
WDR	World Development Report

INTRODUCTION

Agricultural producers, in particular the smallholder farmers of developing countries, are facing unprecedented challenges in the 21st century. With an estimated 9.2 billion people to feed by 2050 – of whom 8 billion will be in developing countries – and increasing scarcity of land and water, productivity gains will have to be the main source of growth in agriculture and the primary means to satisfy increasing demand for food and other agricultural products. With globalization and new supply chains, farmers will need to continuously innovate to respond to changing market demands and remain competitive. Moreover, “climate change has the potential to irreversibly damage the natural resource base on which agriculture depends.”¹ **All regions of the world, and especially the diverse and vulnerable rainfed systems of sub-Saharan Africa, need technologies, knowledge and practices that simultaneously increase their productivity, their resilience to climate change and their contribution to its mitigation.**²

Climate change is increasing production risks in many farming systems and reducing the ability of farmers and rural communities to manage these risks on their own. Around the world, resource-poor farmers and pastoralists are trying to adapt to the effects of climate change, which affect them disproportionately: (i) dwindling crop yields; (ii) desertification and land degradation processes, exacerbated by changes in rainfall patterns; (iii) rising sea levels, affecting in particular the livelihoods of coastal communities; (iv) diminishing natural resource productivity; and (v) in some areas, irreversible loss of biodiversity.

For example, in sub-Saharan Africa, it is projected that an additional 17-50 million people could be undernourished in the second half of the century because of climate change. Extreme wind and turbulence could decrease fish productivity by 50-60 per cent in countries like Angola, Congo, Côte d’Ivoire, Mali, Mauritania, Niger, Senegal and Sierra Leone. Projected sea-level rise along the eastern and western coasts of the continent will cause coastal agriculture, a major source of livelihoods for smallholders in Benin, Côte d’Ivoire and Ghana, to be at risk of inundation, soil erosion and salinization.³

The agricultural sector offers opportunities for mitigating climate change. Agriculture has strong potential to reduce greenhouse gas (GHG) emissions by promoting clean and efficient energy, reducing deforestation and promoting sustainable agricultural practices such as the rehabilitation of degraded lands, water conservation and management, and increased biomass production. Since rural people manage vast areas of land and forest, they are important players in natural resource management and carbon sequestration. However, they are not usually compensated for their efforts in any significant way.

In the second half of the last century, agricultural research played a major role in rapidly increasing agricultural production and reducing rural poverty in Asia. But after 20 years of disengagement, progress in productivity gains has slowed, environmental damage has increased, global warming has accelerated and the number of hungry people is on the rise. **All of these situations call for reinvesting in agricultural knowledge, science and technology for achieving equitable and sustainable development.**⁴

The purpose of this paper is to discuss: (i) the potential role of agricultural research in improving small farmers’ productivity and ability to adapt to and mitigate climate change; and (ii) how to increase investments in international research and sharpen its focus on the challenges faced by regions that are most vulnerable to climate change.

¹ Agriculture at a Crossroads, IAASTD, 2009.

² World Development Report – World Bank 2008.

³ Intergovernmental Panel on Climate Change (IPCC).

⁴ Agriculture at a Crossroads, IAASTD, 2009.

I. Role of agricultural research in improving small farmers' productivity and ability to adapt to and mitigate climate change

I.1 Adaptation

The performance of crops, wild plants, livestock and aquatic resources under stress depends on both their inherent genetic capacity and the whole ecosystem in which they grow and are managed.⁵ For this reason, any efforts to increase the resilience of developing-country agriculture in the face of climate change must involve the development of improved crop varieties and animal breeds, as well as more prudent and integrated management of crops, animals and the natural resource base that sustain their production, while providing other vital services for people and the environment

The potential of improved varieties, animal breeds and aquatic resources

Since the 1960s, research aiming at adapting improved varieties, animal breeds and aquatic resources to subtropical and tropical conditions has generated high returns and favourable pro-poor impacts. Improved varieties suited to smallholders in subtropical and tropical areas combined with high levels of inputs – two major ingredients of the Green Revolution – has been one of the major success stories of rural development.

Improved varieties are now sown on 80 per cent of the cereal area in India, in irrigated and rain-fed areas. Newer generations of improved wheat varieties have provided an annual increase in yields of 1 per cent since 1981, largely in rain-fed areas.

With respect to genetic improvement of livestock and fish, improved pig and poultry have been adopted through, for example, cross-breeding of local breeds with exotic breeds mainly from the Northern countries. Artificial insemination is also playing an increasing role. Similarly, genetically improved tilapia is changing aquaculture into one of the fastest-growing agricultural sectors in Asia.⁶

However, genetic improvements in crops, animals and fish have reached only a small share of developing-country farmers, particularly in sub-Saharan Africa. This is partly due to constraints of delivery systems for these new varieties and breeds and to the lack of assets of the small holders to apply them.

Furthermore, progress in varieties performing well under drought, heat, flood and salinity has been generally slower than the progress achieved by disease- and pest- resistant varieties. As a consequence, in Africa due to water and soil constraints, the results of genetic improvement have been slower than in Asia. Only a few improved varieties are finally making an impact on some food staples – for instance cassava in Nigeria, or NERICA rice in Western Africa. The International Maize and Wheat Improvement Centre (CIMMYT) is only seeing positive results today in Eastern and Southern Africa, after 30 years of research to produce drought-tolerant maize varieties and hybrids.

In a context where the climate conditions are becoming more extreme, genetic improvement of varieties, animal breeds and aquatic resources is increasingly challenging, particularly in less-favoured areas. Rapid advances in the biological and informational sciences could be tapped to increase both productivity and resilience, particularly through the first-generation biotechnologies. For example, plant tissue culture for micro propagation, production of virus-free planting materials, and molecular diagnostics of crop and livestock diseases have already proven their effectiveness in Asia. The second-generation biotechnologies allow the development of molecular markers to

⁵ CGIAR: Global Climate Change: can agriculture cope.

⁶ World Development Report 2008.

help select improved lines in conventional breeding and have the potential of “speeding the breeding”, even if they are still costly.

More controversial biotechnologies are the transgenic or genetically modified organisms (GMOs), because of potential environmental and health risks. The outcomes of GMO use are still questioned: yield gains are highly variable (10-33 per cent) in some places and actually decline in others. Furthermore, the use of patents for transgenes introduces additional issues: in developing countries especially, instruments such as patents may drive up costs, restricting experimentation by the individual farmer or public researcher.⁷

In any case, **improved varieties and breeds alone are not sufficient**: low soil fertility, lack of reliable water, and lack of disease control are some of the major constraints that cannot be overcome through genetic enhancement alone.

Integrated farming systems and management of natural resources

The Asian Green Revolution has shown that if high inputs technology can be effective in terms of productivity, there is a price to pay in terms of environmental degradation – soil infertility, water depletion and contamination, and a loss of biodiversity. In response, agricultural research for development has become increasingly focused on promoting environmentally sustainable systems and on improving the integrated management of crop, livestock and natural resource systems. As an illustration of this trend, the Consultative Group on International Agricultural Research (CGIAR) invests about 35 per cent of its resources in sustainable production systems, twice as much as it invests in genetic improvement.⁸

In a context where the impact of climate change on the natural resource base is dramatically increasing, adoption of location-specific integrated management of natural resources for higher productivity and better resilience to erratic climatic events is becoming even more crucial. **The research programmes must be sensitive to local conditions affecting rural people and receptive to local/traditional knowledge.** Since small farmers and rural communities are the starting point for efforts to adapt to climate change, the problems and solutions should be defined with their direct and active participation. It is necessary to use participatory processes that empower smallholders to: draw on their expertise about ecology and management; overcome the constraints they face; create a sense of ownership; and share their visions and experiences with other partners.

Through different denominations (e.g. Doubly Green Revolution, Conservation Agriculture, Ecoagriculture, Agroecology, Evergreen Revolution), research has implemented many initiatives at field level to develop integrated management of natural resources, including: soil moisture management practices aimed at better capturing and maintaining water in the root zone; technologies for water harvesting and water storage micro-schemes; small-scale community-based irrigation schemes; and planting pits and demi-lunes⁹ in dry-land farming areas to channel run-off and check soil erosion and degradation.

Among the most successful examples of resource management is zero tillage, which minimizes or eliminates tillage and maintains crop residues as ground cover. It has many advantages over conventional tillage, including: savings in labour and energy; conserving and even improving soil fertility and productivity; increasing soil moisture and tolerance to drought; and reducing GHG emissions. In Latin America, it is now used on more than

⁷ Agriculture at a Crossroads, IAASTD, 2009.

⁸ World Development Report 2008.

⁹ Traditional tillage techniques that were revived and refined during exchanges between organized groups of farmers from Burkina Faso and Niger, with the support of an IFAD project.

40 million hectares. Originally adopted by large and mid-size farmers, the practice has spread to small farmers in Southern Brazil.¹⁰

Where lower population pressure still allows, fallowing remains an important strategy for long-term soil restoration. Improved fallows, using legumes and trees, have shown positive impacts on soil fertility and on controlling floods, particularly in coastal areas. Integrating cropping with livestock production has also triggered many spin-off benefits for soil fertility management.

Enhancing the productivity of water can be promoted through drip irrigation, water harvesting, enhanced management of rain water or collective action to protect shared resources. For instance, the International Water Management Institute (IWMI) is working with local partners in Burkina Faso on local low-cost irrigation systems; the International Centre for Agricultural Research in the Dry Areas (ICARDA) is promoting mechanized construction of traditional micro-catchment ridges to expand water harvesting in degraded rangelands.

Although success stories can be observed in many situations, they cannot be generalized. There are still many constraints to be addressed for effective upscaling of their benefits. For example, measures to address water control and soil structure/organic content take time and long-term investment. Rotation, manuring, composting and other “sustainable agriculture” and “low external input” techniques are valuable, but often require considerable labour and skills, as well as large volumes of biomass. Fallowing requires extensive areas of land, which is an issue in areas where demographic pressure is rapidly increasing. Conservation tillage approaches can work well, but they may also reduce the availability of crop residues, often a critical source of fodder in mixed crop-livestock systems. Zero tillage requires some use of herbicides that make it unaffordable for poorer farmers.

Therefore, if practices related to conservation agriculture have already demonstrated their effectiveness in specific conditions, much more needs to be done to broadly increase small farmers’ productivity and resilience. In this regard, Michel Griffon,¹¹ for example, advocates for going further in the understanding of natural phenomena and the way they develop and interact. This would imply new and advanced research in ecology to better understand and take advantage of: functional ecology and biogeochemical cycles; population ecology and ecosystem trophic networks; landscape ecology and the complex interactions of its various components; and soil functional biology. Advanced knowledge is also needed in plant and animal genomics, particularly for innovation in varieties and breeding and for identifying natural molecules (for example, to replace chemical pesticides).

I.2 Mitigation of GHG emissions

Carbon trading, carbon tax and other climate change mitigation mechanisms, which are poised to increase dramatically, hold great potential to fund projects and initiatives contributing to mitigation of GHG emissions. This constitutes a significant opportunity for developing countries to attract investments and reduce poverty.

Investments and financial flows for developing countries linked to climate change mechanisms are currently dominated by the Clean Development Mechanism¹² (CDM)

¹⁰ WDR 2008.

¹¹ Nourrir la Planète, 2007.

¹² Clean Development Mechanism (CDM): Mechanism allowing the transfer of Certified Emissions Reductions (CERs) to industrialized countries from projects located in developing countries that create credible and measurable reductions of GHG emissions or sequestration of GHGs.

market of the United Nations Framework Convention on Climate Change (UNFCCC). Project activities under the CDM relate to a broad range of sectors and regions where carbon offsetting is possible. Given the strong correspondence between the location of indigenous peoples and areas with the highest biodiversity and relatively intact natural resources, indigenous peoples have a role to play in designing and implementing mitigation measures, especially those related to preventing deforestation.

However, developing countries, particularly in Africa, do not benefit as much as they could, mainly because of the limited coverage of the CDM with respect to afforestation and reforestation. **The majority of the “win-win” mitigation opportunities that can be identified at field level and could benefit small farmers in developing countries are currently not eligible under the existing mechanisms.** Policy research is required in this field to develop systems that reward rural communities for the environmental services they do/could provide. The research should focus on how to support appropriate pro-poor policies to ensure flow of carbon funds, and technologies that enhance, measure and monitor carbon capture and storage. Mitigation opportunities include:

- land use approaches with lower rates of agricultural expansion into natural habitats and increased efforts to avoid deforestation
- promotion of agroforestry
- implementation of agroecological system approaches
- restoration of underutilized or degraded lands and rangelands
- carbon sequestration in agricultural soils
- reduction in and more efficient use of nitrogenous inputs
- energy-related actions such as promotion of clean energy and reduction of consumption of fossil fuel
- in the livestock production system, effective manure management (collection, storage, spreading), management of feed crop production and use of feed that increases digestive efficiency.

Reduction of methane emissions is also possible through better irrigated rice production and livestock management. For example, the International Rice Research Institute (IRRI) is promoting the development of rice with lower emissions of GHG and greater resilience to the impacts of climate change; and researchers at the International Center for Tropical Agriculture (CIAT) have identified leguminous forage species possessing high tannin content, which suppresses methane emissions.

Payment for ecosystem services (PES), also termed reward for ecosystem services, is a relatively new approach to conserving and restoring resources, through different kinds of contracts between stewards of ecosystems and beneficiaries of ecosystem services. Successful PES projects are being implemented by the International Centre for Research in Agroforestry (ICRAF) in Asia (Rewarding the Upland Poor in Asia for the Environmental Services They Provide – RUPES) and Africa (Pro Poor Rewards for Environmental Services in Africa – PRESA). They mainly target hydrological services and biodiversity conservation. However, the application of PES schemes to carbon sequestration implies a number of challenges, including: identifying the appropriate market; establishing appropriate policies; addressing transaction costs; building the capacities of farmers to use the approved methodologies and to understand and follow existing regulations; and developing a system to effectively measure the amount of carbon sequestered.

II. Increasing investments in international research and sharpening its focus on the challenges faced by the regions that are most vulnerable to climate change

II.1 Organization of the international research system

Agricultural research first benefits the wealthier farmers in the better agricultural areas. **There is a need for a stronger and more explicit focus on poor and disadvantaged farmers in marginal areas, and to involve and engage users throughout the research process** – from problem analysis to evaluation of project/programme outcomes. Participatory research that suits local ecological conditions is a must. The approach should promote the incorporation of indigenous knowledge on coping with climate variability into research projects (which, among other things, would lead to better-defined research questions), and facilitate the process of transferring or devolving results and skills to those who will use them.

The innovation-driven activities supported by research should be “pro-poor”, providing high returns to small-scale rural producers while building on their knowledge and ingenuity – the communities need to be looked upon as researchers in their own right. In cases where this approach was adopted, significant pay-off has been demonstrated in terms of improvement in the quality and productivity of staple crops, livestock and aquaculture, thus resulting in higher food security and improved living standards.

For example, in Nicaragua, farmers decided themselves to grow sorghum instead of maize (which requires too much water), in response to changes in local climate. Then they expressed their interest in improving their farming system and the varieties they were growing. In partnership with a local NGO,¹³ an international research institute¹⁴ and the national agricultural research institute,¹⁵ they began a participatory programme. As a result of this process, farmers have improved their cropping systems and are now growing new varieties of sorghum that are giving higher and more stable yields.

Business as usual for agricultural research for development is not a viable or sustainable option. **The lack of linkages between research, education and extension requires a fundamental reorganization** in order to break down institutional divides and put the needs of society and of the poor at the very heart of their activity.

Helping poor rural people adapt to the impacts of climate change and enabling them to contribute to mitigation is not a task that can be performed by a single agency alone; **it requires cooperation and a coordinated approach from the international community**. Research needs to draw significantly on the scientific resources of regional and international centres of excellence by commissioning specific poverty-relevant research programmes, with local research and development (R&D) partners including, in particular, the farming communities themselves. Cross-country learning is essential in order to respond to the challenge of practical innovation and to bring the best available knowledge to the service of poor rural people, building on the rich diversity of their own knowledge.

With the rapid growth of the national agricultural systems in Brazil, China, India and South Africa, the space that international research centres occupy has altered. Some of these national programmes have developed the capacity to partner with the CGIAR on equal terms to work jointly towards meeting their food production needs. The entry of strong new actors into the field of agricultural research means that the CGIAR may no

¹³ CIPRES.

¹⁴ CIRAD: French Agricultural Research Centre for International Development International Development.

¹⁵ INTA: Nicaraguan Institute for Agricultural Technology.

longer be perceived as the only provider of solutions for agricultural productivity, natural resource management or policy advice.

Within this context, the CGIAR has undergone an extensive reform exercise, involving virtually all the constituencies which have a stake in Agricultural Research for Development (ARD). A revitalized CGIAR promises to strengthen and position the CGIAR and its partners to better serve the billions of people who depend on agriculture. The reform model is being refined during a transition phase in 2009 towards developing a clear strategic focus; improved research output, outcome and impact; greater efficiency, effectiveness and relevance; simplicity and clarity of governance; enhanced decentralized decision making; and active subsidiarity to capitalize on complementarities within the CGIAR Centres, but more importantly to build on synergies with other partners in the ARD continuum including the National Agricultural Research Systems (NARS) and including the civil society and the Private Sector through Public Private Partnerships.¹⁶

The newly reformed CGIAR and its NARS partners have an important role to play in this context. They can improve the efficacy of research and capacity-building partnership-programmes that involve different stakeholders (including farmers' organizations and the private sector) and inter-disciplinary engagement to address adaptation to and mitigation of climate change – building on local knowledge and blending it with the best state-of-the-art formal science.

There is a need to foster a progressive paradigm shift in ARD towards a holistic "knowledge-intensive agriculture", mobilizing the knowledge and experience of small and poor farmers and scientists as partners in Innovation Systems. The Global Forum for Agricultural Research (GFAR) serves as a good platform for this purpose: the GFAR philosophy embraces principles of: research that is demand-driven and implemented through productive and meaningful partnerships among key stakeholders; research agenda priorities set with a focus on the perspectives of poor farmers and rural communities; and research design and technology dissemination that fully engages intended users and beneficiaries. These stakeholders include national programmes, agricultural universities, farmers' organizations, the private sector and donors, all promoting the development of promising pro-poor technologies, drawing on their comparative advantage and strengthening synergies. The 2009-2010 GFAR Plan of Work identifies climate change as a key strategic theme, to be addressed through programmes of concerted action and to generate and share knowledge.

II.2 Funding innovations and new commitment to Agricultural Research for Development

Underfunding of agricultural research is pervasive. In most of the developing countries, "research intensity" (agricultural research expenditure as a percentage of agricultural GDP) is less than the global average of around 1 per cent.¹⁷

Underfunding of agricultural research is even more alarming when one considers that the diversity and location-specificity of the impacts of climate change reduce the replicability of technologies from one region to another. In particular, the budget dedicated to agricultural research in Africa has sharply decreased since the structural adjustment programmes, and many national agricultural research systems are lacking the resources to work efficiently and maintain adequate staffing. Private research has not compensated the decrease, as it tends to focus more on intensive agriculture with a higher potential return on investment.

¹⁶ Cooke et al, CGIAR Change Steering Team.

¹⁷ Pardey and Beintema, 2001.

Variability of funding is another problem, in view of the long gestation period for new crop varieties and livestock breeds and the desirability of assuring long-term employment for scientists and other staff. Underfunding or unpredictable funding encourages an overemphasis on short-term projects or on projects with short lags between investment, outcomes and adoption.¹⁸

In general, the private share of total research funding is small in developing countries and should not be expected to displace public funding to any great extent in the near future. Any significant expansion in private funding, even through public-private partnerships, will require a clear and effective system of intellectual property rights (IPR) in order to get the incentive framework right.

Given this situation, most developing countries will continue to experience negligible private sector involvement in agricultural R&D. Therefore, **the role of the state remains central, and public involvement will be required for specific products to be developed for small farmers.** As highlighted in the Nairobi Work Programme,¹⁹ it is important for developing countries to: (i) improve their understanding and assessment of impacts, and vulnerability and adaptation to climate change; and (ii) make informed decisions on practical adaptation actions and measures to respond to climate change on a sound scientific, technical and socio-economic basis.

Governments and regional organizations are already taking action towards climate change adaptation. For example, the Environment Initiative of the New Partnership for Africa's Development (NEPAD) prioritizes climate change as one of ten programmatic areas. National Adaptation Programmes of Action (NAPA) provide an important way to prioritize urgent adaptation needs for least-developed countries. They draw on existing information and community-level input to identify adaptation projects to enable these countries to cope with the immediate impacts of climate change.

More needs to be done. National governments in developing countries could also take certain initiatives, including: (i) increasing the total amount of government funding for their NARS; (ii) setting up an effective system of IPR to attract private investment and tailoring the institutional and policy details of IPR to fit local circumstances; (iii) introducing institutional arrangements and incentives for private and joint public-private funding, such as matching grants and check-off funds; and (iv) improving the processes by which agricultural research resources are administered and allocated. They also have an important regulatory role as innovations and new research agendas are being developed. For example, in the case of GMOs, public involvement is required to assess the technical, social, gender, legal, environmental and economic implications.

Such initiatives alone may not be sufficient. Addressing climate change at global level requires resource mobilization beyond the capacity of many national organizations. **Another role for developing-country governments and farmers' representatives will be to advocate to the international community, and particularly to developed countries, for more support in rebuilding their research systems.** The adverse effects of climate change cannot be tackled by a single organization or government. Partnerships, including a broad range of government and non-governmental stakeholders, need to be established for various purposes – for instance, funding, technical assistance/research, learning and knowledge sharing, implementation, monitoring and evaluation, strategy formulation. An integrated approach is needed to bridge the gap between local development and the global challenge of climate change.

¹⁸ IFPRI, 2008.

¹⁹ UNFCCC Nairobi Work Programme, 2006.

The issues and options described in the preceding pages are meant to provide some direction for a discussion during the Round Table. They have been broadly recast below as questions posed to the panellists and discussants for their response.

Questions to guide the Round Table discussion

- How can investments in agricultural research be significantly increased to improve the resilience of smallholder farmers to the effects of climate change, improve their productivity in a context of risk and uncertainty, and contribute to rewarding communities for the environmental services they provide?
- What is needed to sharpen the focus of international research on the challenges faced by the regions that are most vulnerable to climate change, and that are also the least prepared in terms of institutional capacity (and are primarily in Africa)? How can the concerns of marginalized rural communities be given a voice and influence the research agenda?

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