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Smallholder Agriculture and Food Security in the 21st Century

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

Discussion Paper and Proceedings Report of the Governing Council Round Table held in conjunction with the Thirty-second Session of IFAD's Governing Council, February 2009

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Background Paper No. 3

The number of poor and hungry people has been increasing, and the world now faces a major economic downturn. Climate change, growing competition for land, and the volatility of prices for food and inputs are having a negative impact on rural women and men in developing countries, and particularly on the poorer and most vulnerable households. At the same time, all over the world, family farmers, local communities, private enterprises, governments and development partners are bringing new responses to these challenges and new reasons to believe in a future without hunger and poverty.

IFAD, in preparation for the publication of its Rural Poverty Report later in 2009, held three round-table discussions on the challenges and opportunities for smallholder agriculture during the thirty-second session of its Governing Council in February 2009.

Round Table 1 – *Food price volatility – how to help smallholder farmers manage risk and uncertainty.*

Round Table 2 – *The growing demand for land – risks and opportunities for smallholder farmers.*

Round Table 3 – *Research and innovation for smallholder farmers in the context of climate change.*

The discussions focused on identifying policies and strategies that can be applied at the national level to ensure that the needs of smallholder agriculture are met, and on the research and technology needed to advance smallholder agriculture.

The section that follows describes the proceedings of Round Table 3 "*Research and innovation for smallholder farmers in the context of climate change"* and includes a discussion paper on the topic.

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

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, raise 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 international research focus on the challenges of the regions that are most vulnerable to climate change, which are also the least prepared in terms of institutional capacity, and which are for the most part in Africa? How can the concerns of marginalized rural communities be voiced and influence the research agenda?

Chairperson: Rodney Cooke, Director, Technical Advisory Division, IFAD

Panellists:

- **Hans R. Herren**, President, Millennium Institute
- **Ma. Estrella A. Penunia**, Secretary General, Asian Farmers' Association for Sustainable Rural Development (AFA)
- **Michel Griffon**, Director General, National Research Agency, France
- **Eija Pehu**, Senior Advisor, Agriculture and Rural Development Department, World Bank

1. Opening remarks

This round table was opened by **Dr Rodney Cooke**, Director of the Technical Advisory Division of IFAD, who highlighted the enormous challenges to humanity of continuing to feed itself in the face of demographic pressures, changing dietary patterns and increasing scarcity of land and water, and in a context of increasing climate volatility and unpredictability. These challenges are forcing farmers to innovate to respond to changing market conditions and to become more productive in riskier conditions. Concomitantly, resource-poor agricultural communities are becoming more and more marginalized, particularly in terms of their access to knowledge, technologies and resources. He stated that there are about 500 million small-scale farms, and that is where many of the almost 1 billion people existing on less than one dollar a day are living. Smallholder food production is therefore essential to the survival of both rural and urban communities.

Dr Cooke stressed that these new challenges call for new solutions and hence the need for research and innovation for rural development. Although a considerable amount of research has been conducted on genetic improvement – and improved varieties are an essential part of innovative approaches – it is not enough. Even the most elite crop varieties cannot extract water and nutrients from the soil where they do not exist. Hence the focus on integrated farming systems and natural resource management approaches – variously known as the Doubly Green Revolution, Conservation Agriculture, or the Evergreen Revolution – which have proved to be adaptable to climate change and trigger increases in productivity at the same time. The question is how to extend these positive results and go further in promoting agricultural innovation systems. Dr Cooke concluded his opening statement by drawing attention to the fact that many opportunities for mitigating climate change are not available to smallholder farmers under existing mechanisms.

2. Panellist presentations

The first presentation was given by **Dr Hans R. Herren**, President, Millennium Institute and co-chair of the International Assessment of Agricultural Science and Technology for Development (IAASTD). He began by stating that climate change is fairly recent, but is having an enormous effect on agriculture. At the same time, natural resources and the environment as a whole are increasingly endangered by agriculture and by industry. The challenges identified by the IAASTD, which are not new, relate to: reduction of hunger and poverty; improvement of rural livelihoods and human health; and facilitation of equitable and socially, environmentally and economically sustainable development. These global challenges are interlinked and need to be addressed with new knowledge, science and technology.

Dr Herren emphasized that new thinking is required: no more business as usual, neither in the north nor in the south, because the type of agriculture practised in both leads to problems. It is necessary to search for a new paradigm and this is up to the farmers, but also to those working in agricultural extension, the scientists and the policymakers. African agriculture in particular is extremely vulnerable, and the African continent has already experienced a series of droughts, floods and, in general, more extreme weather patterns. Aside from extreme weather events, rising sea levels will affect many highly fertile coastal areas.

One of the main issues related to agriculture is water availability and use. The foreseen decrease in the quantity of available water in the future could have serious implications for irrigation. Water tables are being lowered everywhere as a result of excessive pumping of water for agriculture. Soil quality is also critical. Dr Herren stated that humans have been "raping" the soil, both in the south and in the north, by overexploiting it, overfertilizing it and using bad rotation practices. However, very little is known about how the soil works, the function of its different organisms and the ecological mechanisms at play.

There are a number of actions that can be taken both in the immediate future and in the longer term. Above all, it is necessary to think more about infrastructure that is

more conducive to sustainable agriculture. More institutional development is required and farmers need to have the opportunity to mobilize, particularly smallholder farmers because they have the capability and incentives to take care of the environment.

Dr Herren went on to speak about risk. By reason of their meagre assets, smallholder farmers are risk-averse, but if no risks are taken, little progress can be made. It is therefore vital to consider how to reduce risks and how to create more safety nets for smallholder farmers. It is also fundamental to increase the resilience of farms. Again, this starts with fertile soil. In addition, as crop diversity increases, so does resilience. Having more diversity is important, but it is also important to understand the role and impact of this diversity. He mentioned conservation agriculture and integrated crop production as important areas of research required to close the carbon loop as far as possible. He also highlighted the need for technologies, including biotechnologies. Information technologies are particularly valuable in increasing the knowledge that should reach the farmers. In an era of dramatic development of the internet and mobile phones, information available thanks to early warning systems can be forwarded to farmers and help them prepare for and adapt to forthcoming climate events.

There is no point in the farmers producing more if they cannot sell their produce. It is thus important to invest in relevant, effective and efficient value chains and in agricultural product processing, through which rural people, and particularly smallholder farmers, can increase their income and enhance their employment opportunities. Dr Herren concluded by underscoring that the multifunctionality of agriculture must be internalized at the policy, research and farm levels.

The second presentation was given by **Ms Ma. Estrella A. Penunia**, Secretary General, Asian Farmers' Association for Sustainable Rural Development (AFA). Ms Penunia emphasized the timeliness of the round table, given the issues currently faced by smallholder farmers. For example, in the Philippines, the people are now experiencing extensive rainfall, and even flooding in the traditionally dry months from December to April. Climate change affects everyone on the planet, but men and women who are smallholder farmers face the greatest impact because they rely so heavily on natural resources for their livelihoods.

At the same time, smallholder farmers serve as responsible stewards of their land. They are most likely to use sustainable farming techniques to protect their natural resources and health. For centuries they have been developing their own culture and practices within their environment to meet their nutritional needs, to reduce their risks and to maintain soil fertility. Ms Penunia gave an example of smallholder farmers in Thailand who have intercropped rice and cowpeas or soybeans for many decades. NGOs in the Philippines have been supporting the development of integrated farming systems on plots of 1 hectare of irrigated land, from which a farmer’s family can obtain its fish, rice, vegetables and organic fertilizers and still have some surplus to sell to finance their children’s education.

On the basis of this understanding, Ms Penunia outlined AFA's responses to the questions posed for this round-table discussion:

- AFA is concerned about the increasing interest of private companies, especially transnational corporations, in agriculture and notes that the public sector is investing little in agricultural research and development. Efforts should be made to develop innovative, public-private partnerships to raise funds for the public research agenda.

- Research should aim at improving crop resilience, diversity and adaptability through traditional and modern breeding techniques. Smallholder farmers and their organizations should be involved in the research programmes.

- Documentation should be collected on local knowledge and on practices in crop breeding, seed banking, pest management, organic fertilizers and energy-efficient mechanisms. For example, Indonesian farmers can produce charcoal briquettes from coconut. This technology should be fully described and shared with coconut farmers in the Philippines.

- Links among research, advisory and extension services should be strengthened to promote sustainable and organic agriculture, particularly targeting women. Agricultural extension workers are not there when needed, primarily because they are few in number and have many areas to cover or tasks to undertake. Sometimes their advice is not aligned with smallholder farmers' needs and often they do not have the knowledge to answer smallholder farmers' questions. Furthermore, it is only when farmers are empowered that they can claim accountability and command an adequate response to their requests from the extentionists. For example, in Taiwan, the production of rice and wax apples increased significantly as a result of the close cooperation among the research institute, the extension services, the National Pingtung University of Science and Technology and the farmers themselves.

- Efforts should be made to support farmer-led and civil society-initiated research and development efforts, such as participatory plant breeding and community-based genetic resource conservation efforts. AFA members in the Philippines were part of the initial group that conducted participatory research in 1986 on the effects of the Green Revolution on incomes and on the health of soils and animals. This research made farmers realize that chemical-intensive farming, while increasing incomes, also increased production costs, killed certain fish in farms producing rice, contaminated water, increased risks to health and depleted soils. Based on this research, farmers set as one of their goals the promotion of sustainable agriculture and partnerships with scientists to establish a traditional rice seed bank and develop organic rice farming practices so as to gradually phase out chemical fertilizers.

In closing, Ms Penunia stated AFA's belief that sustainable organic agriculture, which is owned, controlled and managed by smallholder men and women farmers and

supported by government policies and programmes, is a strategic agricultural measure to adapt to and mitigate climate change, ensure food security and reduce poverty among smallholder farmers. AFA advocates for strong support for this kind of agriculture through funding public research and development, communication and information dissemination, and the scaling up of initiatives. She stated that AFA looks forward to the establishment of meaningful partnerships among all the stakeholders: government, business, civil society and farmers' organizations.

The third presentation was given by **Dr Michel Griffon**, Director General, National Research Agency (ANR), France. Dr Griffon presented the concept of "ecologically intensive agriculture" as one possible solution to the following equation: how to feed the developing world in 2050 (8 billion people, compared with the present population of 5.7 billion, mostly in megalopolises), and help poor people overcome poverty while protecting natural resources, particularly forests and biodiversity, in the increasingly unpredictable context of climate change. Smallholder farmers, who have few alternatives to agriculture for emerging from poverty, constitute the centre of the solution to this equation.

Dr Griffon stated that production increases can only come from a moderate expansion of acreage if forest areas and biodiversity are to be preserved. This means that yields have to be upgraded considerably. The Green Revolution was based on high-input technologies and genetic improvements of seeds placed in optimal conditions. Its success was enormous and may still prove useful in the future in certain contexts, but its ecological and economic costs have proved to be considerable and are unaffordable for smallholder farmers. Therefore, new technologies are needed that are more respectful of the environment: causing less pollution through chemical fertilizers; using fewer pesticides that pollute soils and water; and costing less. In terms of costs, he gave the example of nitrogen-based fertilizers, the price of which is closely linked to that of oil and will become more expensive. The price of phosphate-based fertilizers will also rise because phosphate is a limited natural resource and increasingly hard to find.

Dr Griffon explained that a more holistic approach is needed that takes into account the productivity of the entire ecosystem. This is what is referred to as integrated agriculture, including the management of soil, water, plants, animals, diseases and pests, and the management of the landscape as a whole. Ecologically intensive agriculture intends to go further than integrated agriculture by imitating natural phenomena and using them as an inspiration for the development of new inputs. For example, much still needs to be understood about the way soils function and live. Too often, soil has been seen as a physical substrate, but it is first and foremost a biosphere, a living ecosystem. Biomass decomposition, humus generation and mineralization all give rise to soil nutrients and are very complex processes that are little understood. They make use of earthworms, nematodes, microscopic mushrooms, protozoa, arthropods, and billions of bacteria we know nothing about.[1]

[1] ANR has proposed the establishment of an international consortium to sequence the genome and metagenome of soil bacteria and thus improve the understanding of how the soil actually operates so that better use can be made of its capacity as a renewable resource. (See http://www.agence-nationale-recherche.fr for further details.)

Dr Griffon went on to describe different techniques. For example, water retention in soil or in an ecosystem can be enhanced by using mulch covering, prevents the run-off of rainwater and facilitates infiltration. The role of earthworms, which penetrate deeply into the soils and facilitate aeration and mineral exchanges, can be enhanced to produce a high fertility level. Another innovative area is that of "soil cover technologies": as the soil is not covered by plants during the intercropping seasons, programmes are being developed to improve the use of plants to collect solar energy and to enhance the production of biomass and, through its further decomposition, overall soil fertility. Programmes based on biomimetics are also promising. Certain algae and bacteria can capture the nitrogen from the air and convert it into fertilizer. This can be enhanced, for example, by genetically modifying the bacteria, which entails using an existing physiological or biological process and upgrading it through biomimetics.

For pest and disease control, Dr Griffon explained that it is also possible to create new molecules imitating those found in nature. For example, molecules emitted by plants that repel insects can be transferred to other plants to prevent insect infestation. A new generation of insecticides, which would mimic or imitate the existing molecules already found in nature, could be developed. For weed control, a solution could be found through the promotion of a natural phenomenon known as allelopathy: certain plants prevent others from growing in their immediate vicinity, through the production of molecules produced by their roots or by bacteria that are intermingled within their roots. A better understanding of molecules having such allelopathic properties could provide alternatives to chemical herbicides.

Dr Griffon concluded by underscoring the two main components of ecologically intensive agriculture: (i) the very simple technologies already available and built on observation, which are knowledge-intensive and labour-intensive technologies but require minimal investment and are accessible to poor farmers; and (ii) ecologically intensive agriculture, which is a realm for high-technology research, including genomics, chemical synthesis, transgenesis and functional ecology. Ecologically intensive agriculture is already under way, with initiatives being implemented in many countries by smallholders and wealthier farmers alike. This movement needs to be enhanced and research scientists must accompany the movement.

The final presentation was given by **Dr Eija Pehu**, Senior Advisor, Agriculture and Rural Development Department, World Bank. Dr Pehu presented six pragmatic points related to the type of institutional arrangements required for moving forward.

- *Innovation systems context.* It is important to view research and innovation in an innovation systems context, rather than looking at investments in agricultural research institutions as such, or even through the triangulated farmer/extension/research entities, and then going beyond to involve the private sector, local communities, smallholder farmers, NGOs and others in the innovation process. More understanding is needed of how to retain a dynamic innovation system – for example, when to use an innovation fund, when to use a technology fair, when to invest in the research institutions in a

particular country. In the context of climate change, it is not enough to rely solely on local in situ knowledge. Traditional knowledge gathered from other locations, similar ecosystems or from South-South collaboration is pivotal.

- *Agricultural biotechnology.* There is scope for agricultural biotechnology to play an important role. Climate change is causing increasing variation in rainfall patterns, temperature stress, onset of drought, etc. Much can be done with conventional breeding or crop management, but the toolkit also includes agricultural biotechnology, which is underutilized as a pro-poor tool generally and for crops that are important for the food security of smallholder farmers, such as roots and tubers and cereals. Because this is a new technology, it is important to support countries in biosafety, food safety regulations, and in developing the necessary regulatory and enforcement capacity. The public sector needs to increase investment in biotechnology research; the private sector, which is now very much driving the agenda and doing very good work, is often focused on goals that do not necessarily match those of smallholder farmers.

- *National science and technology agenda.* Agricultural research needs to be viewed in the context of the science and technology agenda in developing countries. There is good momentum driven by science ministries, some research-oriented companies, and university and academic research. But it is often divorced from the agricultural research that is supported by land or agricultural ministries. Much can be learned through information technology and virtual networks, about using diasporas in innovation or South-South collaboration. There is an opportunity to bring high-technology knowledge and information systems to the sphere of agricultural research as well, and to link it to the challenges that smallholder farmers are facing.

- *CGIAR reform process*. The CGIAR system is expected to become more effective and efficient. It is important to harness that system and to identify technologies that would be useful for smallholders in responding to the issues presented by climate change. There is a need to have an instrument dedicated to agricultural research for development. However, the CGIAR should not reach too far into development, but rather retain its comparative advantage in the research sphere. Nevertheless, the interface with development could be enhanced further.

- *Strong producers' organizations.* In order to achieve economies of scale and articulate and request research and advisory services, strong rural producer organizations are required, with independent resources to make resource allocations based on their own priorities.

- *Gender mainstreaming.* Managing mainstreaming of gender into agricultural innovation, research and advisory services is fundamental. It is important to identify who will benefit from (or be harmed by) proposed technologies, and to promote women's leadership and active participation in the research organizations, extension services, producers' organizations and the range of

intermediary organizations. The commitment of leaders from donor and national organizations is required, as are incremental resources that are explicitly earmarked. Technical advice is also needed; in this regard the Gender in Agriculture Sourcebook (http://worldbank.org/genderinag) is useful.

3. Round-table discussions

There were approximately 120 participants in the round table. The main issues that emerged during the discussions are summarized below.

Organic farming and sustainable agriculture. Even if some participants expressed the opinion that organic farming cannot feed the world, there is evidence that organic agriculture can have large-scale impacts: for example, farmers who practise sustainable organic rice farming in Asia proved that their production is higher and more stable than when they used chemical-intensive farming. Conversion of large-scale production to organic farming could also be relevant, for example to enhance soil fertility and reduce water pollution. However, organic farming is not always synonymous with sustainability. For example, there are very large farms that are labelled organic but are not sustainable. Broader conservation technologies are needed in which all components of the ecosystem are taken into account. Ecologically intensive agriculture can go beyond organic farming and develop integrated solutions based on organic approaches, while also requiring, in certain conditions, external inputs or even biotechnologies.

Research linkages with climate change 'hot spots'. It is important for agricultural research to recognize the hot spots for climate change and the number of smallholder farmers concerned. The Intergovernmental Panel on Climate Change provides climate change scenarios, but it is essential to scale them down to these hot spots and then concentrate research here in order to help the smallholder farmers in these areas. Agricultural research needs to establish collaborative linkages with meteorological services in order to develop early warning systems, and to learn more about extreme events and their impacts in terms of natural disasters, which demonstrably have a greater impact on smallholder farmers than on large-scale farmers. Research must take cognizance of these forecasts and inform smallholder farmers of preventive action or preparedness strategies that they can adopt. Hot spots are related to agriculture but also to water and sanitation for human health. It is therefore important to work in collaboration with the health research community.

Adaptation and genetic improvement. Smallholder farmers need specific research and innovation on adaptation. Adaptation can come through genetic improvement, and farmers' own practices should be considered first. Farmers in developing countries usually cultivate a large number of varieties, thus mitigating risks arising from potential climatic events or sudden insect attacks and diseases. This diversity needs to be maintained and even increased to enhance the resilience of agricultural systems.

Putting agriculture on the Copenhagen table. In view of the forthcoming Climate Conference in Copenhagen (December 2009), it is fundamental to introduce agricultural issues into the mitigation agenda, which is currently focused on deforestation and reforestation. Strategic partnerships are needed to build the negotiation capacity of parties going into the Copenhagen talks, in order to integrate the points that relate to smallholder agriculture into the Kyoto mechanisms and biocarbon markets.

Empowerment of smallholder farmers*.* Smallholder farmers are highly vulnerable to the impacts of climate change. Capacity development must not only increase the number of scientists in research organizations but also include additional extension workers and smallholder farmers. The latter in particular must be directly involved in identifying research needs and priorities, and be part of all research and development programmes. There is a need to set up more vocational schools for farmers. Farming is becoming more and more complex, which means that knowledge accumulated over the years is of crucial importance, but new science and technology are also required. In this regard, the experience of farmers' field schools is very relevant. More needs to be done in this direction, as it is a key element in providing farmers with more knowledge and information.

Political will and investment in public research. Political will and commitment are fundamental if research and innovation are to be effective. Investments in public research have been dramatically reduced in recent decades. It is critical for governments to reinvest in agriculture. The research undertaken by the private sector can be useful, but it often becomes locked in patents and is not focused on the priorities of smallholder farmers. The results of public agricultural research must be regarded as a public good, available to everyone and therefore supported by the public sector. The donor community is recognizing the need for investment in agriculture. Donors should work together with the national governments to enhance their political will, and make available the required investments for agricultural research.

Institutional support. More research and innovation are needed, but serious consideration needs to be given to which appropriate institutions can deliver which appropriate technologies. Research on institutional innovation should be undertaken to define how to invest in local institutions and develop their absorptive capacity to facilitate technology exchange among them, and how to enhance their ability to work with the various stakeholders, particularly smallholder farmers. The critical priorities of these local institutions need to be identified, as do the barriers they face at the local level, so that they are more able to engage with the newly reformed CGIAR system, developed at the national and global levels.

II. Summary of the round table discussion presented to the Governing Council

Based on the round table discussion, a summary statement and recommendations was prepared and presented to the Governing Council. The summary is provided below.

Round Table 3: Research and innovation for smallholder farmers in the context of climate change

- Agricultural producers, in particular smallholder farmers of developing countries, are facing unprecedented challenges in the twenty-first century. They will have to feed 9.1 billion people in 2050 while they have little scope for increasing the amount of land they can cultivate without cutting down forests, and while climate change can irreversibly damage the natural resource base on which future harvests depend. Therefore, most of the increased production must come from higher productivity on existing farmland, in a context in which adaptation and resilience to climate change has to be enhanced.

- Those new challenges require renewed effort and fresh approaches in research and innovation. They also require a stronger commitment from governments and the international community to support public agricultural research and improve the productivity and resilience of smallholder farmers.

- Modern scientific knowledge needs to be integrated with the traditional knowledge of rural communities that is too often neglected. In that regard, conservation agriculture has shown its efficiency in various contexts, increasing the productivity and resilience of agricultural systems. Research needs to go further through a better understanding of the ecological processes and the promotion of an "ecologically intensive agriculture", less dependent on external inputs, and more productive as a result of using biological processes to better advantage.

- There is a need to go beyond the traditional "farmer/researcher/extensionist" triangle to encompass a dynamic and multidisciplinary innovation system that links various and diverse stakeholders at the local, national, regional and global levels. Supporting smallholder farmers' organizations is key to enabling them to identify research needs and priorities, and empowering them to implement research results.

- Because women play a primary role in agriculture, mainstreaming gender is pivotal in the various stages of research (e.g. priority setting, monitoring and evaluation), and in the staffing of research institutions.

III. Discussion Paper for Round Table

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

Discussion paper prepared for the Round Table organized during the Thirty-second session of IFAD's Governing Council, 18 February 2009

Prepared by: R. Alcadi, S. Mathur and P. Rémy

ACRONYMS

CDM	Clean Development Mechanism
CGIAR	Consultative Group on International Agricultural Research
GHG	greenhouse gas
GMO	genetically modified organism
NARS	National Agricultural Research System

INTRODUCTION

Agricultural producers, in particular the smallholder farmers of developing countries, are facing unprecedented challenges in the twenty-first 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 of satisfying 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."[2] 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.[3]

Climate change is increasing production risks in many farming systems and limiting 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.[4]

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 developing 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

[2] Agriculture at a Crossroads, IAASTD, 2009.
[3] World Development Report 2008.
[4] Intergovernmental Panel on Climate Change (IPCC).

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 reinvestment in agricultural knowledge, science and technology to achieve equitable and sustainable development.[5]
The purpose of this paper is to discuss: (i) the potential role of agricultural research in improving small-scale 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.

I. Role of agricultural research in improving small-scale 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.[6] 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, in addition to more prudent and integrated management of crops, animals and the natural resource base that sustains 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 aimed 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 rainfed areas. Newer generations of improved wheat varieties have provided an annual increase in yields of 1 per cent since 1981, largely in rainfed areas.

With respect to genetic improvement of livestock and fish, improved pig and poultry have been introduced through, for example, cross-breeding of local breeds with exotic breeds mainly from northern countries. Artificial insemination is also playing a progressively more substantial role. Similarly, genetically improved tilapia is changing aquaculture into one of the fastest-growing agricultural sectors in Asia.[7]

[5] Agriculture at a Crossroads, IAASTD, 2009. See also: http://www.greenfacts.org/glossary/def/equity.htm.
[6] CGIAR, Global Climate Change: Can Agriculture Cope?
[7] World Development Report 2008.

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 on delivery systems for these new varieties and breeds and the lack of assets among the smallholders to apply them.

Furthermore, progress in varieties performing well under drought, heat, flood and salinity has been generally slower than the progress achieved with disease- and pest- resistant varieties. As a consequence, because of water and soil constraints in Africa, the results of genetic improvement have been slower here than in Asia. Only a few improved varieties are finally making an impact on some food staples – for instance cassava in Nigeria, or NERICA (New Rice for Africa) 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 in which 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 information 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 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 those using 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.[8]

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 solely through genetic enhancement.

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 focused more

[8] Agriculture at a Crossroads, IAASTD, 2009.

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.[9]

In a context in which 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-scale 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 in 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 the field level to develop integrated management of natural resources, including: soil moisture management practices aimed at improving the capture and storage of 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-lunes[10] in dryland 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 40 million hectares. Originally adopted by large- and medium-scale farmers, the practice has spread to smallholders in Southern Brazil.[11]

Where lower population pressure still allows, fallowing remains an important strategy for long-term soil restoration. Improved fallows, using legumes and trees, have been shown to have 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.

Enhanced water productivity can be promoted through drip irrigation, water harvesting, improved management of rainwater or collective action to protect shared resources. For instance, the International Water Management Institute is

[9] World Development Report 2008.
[10] These are 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.
[11] World Development Report 2008.

working with local partners in Burkina Faso on local low-cost irrigation systems; the International Center for Agricultural Research in the Dry Areas 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 in effectively scaling up 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, in addition to 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-scale farmers' productivity and resilience. In this regard, Michel Griffon,[12] for example, advocates 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 improve the understanding and application 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 Mechanism[13] (CDM) market of the United Nations Framework Convention on Climate Change. 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.

[12] Nourrir la Planète, 2007.

[13] The Clean Development Mechanism is a mechanism allowing the transfer of certified emission reductions to industrialized countries from projects located in developing countries that lead to credible and measurable reductions of GHG emissions or sequestration of GHGs.

However, developing countries, particularly in Africa, do not benefit as much as they could, mainly because of the limited coverage by the CDM of afforestation and reforestation. Most of the win-win mitigation opportunities that can be identified at field level and could benefit small-scale 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 sustained 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 fossil fuel consumption
- 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 improved irrigated rice production and livestock management. For example, the International Rice Research Institute is promoting the development of rice with lower GHG emissions 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 a high tannin content, which suppresses methane emissions.

Payment (or reward) for ecosystem services (PES) 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 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,[14] an international research institute[15] and the national agricultural research institute,[16] 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 one 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 partners including, in particular, the farming communities themselves. Countries need to learn from one another in order to be able to respond to the challenge of practical

[14] CIPRES: Centro para la Promoción, la Investigacion y el Desarollo Rural y Social.
[15] CIRAD: French Agricultural Research Centre for International Development.
[16] INTA: Nicaraguan Institute for Agricultural Technology.

innovation and ensure that the best available knowledge reaches poor rural communities so that they can build on the wealth of expertise they themselves possess.

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 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 that have a stake in agricultural research for development (ARD). A revitalized CGIAR promises to strengthen and position itself and its partners to better serve the billions of people who depend on agriculture. The reform model is being refined during a transition 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 such as the National Agricultural Research Systems (NARS), and with civil society organizations and the private sector through public-private partnerships.[17]

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 interdisciplinary 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-scale poor farmers and scientists as partners in Innovation Systems. The Global Forum on 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 advantages and strengthening synergies. The GFAR Plan of Work 2009-2010 identifies climate change as a key strategic theme to be addressed through programmes of concerted action.

[17] Cooke et al., CGIAR Change Steering Team.

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.[18]

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 NARS lack the resources to work efficiently and maintain adequate staffing. Private research has not compensated for the decrease because it tends to focus more on intensive agriculture with a higher potential return on investment.

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 intervals between investment, outcomes and adoption.[19]

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) if the incentive framework is to be successful.

Given this situation, most developing countries will continue to experience negligible private sector involvement in agricultural research and development. Therefore, the role of the state remains central, and public involvement will be required for specific products to be developed for small-scale farmers. As highlighted in the Nairobi Work Programme,[20] it is important for developing countries to: (i) improve their understanding and assessment of impacts, vulnerability, and climate change adaptation needs; and (ii) make informed decisions on practical adaptation actions and measures to respond to climate change on a sound scientific, technical and socioeconomic 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 provide an effective means of prioritizing urgent adaptation needs for least-developed countries. They draw on existing information and community-level input to identify adaptation projects to enable such countries to cope with the immediate impacts of climate change.

[18] Pardey and Beintema, 2001.
[19] IFPRI, 2008.
[20] UNFCC Nairobi Work Programme, 2006.

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 for more support in rebuilding their research systems from the international community, and particularly from developed countries. No one organization or government can tackle the adverse effects of climate change single-handedly. 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.

The issues and options described in the preceding pages are intended 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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