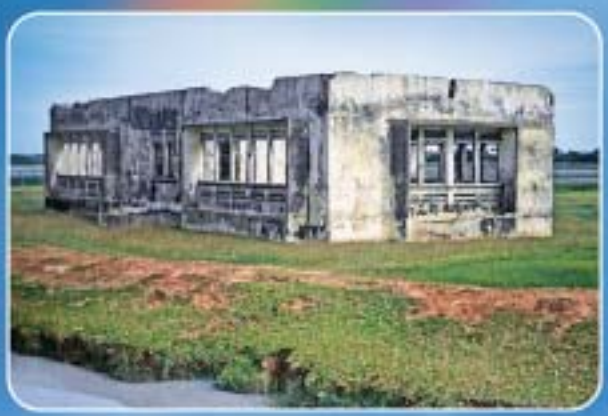
Healing Wounds

How the International Research Centers of the CGIAR Help Rebuild Agriculture in Countries Affected by Conflicts and Natural Disasters



CGIAR

Consultative Group on International Agricultural Research

Healing Wounds

How the International Centers of the CGIAR Help Rebuild Agriculture in Countries Affected by Conflicts and Natural Disasters

Surendra Varma
and
Mark Winslow

CGIAR

Consultative Group on International Agricultural Research

Recommended citation:
Varma, Surendra and Winslow, Mark. 2004. Healing Wounds: How the International Centers of the CGIAR Help Rebuild Agriculture in Countries Affected by Conflicts and Natural Disasters. Consultative Group on International Agricultural Research (CGIAR), Washington, DC. xiv + 80 pp.

Dr. Surendra Varma (s.varma@cgiar.org) is Head, Communication, Documentation and Information Services at the International Center for Agricultural Research in the Dry Areas (ICARDA), Aleppo, Syria.

Dr. Mark Winslow (m.winslow@t-online.de) is Consultant for International Development and is based in Germany.

Design: George Chouha, ICARDA

Cover: Left: Ruins of the Toul Kaktrap research station in Suay Rieng, Cambodia. Right: Damaged research station in Badam Bagh, near Kabul, Afghanistan.

ISBN: 92-9127-153-9

This study is based on information provided by the CGIAR Centers to the authors. Some material was also drawn from Center websites, research reports, media releases and similar sources. Every effort has been made to provide citations to the published materials used. References to countries, specific areas or geographic regions do not imply the expression of any opinion whatsoever on the part of the authors or the publishers concerning their legal status, authority, frontiers or boundaries.

Produced by the International Center for Agricultural Research in the Dry Areas (ICARDA) and published by the Consultative Group on International Agricultural Research (CGIAR).

Single copies of this publication may be requested free of charge from the CGIAR or ICARDA.

Consultative Group on International Agricultural Research (CGIAR)
1818 H Street, N.W.
Washington, D.C. 20433 USA
Tel: 1-202-473-8951
Fax: 1-202-473-8110
E-mail: cgiar@cgiar.org or cgiar@worldbank.org
Website: http://www.cgiar.org

International Center for Agricultural Research in the Dry Areas (ICARDA)
P.O. Box 5466, Aleppo, Syria
Tel: (+963)(21) 2213433, 2213477, 2225112, 2225012
Fax:(+963)(21) 2213490, 2225105, 5744622
E-mail: ICARDA@cgiar.org
Website: http://www.icarda.org

About the CGIAR

The Consultative Group on International Agricultural Research (CGIAR) is a strategic alliance of countries, international and regional organizations, and private foundations supporting 15 international agricultural research centers (see pages 78-80) that work with national agricultural research systems and civil society organizations including the private sector. The alliance mobilizes agricultural science to reduce poverty, foster human well being, promote agricultural growth and protect the environment.

The Food and Agriculture Organization of the United Nations (FAO), the International Fund for Agricultural Development (IFAD), the United Nations Development Programme (UNDP), and the World Bank serve as co-sponsors of the CGIAR.

More than 8,500 CGIAR scientists and staff, working in over 100 countries, address every critical component of the agricultural sector including agroforestry, biodiversity, food, forage and tree crops, pro-environment farming techniques, fisheries, forestry, livestock, food policies and agricultural research services. Thirteen of 15 CGIAR Centers are based in developing countries.

The knowledge generated by the CGIAR–and the public and private organizations that work with the CGIAR as partners and advisors–pays handsome dividends for poor farmers through increased agricultural production and productivity, greater incomes, and sounder utilization of resources. The products of CGIAR research are kept within the public domain available to all. These include improved crop varieties and production technologies suited to local conditions, better farming systems that protect natural resources, and policies/practices to combat major global challenges such as climate change. CGIAR research partnerships help achieve the Millennium Development Goals and support major international conventions (Biodiversity, Climate Change, and Desertification).

Contents

Foreword

Agriculture lies at the heart of the social and economic fabric of the world's developing countries. Most of the world's poor live in those countries and are engaged in agriculture. When conflicts and natural disasters strike, they not only take a heavy toll on human lives but also cause serious damage to agriculture and to the natural resources on which agriculture depends. The poor suffer most when agriculture, the main source of their livelihood, is damaged. They are also the ones whose lives are most at risk during attacks of the forces of nature or in man-made conflicts.

Research has shown that poverty and hunger breed despair and desperation, compelling the poor to make unthinkable choices. Without hope for a better future, illiterate youth are tempted into an alternative life of banditry, violence, and terrorism for pay and plunder. If poverty and hunger can be alleviated, the frequency of man-made conflicts can be greatly reduced.

For nearly three decades the Consultative Group on International Agricultural Research (CGIAR) has focused its mission on helping developing countries turn agriculture into an engine of pro-poor, sustainable economic growth. Conflicts and natural disasters have often interfered with this mission, and disrupted the long-term work in strengthening human and institutional capacities, establishing more productive cropping systems, and improving the sustainability of farming. Nevertheless, the CGIAR Centers quickly reworked their strategy, partnering with donors, governments, emergency relief agencies, non-governmental organizations and others to ensure that emergency assistance made the best possible use of available knowledge and technology. As soon as they could, they moved on to help the affected countries rebuild their agriculture, as well as human capacity and research infrastructure so critical to long-term recovery.

Over the course of dealing with crises caused by conflicts and natural disasters in at least 47 countries across Africa, Asia, and Latin America, the CGIAR Centers have been learning important new lessons. It became clear that by reducing poverty, pro-poor agricultural development could actually diminish some of the conditions that lead to conflict and render people susceptible to natural disasters. Agricultural development and poverty reduction strengthen resilience by establishing coping and recovery mechanisms, such as international skill networks and gene bank safety nets. And a knowledge-based approach to helping countries rebuild increases the effectiveness and cost-efficiency of relief operations—an approach that has been referred to as 'smart aid' in this study.

These lessons have convinced us that an ongoing partnership between research and emergency aid can significantly improve the ability of the international community to prepare for, as well as respond to the inevitable future crises. Such a pre-emptive approach will alleviate more suffering than dealing with each emergency as an ad-hoc event, after the fact. We hope "Healing Wounds" brings this point home. The volume, indeed, brings to light an important role of the CGIAR that has remained less known and unrecognized. It reminds all of us in both the research and the emergency relief sectors of how much we need each other, and, above all, how much the poor need us, especially in times of crises.

Adel El-Beltagy Director General ICARDA	Kanayo Nwanze Director General WARDA	William Dar Director General ICRISAT

Executive Committee of the
Center Directors Committee of the CGIAR

Preface

The involvement of CGIAR Centers in rebuilding agriculture in countries affected by conflict and natural disasters spans nearly three decades and has benefited more than 47 countries across Africa, Asia, and Latin America. But the information on the role played by the Centers and the impact of their work is fragmented and dispersed. This study consolidates that information and analyzes it to extract key lessons about how to use emergency aid in the future. It should serve both as a reference source and an indicator of ways to build more effective partnerships between research and emergency aid organizations.

It is not always easy to delineate conflict/disaster work from the ongoing research of Centers that contributes to preventing or mitigating these crises. Often there is no clear line between an impending or subsiding disturbance, and an emergency significant enough to be labeled a disaster/conflict. For this study our focus was on climatic disasters and violent conflicts, which excludes certain other types of disaster/strife that are nevertheless of enormous consequence to the poor, such as HIV/AIDS, crop disease and pest epidemics, and non-violent political instability.

The first task in getting this study off the ground was to collect information from the CGIAR Centers that have been involved in rebuilding agriculture, and conduct searches to fill the gaps in the information collected. By the deadline set for material collection, we had case study reports provided to us for 31 countries by our colleagues from 12 CGIAR Centers involved in rebuilding agriculture. Therefore, our coverage of 31 of those countries should be viewed as a representative rather than a comprehensive survey.

Instead of presenting the work of the Centers in chronological or geographic order, we felt that a thematic analysis of the major benefits gained and lessons learned might be more valuable. Since the themes covered in this study are interlaced, and since the major case studies contribute to more than one theme, they are revisited in different chapters. We appreciate readers' understanding of this inevitable repetition of the various case studies in the text.

Chapters 1 and 2 review the nature of the conflict and disaster problems that face developing countries, and how the CGIAR Centers' comparative advantages and capabilities form a strategic resource for rehabilitating agriculture. Chapters 3-7 explore specific cases in which the CGIAR Centers have contributed to alleviating hunger; preserving agrobiodiversity; rebuilding human and institutional capacities; reducing future vulnerability to conflicts and disasters; and making relief aid more efficient.

The study found that the CGIAR Centers' efforts to help countries rebuild agriculture have been heavily dependent on partnerships and the generous support of development investors. The contributions of those valued supporters are highlighted in this study.

Acknowledgements

This study represents one of the projects of the Marketing Group of the CGIAR, approved in 2003 and implemented working with a team of communication professionals from the CGIAR Centers. These included Fionna Douglas (CGIAR System Office), Nathan Russell (CIAT), Michael Hailu (CIFOR), Kelley Cassady (CIMMYT), Christine Graves (CIP), Eric McGaw (ICRISAT), Evelyn Banda (IFPRI), David Mowbray (IITA), Susan McMillan (ILRI), Ruth Raymond (IPGRI), Duncan Macintosh (IRRI), Ian Makin (IWMI), Savitri Mohapatra (WARDA), Helen Leitch (WorldFish), and Jason Wettstein (Future Harvest). They also helped develop the approach, provided valuable advice as writing progressed, and reviewed the drafts. We sincerely thank them all.

We were also fortunate to receive inputs and clarifications on specific issues from Center staff and external partners. We thank Mohan Saxena, William Erskine, Johann Bell, Mark Bell, Tom Blake, Lydia Flynn, Annie Hamel, Peter Hazell, Eugene Hettel, Gary Jahn, Edwin Javier, Richard Jones, Roger Kamidi, Mike Listman, Cecilia Lopez, Jean-François Mercier, Jean Ndikumana, Harry Nesbitt, Michael Rubinstein, Louise Sperling, S. Srinivas, Antony van Gastel, Nasrat Wassimi, and Swathi Sridharan for their valuable help.

Our grateful thanks are also due to two distinguished external reviewers who helped us improve the document considerably: Dr. Uma Lele, Senior Advisor, The World Bank; and Dr. Mohamed A. Nour, former Director General of ICARDA.

Finally, we wish to thank the CGIAR Center Directors Committee and System Office for endorsing and funding this initiative.

Fig.1. Rebuilding agriculture by CGIAR Centers in countries affected by conflicts and natural disasters

1. Afghanistan; 2. Algeria; 3. Angola; 4. Armenia; 5. Azerbaijan; 6. Bhutan; 7. Cambodia; 8. Colombia; 9. D.R. Congo; 10. Cuba; 11. Cyprus; 12. Eritrea; 13. Ethiopia; 14. Georgia; 15. Honduras; 16. India; 17. Indonesia; 18. Iraq; 19. Iran; 20. Jordan; 21. Kenya; 22. Kuwait; 23. Lebanon; 24. Liberia; 25. Libya; 26. Malawi; 27. Mozambique; 28. Nepal; 29. Nicaragua; 30. North Korea; 31. Palestine; 32. Pakistan; 33. Panama; 34. Peru; 35. Philippines; 36. Rwanda; 37. Sierra Leone; 38. Solomon Islands; 39. Somalia; 40. Sri Lanka; 41. Sudan; 42. Syria; 43. Tajikistan; 44. Timor-Leste; 45. Uganda; 46. Yemen; 47. Zimbabwe

Note: In some countries marked on the map, the CGIAR Centers are involved only in specific areas that have suffered from conflict or natural disasters, and not the entire country. The objective of this map is only to show the locations where the CGIAR Centers have been involved in rebuilding agriculture. The authors or publishers hold no responsibility for the accuracy of political boundaries.

Executive Summary

Over the past three decades, the CGIAR Centers have made major contributions to rebuilding agriculture in at least 47 developing countries affected by conflicts and natural disasters across Africa, Asia, and Latin America (Fig. 1, page viii). In doing so, Center staff and their partners have demonstrated exemplary dedication and commitment to the mission of the CGIAR by continuing to work in difficult conditions, sometimes risking their personal security. As such, the value of their work, which has made a major difference to the lives of millions, cannot be assessed using the currency value of investments in the CGIAR.

This study first reviews current thinking on the underlying causes of conflicts and disasters, identifying poverty as a major driver of both. Poverty breeds frustration, compelling the poor to turn to violence. Most of the poor are involved in rural agriculture, so pro-poor investments in agricultural development can alleviate poverty and thereby reduce the possibilities of conflict and also contribute to natural disaster preparedness. History shows that agricultural research is a particularly high-payoff leverage point for stimulating economic growth and poverty reduction.

Based on case studies for 31 countries-from 12 CGIAR Centers, the study then describes major Center contributions and lessons learned in five key areas: alleviating hunger by rebuilding seed and food systems; safeguarding and restoring agrobiodiversity; rebuilding human and institutional capacities; reducing future vulnerability to these crises; and making relief aid more effective and efficient. It highlights how the Centers' work addresses the root causes of conflicts and disasters, in addition to providing immediate relief by working together with a diverse group of partners, including donors and relief and development agencies, and by building bridges between the various partners for implementing long-term work plans.

Rebuilding seed and food systems

Through the generosity of development investors, CGIAR Centers were able to contribute to a number of major partnerships for emergency relief, including:

- The CIAP project, which helped restore rice production in Cambodia following the Khmer Rouge genocide (IRRI with support from AusAID, CIDA and GTZ, 1988-95);
- The 'Seeds of Hope' project to rebuild Rwanda after the genocide and civil war of 1994-96 (CIAT convening, with CIMMYT, CIP, ICRAF, ICRISAT, IITA, ILRI and IPGRI through support from DFID, SDC, USAID, IDRC, AusAid, and World Vision);
- 'Seeds of Freedom' (mid-1990s) following Angola's civil war (ICRISAT convening, with CIAT, CIP, CIMMYT and IITA through USAID support);
- Restoring sweetpotato production after the 1997-98 El Niño crisis in Peru (CIP with INIA);
- 'Seeds of Hope II' in the wake of Hurricane Mitch that devastated Honduras and Nicaragua in late 1998

(CIAT, CIMMYT, CIP, IPGRI through support from CIDA and USAID);

- The Solomon Islands' ethnic conflict and insurgency (1998)—developing sustainable small-scale coastal enterprises to reduce unemployment and poverty (WorldFish through support from ACIAR, CIDA, the EU, NZAID and the Overseas Fishery Cooperation Foundation of Japan);
- Rebuilding dryland agriculture in post-independence, post-war Eritrea (since 1998—ICARDA and ICRISAT through support from Denmark and IFAD);
- Restoring sorghum and millet seed systems in Somalia, Sudan and Uganda in the late 1990s (ICRISAT through ODI and USAID support);
- Introducing true potato seed technology to North Korea in 1999 to combat famine (CIP through USAID support);
- 'Seeds of Life' launched in 2000 following East Timor's long independence struggle and civil war (ACIAR supporting and convening, with CIAT, CIMMYT, CIP, ICRISAT and IRRI);
- Restoring seed and root crop systems in the Limpopo River Basin after massive floods in southern Africa caused by Cyclone Eline (ICRISAT and IITA through USAID support since 2000);
- Combating the Africa Cassava Mosaic Virus disease that spread during the chaos of the revolution in Zaire (now DR Congo) (IITA through USAID support since 2000);
- Promoting sweetpotato to help Cuba recover from Hurricane Michelle and reduce vulnerability to future hurricanes (CIP since 2001);
- 'Seeds for Life': restoring lost rice seed and germplasm following the Ivory Coast insurgency (Africa Rice Center - WARDA - 2003, with support from CIDA) building on earlier restoration initiatives in these countries as well as Burundi, DR Congo, Liberia, Mozambique, Rwanda and Sierra Leone (1994-2002 through support from WARDA donors, particularly DFID);
- Battling refugee malnutrition caused by Uganda's longstanding insurgency through CIP's Vitamin A for Africa partnership (since 2003 through support from BMZ, the OPEC Fund, the McKnight Foundation, The Micronutrient Initiative, Senior Family Fund and USAID);
- The 'Future Harvest Consortium to Rebuild Agriculture in Afghanistan' (ICARDA convening, with CIAT, CIMMYT, CIP, ICRISAT, IFPRI, ILRI, IPGRI, and IWMI through support from USAID and IDRC); and
- Assisting Iraq and Palestine to build strong research systems and conserve agrobiodiversity (ICARDA and IPGRI through GEF, UNDP, UN/ ESCWA and USAID support).

Safeguarding and restoring agrobiodiversity

Smallholders were found to have surprisingly **resilient local seed systems**. When conflicts were brief as in Rwanda, those systems bounced back quickly, because seed supplies on-farm had not been destroyed or exposed to long periods of decay in storage. On the other hand, intense and/or extended conflicts such as the Khmer Rouge period in Cambodia and the conflict in Afghanistan did degrade agrobiodiversity significantly.

In contrast, **formal seed systems were more vulnerable** to disruption because they depended on centralized infrastructure, institutions and human resources—assets that were often damaged by forces of nature, or came under direct attack during conflicts. These systems are critical for future agricultural growth, so this vulnerability requires special attention.

Regional and international **networks of expertise and gene banks proved to be priceless safety nets** that provided the knowledge and materials needed to restore agrobiodiversity and re-establish seed and food production systems. For example, gene banks helped restore varieties of rice lost to conflict in West Africa and Cambodia as well as for beans in Rwanda. This lesson is being carried forward, for example, by ICARDA, IPGRI and regional partners who are gathering and safeguarding agrobiodiversity in the conflict-prone areas of the Middle East, and working with partners to put it to better use for agricultural development. These vital safety nets deserve continuing support.

Rebuilding human and institutional capacities

Restoring the capacity of national institutions to conduct agricultural research is vital for sustainable recovery. This has been a traditional strength of the CGIAR Centers, and they have applied it vigorously in all the crises situations described. Sometimes it meant building a national system from the ground up, as in Cambodia and East Timor. In other less dramatic but equally important cases it has required decades of steady support to countries at risk through training, networking, joint project partnerships, and technical assistance—such as in the Nile Valley and Red Sea countries of Egypt, Ethiopia, Sudan, and Yemen, being helped by ICARDA since 1979 through support from the EU, Government of Egypt, IDRC, IFAD and the World Bank.

Under intense time pressure to get food systems going again, the **Centers built broad partnerships to accelerate the speed and impact of their work**. In Rwanda, for example, they drew in regional network partners to help train the new Rwandan staff who replaced those that were killed or forced to flee. In Cambodia, the CIAP project worked closely with NGOs, who took responsibility for many outreach functions until national researchers killed by the Khmer Rouge could be replaced and trained.

The CGIAR Centers found that the **restoration of community bonds** is an important part of the recovery process. Refugees returning to Rwanda were resettled in areas that were unfamiliar to them; ICRAF taught them how to use agroforestry to restore the fertility of the degraded lands they had been allocated. In the insurgency-plagued central hill area of Nepal, CIMMYT (through SDC support) provides seed and training to reinforce farmers' groups that collectively manage and sell maize, stabilizing their incomes and food security.

Restarting the small-scale private sector is also crucial, especially input supplies and markets. In Nicaragua and Honduras, Seeds of Hope II fostered the

emergence of small-scale private seed enterprises. Similarly, tree nursery micro-enterprises have been fostered in locations as diverse as Rwanda, Palestine and Afghanistan. Sustainable aqua-farming of black pearl, giant clam, sea cucumber and coral, and ornamental fish and crustacean cultivation are being encouraged by WorldFish in the Solomon Islands; these small-scale livelihoods can alleviate the poverty that fuels ethnic conflict.

Reducing future vulnerability to conflicts and disasters

It is human nature to think of disasters and conflicts as unique events, hoping they will never happen again; but the unfortunate reality is that they will. How are the CGIAR Centers helping aid agencies prepare for the inevitable?

The drama that provided the impetus for the very creation of the CGIAR—the race to prevent massive famine in Asia in the 1970s, which succeeded brilliantly through the new crop varieties and management practices known as the Green Revolution—is a striking example of how **preventative investments in research can pay off spectacularly**. The same South Asia zone is currently the subject of another forward-looking effort, the Rice-Wheat Consortium for the Indo-Gangetic Plains, convened by CIMMYT and IRRI and also engaging CIP, ICRISAT and IWMI—made possible through support from ACIAR, the Asian Development Bank, DFID, IFAD, Japan, The Netherlands, and USAID. It aims to forestall the next productivity plateau by finding more sustainable and productive ways to crop these areas, such as precision farming and crop diversification.

Disaster and conflict elevate the risk of malnutrition, since refugees inevitably face restricted food choices. CIP is seeking to increase dietary vitamin A through the introduction of orange-fleshed sweetpotato for refugees in Uganda. A CGIAR-wide effort on 'biofortification'—breeding crops for increased vitamin and nutrient content—has recently been launched. This work will take time, but the benefits will be especially great for peoples suffering in the wake of catastrophe.

Helping countries and regions with **long-term strategic planning** to reduce the likelihood and impact of crises is another important role the Centers have played. For example, through support from the Arab Fund for Economic and Social Development and IFAD, ICARDA and IFPRI have helped the West Asia/ North Africa region by convening international conferences and research on drought preparedness, coping and recovery strategies. Steps such as the establishment of early-warning systems, institutions and systems for the efficient stocking and de-stocking of animal herds in synchronization with drought cycles, policies such as drought insurance, livelihood diversification, and crop growth models to advise farmers on the best coping strategies have been identified as potentially high-payoff investments.

Another forward-looking type of Center assistance has been in **building agricultural systems and institutions**. In addition to examples mentioned earlier, ICARDA,

with support from the Asian Development Bank, GTZ, IFAD, USAID, and the World Bank, and in partnership with eight other CGIAR Centers (CIP, CIMMYT, ICRISAT, IFPRI, ILRI, IPGRI, ISNAR and IWMI) is convening a Central Asia and the Caucasus (CAC) Consortium to help these new nations chart the course ahead. The region is beset by a sobering array of challenges: widespread poverty, environmental degradation, the need for transitioning to a new set of social systems and institutions, the loss of support services and infrastructure formerly provided by the Soviet Union, and many more. A long-term effort is clearly required.

Perhaps the most massive disaster-in-the-making is global warming. The Centers have a key role to play in **helping agriculture adapt to climate change**. The degree and geographical distribution of impending climate change is still unclear, which makes preparing for it all the more difficult. Temperature and moisture changes will trigger fundamental, complex changes in ecosystems. To handle this uncertainty and complexity, CGIAR Centers and their partners are developing models to predict the outcomes of different possible scenarios—helping aid agencies and nations envision the range of risks they face, and options they should consider.

As some areas grow drier, farmers will have to shift to more drought-tolerant varieties or crops. Several Centers are working hard on increasing drought resistance, and tangible progress is being made for this difficult trait. CIMMYT and ICARDA, for example, are achieving significant gains in drought resistance in new varieties of maize, wheat and barley that are spreading rapidly in Southern, Eastern and North Africa, and in West Asia.

Pests and diseases are also very sensitive to temperature and moisture changes. Global warming may shift their distribution, exposing crops to new threats they were not bred to resist. For example, CIP research in Cañete Valley, Peru found that temperature increases following the El Niño episode of 1997/98 triggered a severe attack of late blight fungus and favored a more aggressive biotype of white fly, devastating the potato and sweetpotato crops. Steady long-term support is needed for research on crop adaptation and breeding, integrated pest management, crop ecology and climate change to combat this threat.

Making relief aid more effective and efficient

The knowledge and expertise contributed by CGIAR Centers has helped aid agencies increase their effectiveness in crisis situations. Such **'smart aid' gets the job done better, more quickly and more efficiently.**

The power of smart aid was evident in the Seeds of Hope project in Rwanda. Rather than blanketing the country with non-adapted seed—a practice employed all too frequently in the haste of emergency relief initiatives—the Centers built on a decade of prior experience there to quickly draw together complementary partners and identify seed sources appropriate to specific

localities and needs. As a result, **aid was precisely targeted**. The right seed got to the neediest people, quickly—and equally important, local agrobiodiversity and seed enterprises were not pushed aside.

Extending this learning, seed aid donors and NGOs such as Catholic Relief Services partnered with ICRISAT in the Horn of Africa region, and with ICARDA in Afghanistan, to devise smarter ways of restoring seed systems. The research confirmed that indiscriminate seed giveaways undermine local seed enterprises. The partners devised a better way: providing aid in the form of vouchers that poor farmers could use to buy seed from local suppliers of their choice. **Supporting local institutions and social networks** builds local resilience and food security.

In order to make its aid investment smarter, USAID's Office for Foreign Disaster Assistance asked ILRI to help it **break away from a 'handout' approach** to a new mode that would build self-reliance and resilience in the conflict-ridden and drought-plagued Horn of Africa region. Jointly with ASARECA's A-AARNET network, ILRI assessed traditional systems of coping with drought and elucidated a new set of approaches that built on traditional knowledge and skills. The new approach shifts the focus **from relief to development**: re-directing aid investments towards **preventative, coping and recovery** capabilities such as drought early-warning, herd size management, improved animal health services, dry-season fodder supplies, and training.

When embarking on major rebuilding efforts, **the Centers' diagnostic and analytical capabilities contribute significantly** to steer aid in the right direction. The Future Harvest Consortium in Afghanistan, for example, conducted an in-depth needs assessment that reached every province of the country, talking to thousands of farmers. The information fed into priority-setting deliberations by a wide range of assistance entities, including Afghanistan's own Ministry of Agriculture and Livestock, USAID, US universities, NGOs, FAO and private sector organizations. IFPRI led a similar study to help Mozambique identify priorities for rebuilding after its long independence struggle and civil war.

The **advanced tools and skills** of CGIAR Centers have been important elements of 'smart aid'. Geographic information systems (GIS) and models have been particularly useful. CIAT's 'Mitch Atlas' GIS dataset became the guiding light for aid agencies in targeting their assistance in the wake of that 'hurricane of the century'. ICARDA and Michigan State University are using GIS to assist Afghanistan with rangeland recovery, directing herders to optimum pastures to reduce overgrazing. Other advanced techniques include CIAT's use of molecular markers to detect changes in bean biodiversity following the Rwandan crisis, and IITA's use of virus diagnostics and tissue culture multiplication techniques to combat the African Cassava Mosaic Virus.

Returns on investments

The CGIAR's knowledge-based approach, referred to as '**smart aid' makes relief assistance more efficient,**

effective and targeted. It helps aid agencies to achieve more relief per dollar, reach the truly poor and avoid counterproductive outcomes such as the undermining of local mechanisms of resilience. The CIAP effort to rebuild Cambodia's rice economy, for example, generated an internal rate of return of 32% per annum on the humanitarian investment, worth US$1.3 billion (Young et al. 2001)[a]. The entire CGIAR System's three-decade (1971-2001) cost of US$7.1 billion was vastly exceeded by an estimated $65 billion in benefits (Raitzer 2003)[b] related to the prevention of food insecurity crises. Clearly, smart aid pays.

In addition to providing relief from disasters and conflicts when they occur, it is important to attack their root causes for the longer term. Poverty breeds desperation that can cause some of the poor to resort to violence. Poverty also prevents investments in structures and systems that could help protect them from disasters such as storms, droughts and earthquakes. Most of the rural poor are involved in agriculture. Steady, long-term support to **agricultural research such as that conducted by the CGIAR Centers contributes to poverty reduction, and therefore to reducing human suffering from conflicts and natural disasters.**

CGIAR Center **partnerships with aid agencies should be continuous and organic,** not formed only in haste after emergencies strike. Ongoing partnerships will help prepare for, mitigate, and accelerate recovery from disasters and conflicts. Major institutions such as the United Nations, the World Bank and many donor agencies are now convinced that it is more cost-effective and humanitarian to invest in preventive steps to mitigate the effects of disasters and conflicts, rather than just dealing with their aftermath. **Research is essential for devising these preventive, coping and recovery solutions.** The CGIAR Centers will continue to contribute importantly to this endeavor.

---

[a]Young, D., Raab, R., Martin, R., Sin, S., Leng, B., Abdon, B., Mot, S. and Seng, M. 2001. Economic impact assessment of the Cambodia-IRRI-Australia Project. Phnom Penh: Cambodian Agricultural Research and Development Institute.

[b]Raitzer, D. A. 2003. Benefit-cost meta-analysis of investment in the international agricultural research centres of the CGIAR. Rome: CGIAR Science Council Secretariat, Food and Agriculture Organization of the United Nations. http://www.cgiar.org/pdf/bcmeta.pdf

Chapter 1

Poverty, Conflict, and Natural Disasters: Persistent Plagues of the Developing World

"When our resources become scarce, we fight over them. In managing our resources and in sustainable development, we plant the seeds of peace."

—Dr. Wangari Maathi, 2004 Nobel Peace Prize Laureate

Disasters and conflicts, by their shocking nature, tend to impress us as unique, one-off events. After they end, our mind prefers to block them out like unwelcome memories. But a scanning of the record reveals that they are all too frequent and share many distressing and recurrent features. Conflicts have especially harmed the poorest countries in recent decades. Understanding the causes of conflict and disasters is the first step towards defeating them.

The causes of violent conflict

During the Cold War many of the conflicts were 'proxy wars' associated with struggles between the superpowers. Conflicts since then have mostly stemmed from economic, ethnic/tribal, and religious strife. They take such forms as terrorism, warlordism, and gangsterism.

A household in Ethiopia. *Photo: ICARDA*

Scholars have examined the causes of conflict. Since the Second World War, four main triggers have been suggested, as described by de Soysa and Gleditsch (1999):

- Modernization: Reaction against rapid development that appears to create equity and cultural gaps between rich and poor, threatening traditional ways of life. Many of the ideological revolutionary movements of the 1950s/60s were attributed to this cause.
- Dependency: Rebellion against the subservient role perceived to be imposed upon developing countries by global capitalism. This theory gained prominence during the 1970s as multinational industries became widespread and influential.
- Mobilization: Oppressive state actions trigger disaffected groups to mobilize and resist. The decline of some dictatorial states in Africa and Asia appears to have followed this pattern.
- Stagnation: Frustration when states fail to provide ways to escape poverty and deprivation. This appears to be emerging as a major trigger in recent years, as exemplified in instability and state-collapse situations in Sub-Saharan Africa, Asia, Eastern Europe and the ex-Soviet Union.

Poverty and conflict

Poverty is a key driver behind stagnation-driven conflicts, according to analyses by the Brundtland Commission (1987), Brown (1996), Collier and Hoeffler (1998), the International Food Policy Research Institute (Messer et al. 1998), Collier (1999), the International Peace Research Institute, Oslo (de Soysa and Gleditsch 1999), and the United Nations (1995 and 2001). Former US President and Nobel Laureate Jimmy Carter, and former UNDP Administrator and World Resources Institute founder James Gustave Speth are just a few of many distinguished leaders who have also emphasized this link (Carter 1999; Speth 1994). The poverty-conflict linkage is one of the reasons the United Nations Millennium Declaration places a high priority on halving the number of people living on less than a dollar a day by the year 2015 (UN 2001).

Poverty goes beyond financial suffering. In the developing world it usually involves both material deprivation and vulnerability to social forces as well as to natural disasters (Hazell and Haddad 2001). Material suffering often includes hunger and malnutrition, squalid housing, and a lack of access to sanitary services, health care and education. Social vulnerability includes unemployment, anguish over inability to provide for loved ones, vulnerability to more powerful and exploitative forces in the community or government, and a lack of support systems to buffer against shocks such as natural disasters, health crises and income shortfalls (World Bank 2000-2001).

Poverty breeds despair and desperation, compelling the poor to make previously-unthinkable choices (Sen 1987). Without hope for a better future, illiterate youth are tempted or coerced into an alternative life of banditry and gang violence for pay and plunder. For example, hunger, poverty and hopelessness were key triggers in the recent instability in Haiti, in brutal conflicts in Liberia, Sierra Leone and Rwanda, and in drug-ring terrorism in Colombia and Peru (de Soysa and Gleditsch 1999; Messer et al. 1998 p. 24-25; Weiner 2004).

If stagnant poverty is at the root of many violent conflicts in modern times, what can be done to alleviate it? Alternatives are needed so that the poor will no longer see violence as the only way out.

Natural disasters wreak increasing havoc

Global warming is expected to trigger an increasing frequency and severity of climatically-related natural disasters in the coming decades. Climate prediction models used by the Intergovernmental Panel on Climate Change (IPCC) suggest that the wet areas will get wetter (and stormier) and the dry areas, drier and hotter—accentuating extreme environmental events such as droughts and floods (Parry 2002). The periodic El Niño phenomenon (every 2–7 years), which sets off a series of weather abnormalities and climatic disasters, has become both more intense and frequent during the last 20 years. This may be associated with global warming.

These trends may already be taking hold. Compared to the 1960s, major climatic natural disasters were three times more frequent during the 1990s, accelerating even more rapidly in the second half of the decade (Delaney et al. 2003). The 1990s was the warmest decade in the last thousand years. Glaciers receded throughout the world, plants bloomed sooner, birds laid their eggs weeks earlier, and damage from storms was up eight-fold from the 1970s.

Half of the world's poorest countries are considered at high risk from natural disasters, and they are increasing in frequency (Freeman et al. 2003). During 1990-1998, 94% of the world's 568 major natural disasters were in developing countries, as were more than 97% of all natural disaster–related deaths (World Bank 2000-2001). The developed countries are also beginning to experience the effects of heat waves and droughts that threaten agriculture in their drier zones (Coghlan 2003).

Major parts of Africa are under constant threat of drought. There have been seven major drought episodes on the African continent in the last four decades: 1965-66, 1972-74, 1981-84, 1986-87, 1991-92, 1994-95 and 2000-01. The 1972-74 and 1981-84 droughts in the Sahel of West Africa and in the Horn of Africa caused massive dislocation and suffering. Morocco's 1994/95 drought cut its agricultural production in half, and droughts frequently wreak havoc in West Asian countries such as Afghanistan, Iraq and Syria.

Suffering from natural disasters is a function not only of the strength of the storm, flood, drought, fire, or earthquake; but also of people's vulnerability to it. This can be summarized in the simple equation (Delaney et al. 2003):

Risk = Hazard + Vulnerability

The poor face a greater risk from a given hazard due to their greater vulnerability. They lack the resources to prepare for these disasters, to endure their onslaught, and to cope with their consequences. Their housing is not strong enough to withstand gale-force wind, rain, or earthquakes; they often live in flood-prone areas avoided by the wealthier class; emergency services may not be available to them, especially in rural areas; they lack paved roads for speedy evacuation; they cannot afford stocks of emergency food and water supplies; and so on. As the poor bear the brunt of each disaster, they are pushed even further down the socioeconomic ladder; women and children especially suffer (World Bank 2000-2001). This makes it even more difficult to endure the next catastrophe.

Agriculture is one of the hardest-hit sectors when natural disasters strike. Crops are leveled by winds, drowned by floods or scorched by

heat and drought. Livestock perish from thirst and starvation. Lands are stripped of fertile topsoil by floods and wind storms, and salinized by seawater incursion. Seed and food stores rot under water from floods or are consumed during droughts. Loans taken to plant crops cannot be repaid. Processing and export industries cannot meet delivery obligations and lose out to competitors. Yet again, the poor are the biggest losers since they are the most dependent on agriculture for a living and have few buffer systems to cushion against these losses.

The environment is also damaged by natural disasters. Trees killed by flooding or drought represent ecological degradation and loss of landscape protection, as well as lost income from timber and lost sources of fuel for poor households. Communities cut down even more trees to rebuild their housing, putting the land at further risk from the next storm. Biodiversity is lost as habitats are laid to waste by floods or left barren by drought. Rapid climate change may outstrip evolution's capacity to adapt to the new climate, or to migrate species to new areas. Hostile/harmful species adapted to the new climate may migrate in and displace the indigenous species.

While there may be little that humans can do to prevent natural disasters, there is much they can do to reduce their vulnerability to these forces of nature. This is one reason why the United Nations has placed development and poverty eradication at the heart of its Millennium Declaration. The Declaration further resolves to "intensify cooperation to reduce the number and effects of natural and man-made disasters" (UN 2000). The Millennium Declaration Road Map recognizes the vulnerability issue and the major conceptual shift from disaster response to disaster reduction including the increased application of science and technology to prevent, mitigate and prepare for disasters (UN 2001).

Poverty reduction would mitigate many vulnerabilities and increase resilience. But what approaches can effectively reduce poverty on a scale large enough to make a difference for hundreds of millions of poor?

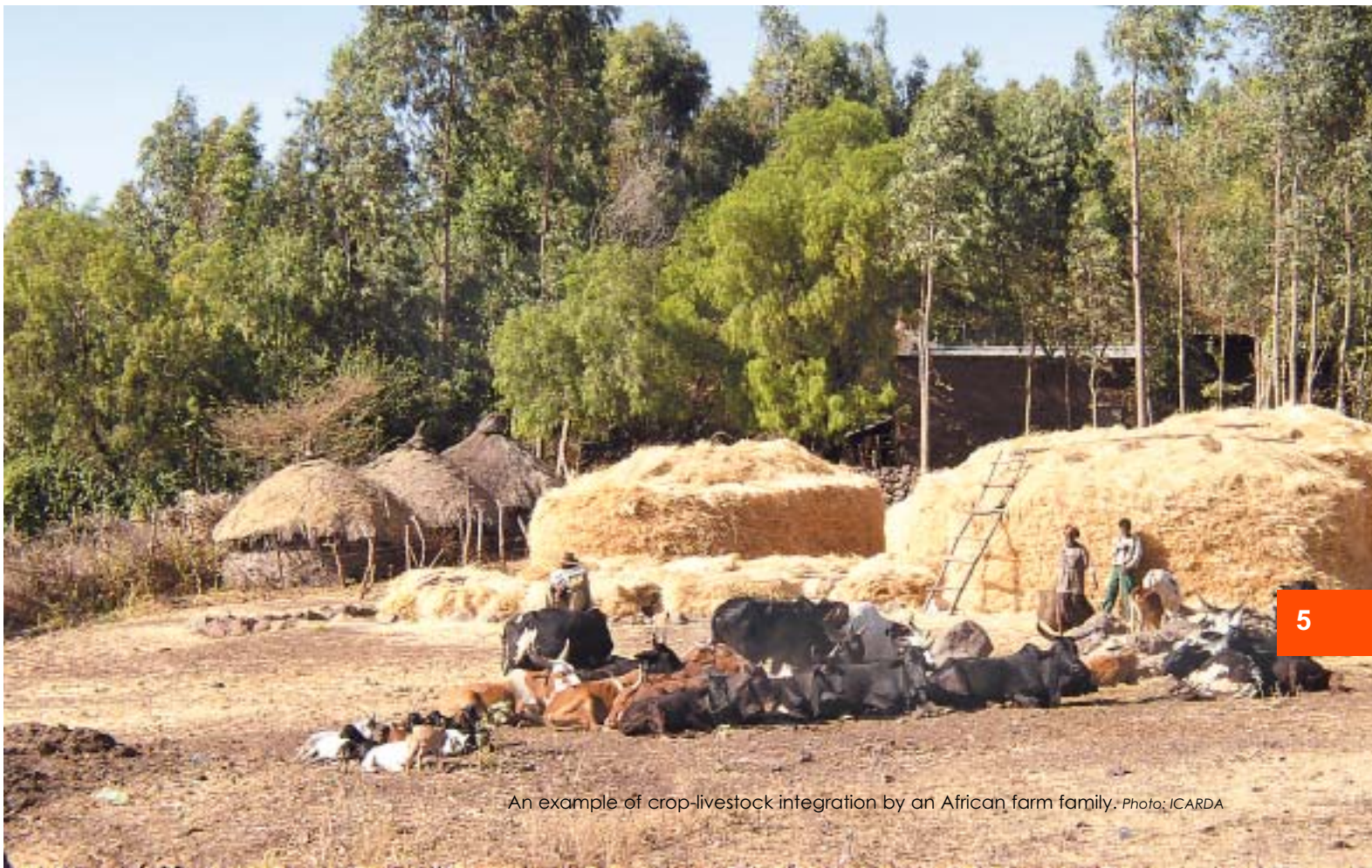
Chapter 2

Agricultural Research and Development: A Way Out?

"History has taught us that wars produce hunger, but we are less aware that mass poverty can lead to war or end in chaos."
—Willy Brandt, Former Chancellor, Federal Republic of Germany

Can agricultural development reduce conflict and disaster vulnerability on a wide scale?

Most poverty is rural, and most of the rural poor are engaged in agriculture (Lipton 2002; UN 2001). Since the poor typically spend more than half of their incomes on food, stimulus to the agricultural sector can provide them with a double benefit as both producers (through more employment and higher incomes) and consumers (through more affordable food). In addition to weakening the underpinnings of violence, more remunerative agricultural livelihoods can free up more financial resources for investing in infrastructure and systems to reduce vulnerability to climatic disasters.



An example of crop-livestock integration by an African farm family. *Photo: ICARDA*

Therefore, investments in agricultural and rural development should be prime candidates for poverty reduction initiatives. Leading experts are convinced by the evidence to date that agricultural development can be a powerful tool for poverty reduction if it is carefully designed to especially reach the most needy (Fan et al. 2000a, b; Hazell and Haddad 2001; Lipton 2002; Lewis 2003; Meinzen-Dick et al. 2003). NEPAD (New Partnership for Africa's Development), Sub-Saharan Africa's self-developed plan for renewal, concurs with this view. Two of its four primary objectives are to eradicate poverty and to place Africa on a path of sustainable growth and development. Agriculture is a priority for policy reforms and increased investment in NEPAD's Program of Action.

Despite this consensus of the global and the African communities, international aid to agricultural development had fallen from approximately 30% of total development assistance in the 1970s to about 10% by the turn of the century (Lipton 2002). The result is that the rural poor are left further behind in the development process. This increases their vulnerability to natural disasters as well as sows the seeds of future violence resulting from frustration and hopelessness.

Research: a catalyst for pro-poor development

To most effectively help the poor, agricultural development must be backed by a solid understanding of their livelihood systems, needs and values, the functioning of markets, climatic constraints and potentials, cropping systems and natural resources, ecological parameters of sustainability, government policies and institutions, and a myriad of other factors that influence the functioning of the agricultural economy. From this understanding, new innovations emerge in the fields of policy, technology, capacity-building and institutional improvement. This is the role of 'research-for-development' (R4D).

R4D can produce high returns on investment because it can transform agricultural systems in fundamental ways (Sachs 2002). Public-sector R4D is particularly important because it focuses on the poor who are a low priority for the private sector. When pursued on an international scale, the results can be impressive.

The achievements of the 15 International Agricultural Research Centers supported by the Consultative Group on International Agricultural Research (CGIAR) and their partners over the past three decades form a prime example. The System's three-decade (1971-2001) investment of US$7.1 billion was plausibly estimated to have returned approximately $65 billion in benefits from just three easily-documented research areas—an extraordinary 34% annual return on investment (Raitzer 2003). A large proportion of these benefits are believed to have reached the poor, mostly through lower food prices and increased small-farm incomes.

Furthermore, this estimate is believed to be quite conservative, because (i) it considers only a subset of all impacts (attributed against total System cost), (ii) it does not include 'multiplier effects,' e.g. how these impacts stimulated additional growth in the non-farm economy (Hazell and Haddad 2001); and (iii) it does not include a wide array of qualitative impacts, such as human capacity

building, adding to the scientific knowledge base, building more effective national institutions etc. The estimate also does not take into account spillover benefits captured by the developed countries, which far exceeds their investment cost in the CGIAR Centers (Brennan et al. 2003).

There is yet another dimension of the CGIAR's work, that of rebuilding agriculture in countries affected by conflict and natural disasters. Over the past three decades, the CGIAR Centers have made major contributions to rebuilding agriculture in at least 47 developing countries affected by conficts and natural disasters across Africa, Asia, and Latin America. The value of financial investments in this work cannot be assessed using the currency market rates, because the CGIAR Center scientists and staff have often carried out these activities at the risk of their personal security and in difficult working conditions. This dimension of the CGIAR's role has remained less known and unrecognized. This volume attempts to document that role, based on case studies for 31 countries provided by 12 of 15 Centers of the CGIAR.

Despite this impressive track record, the CGIAR's core budget for assisting the entire developing world is just half that of a single private sector company, Monsanto (Sachs 2002). Increased investment would accelerate progress towards global food security, poverty reduction, and peace.

The returns to investment in R4D can be especially large when helping to rebuild countries ravaged by conflict or natural disasters. In a crisis, aid agencies are pressured to act quickly. When the knowledge base is deficient, aid is often less effective than the donors intended. It is at these times when prior investments in R4D pay off handsomely, steering relief aid on a course to do the most good. Research, in other words, provides a bridge that connects emergency actions with longer term development—reducing future vulnerability to these hazards.

This study assesses how R4D conducted by CGIAR Centers is helping reduce human suffering from conflicts and natural disasters by:

1. Alleviating immediate hunger and setting food production systems back on track;

2. Protecting and restoring damaged agricultural biodiversity;

3. Rebuilding human capacities and agricultural institutions;

4. Reducing vulnerability of the poor to future conflicts and disasters; and

5. Helping development agencies work more effectively and cost-efficiently.

Chapter 3

Rebuilding Seed and Food Systems

"There is a critical interdependence between sustainable development and human security. Mechanisms of social stability and societal justice usually develop hand in hand with improvements in living standards."
—Road Map Towards the Implementation of the United Nations Millennium Declaration, 2001, UN Secretary General's Report, para. 34

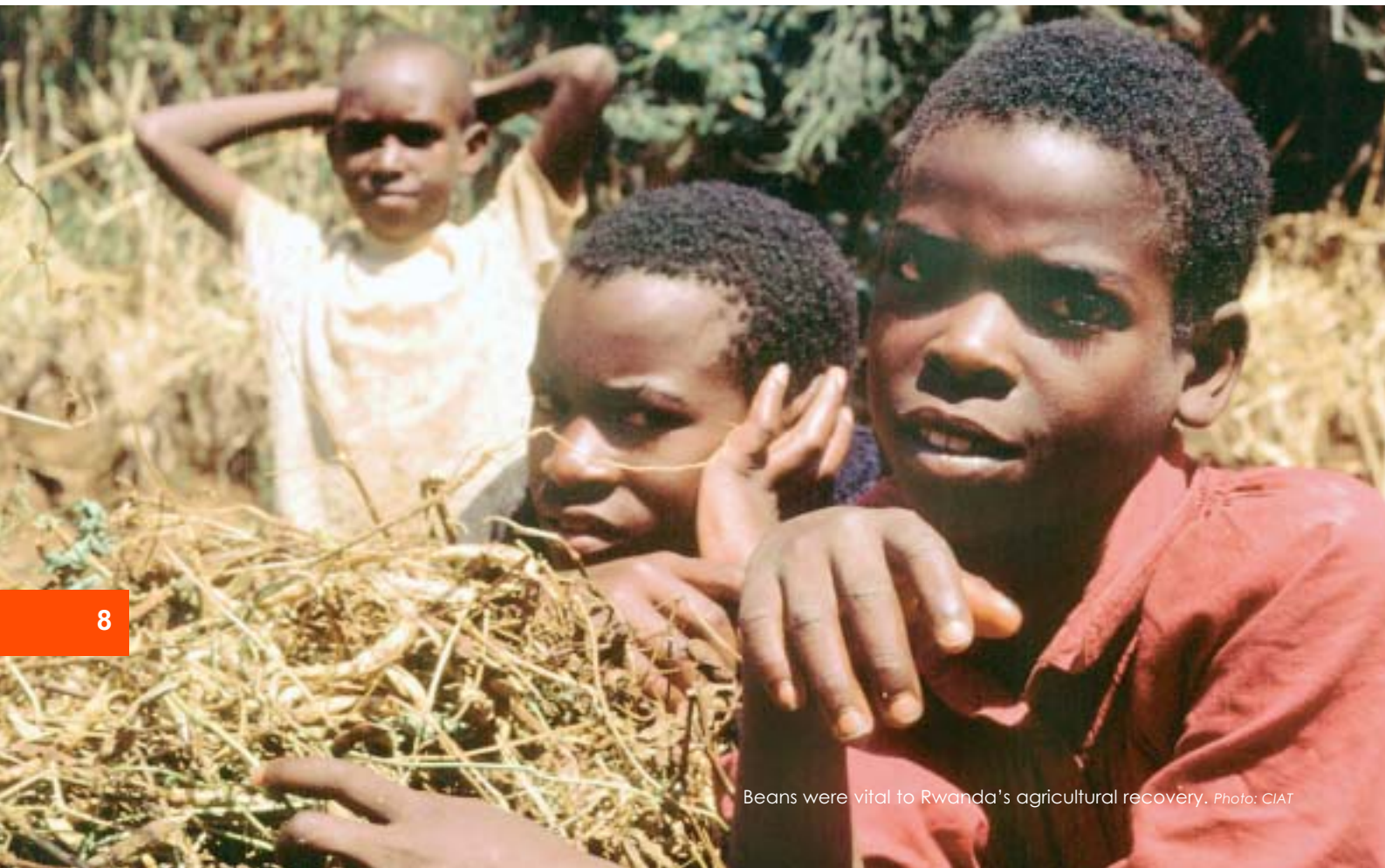
When the agricultural pedestal of a developing nation's economy is toppled by conflict or natural disaster, it must be righted quickly, because lives depend on it. But aid must be provided in ways that build people's capacity to care for themselves rather than create dependency.

The CGIAR Centers have been playing an increasing role in helping nations rebuild their agriculture after conflict and disaster over the past three decades. Much of this work has revolved around the restoration of seed and production systems of basic food crops.

Sub-Saharan Africa

Rwanda: Seeds of Hope

Perhaps one of the best-known examples of the CGIAR's engagement in rebuilding a country shattered by war has been the case of Rwanda. The Rwanda nightmare was a brutal example of the new type of post-Cold War 'stagnation' conflict. Poverty, political unrest and economic stagnation fueled hopelessness and ethnic hatred (see Chapter 1 in this report, and p. 24-25 in Messer et al. 1998). The genocidal campaign and civil war flared most



Beans were vital to Rwanda's agricultural recovery. *Photo: CIAT*

intensely during the first half of 1994, although instability continued for the next two years. It killed approximately 800,000 people and scattered another two million as refugees, or about a third of the total population.

As one of Africa's poorest countries, with about 90% of the population dependent on agriculture for a living, Rwanda had received steady attention from the CGIAR for more than a decade prior to the calamity. When the war began to subside, CIAT convened a consortium of eight CGIAR Centers, including itself, CIMMYT, CIP, ICRAF, ICRISAT, IITA, ILRI, and IPGRI. The Seeds of Hope (SOH) Initiative was formally launched in September 1995.

The national research institutions of Rwanda and its neighbors--Burundi, Ethiopia, Kenya, Malawi, Tanzania, Uganda, Democratic Republic of Congo, and Zimbabwe— were vital SOH partners, along with some brave Rwandans from the Institut des Sciences Agronomiques du Rwanda (ISAR) and the Ministry of Agriculture, who continued to work despite extreme duress. The NARS (National Agricultural Research Systems) contributed through the crop improvement research networks they and the Centers had established previously: RESAPAC/ECABREN (East and Central African Bean Research Network) for beans, PRAPACE (Research Network on Potato and Sweetpotato in East and Central Africa) for potato and sweetpotato, and EARRNET (East African Root Crops Network) for cassava.

Involvement of non-governmental organizations was the third dimension of SOH partnership, especially CARE, World Vision, Catholic Relief Services, Swiss Disaster Relief, and Medicins Sans Frontiers. They monitored developments on the ground as the war and post-war recovery progressed, identifying needy locations and delivering seed aid and technical support.

Development investors that made SOH possible included USAID, ODA (now DFID - UK), Swiss Development Corporation (SDC), IDRC (Canada), Australian Aid, and World Vision—all building upon the steady investments of CGIAR Members prior to and continuing through, and beyond SOH.

The CGIAR Centers helped Rwanda in four major ways:

1. Helping relief agencies find good quality seed of the right varieties that farmers and communities were asking for, avoiding the past pitfall of indiscriminate supplies of seed not well adapted to the target zone;
2. Studied changes in seed diversity and household seed security in the immediate aftermath of the genocide, to understand if and how precious biodiversity might have been damaged;
3. Multiplied seed of a wide range of indigenous Rwandan crop varieties outside the country, so as to be prepared to restore it on a major scale in case of total loss (fortunately, this worst-case scenario did not materialize, but those seeds did prove valuable in rebuilding Rwanda's research capacity); and
4. Helping rebuild human capacities, training those who replaced those who had been killed or forced to flee.

The watershed SOH case touches a number of issues discussed later in this monograph. Here we focus on emergency actions—items 1 and 3 above (see Buruchara et al. 2002 and Sperling 1997 for more detail).

It was unclear at the outset how the war would ultimately affect farmers and the poor; a number of scenarios had to be considered in SOH's planning. If crops in the field were lost, desperate hunger would ensue. Farm families might be forced to eat their seed stocks,

creating a crisis for subsequent seasons. Widespread death and displacement might cause farmers to lose or abandon their traditional wealth of seeds, resulting in a loss of precious biodiversity.

SOH acted on its knowledge to multiply well-adapted seed in neighboring Tanzania and Uganda so that aid agencies would not have to look further afield or bring in non-adapted varieties. This produced 1.5 tons of bean seed of more than 275 different types; 7 tons of sorghum seed adapted to the three major Rwandan agroecologies (low, medium and high elevation); 152 tons of three main adapted varieties of maize; and 20 tons of seed potatoes. Within these efforts, the case of potato was particularly telling. Much of the potato germplasm funneled into Rwanda by the PRAPACE network, derived from seed that Uganda had itself received from the PRAPACE network in 1988 when it was recovering from the nightmare caused by the Idi Amin regime. What goes around, sometimes really does come around.

One impediment in providing relief materials to Rwanda was the difficulty of introducing improved cassava planting materials due to virus diseases that might be carried within the stems of this vegetatively-propagated crop. In an effort to prevent similar bottlenecks in the future, IITA established a Disaster Relief Unit within its Tissue Culture Laboratory at Ibadan, Nigeria in 1996, with start-up funding from USAID. This tissue culture facility can produce disease-free plantlets quickly and on a large scale. These are kept clean in sterile test tubes and can be flown to any country in times of need, often using IITA's own aircraft when commercial flights are not available. Thousands of plantlets have since been delivered to countries all across Africa, accelerating relief and impact.

Once introduced into Rwanda, another cycle of multiplication was made possible largely through the efforts of Service Semencier Selectionnees (SSS), the World Food Programme, and NGOs such as World Vision International (WVI) and CARE, in collaboration with SOH. CARE continued providing advice and assistance on the cultivation of these varieties for years afterwards.

The SOH partners initially met weekly (and later monthly) to assess seed needs in the country and target the right varieties to areas most in need. Partners complemented each other's knowledge: NGOs knew where needs were greatest, CGIAR Center staff knew which seed was best adapted and where, and aid agencies took steps to acquire the seed from external or internal sources (including local and regional markets), guided by seed 'source maps' that Center staff had drawn based on their knowledge.

The feedback from farmer assessments later proved the wisdom of the strategy of targeted distributions of locally-adapted varieties. Yield measurements showed that these varieties were more productive for farmers than other relief seed they had been given that had not been carefully chosen for its adaptation (Buruchara et al. 2002).

A unique contribution of SOH was the research that it conducted as an integral part of the aid effort. Those studies illuminated a number of important principles about how seed relief could be

improved in the future. The research revealed that, despite the conflict, farmers had been remarkably successful in preserving their bean agrobiodiversity (Sperling 1997, Sperling and Cooper 2003). Local bean varieties persisted because the war was of relatively short duration and many farmers were able to harvest parts of their fields, and because local seed markets continued to function, allowing farmers to re-stock their own varieties—if needed. Food aid also helped, because farmers did not need to eat their seeds to stay alive. Rwandan farmers often use bean varietal mixtures rather than pure lines, and reported satisfaction in being able to sort out the varieties they wanted from the mixtures provided by SOH (Buruchara et al. 2002).

Local seed markets quickly recovered after the war and continued supplying diverse and locally-adapted seeds of subsistence crops. In contrast, seed systems for cash crops such as potato that were dependent on a formal seed sector were debilitated due to destruction of their supporting infrastructure and institutions. A key lesson learned was that attention to seed supply channels is essential for understanding the effects of conflict and disaster on agrobiodiversity (Sperling 1997).

The landmark nature of the SOH success built the confidence that led to Center participation in subsequent disaster relief efforts including 'Seeds of Freedom' (catalyzed by the Angolan war), 'Seeds of Hope II' (in response to Hurricane Mitch in Central America), 'Seeds of Life' in East Timor, and current efforts in post-Taliban Afghanistan and in Iraq. Numerous lower-profile yet equally important partnerships between CGIAR Centers and relief agencies continue in other conflict-prone countries, building on the confidence created by SOH.

Misery in Mozambique

Mozambique suffered greatly from internal conflict for most of the 1970s and 80s. When the fighting finally stopped in the early 1990s, the droughts began. ICRISAT stepped in to help the impoverished country rebuild its dry-land cereal systems (sorghum and millet). It collaborated closely with World Vision, which was engaged in a large-scale agricultural rehabilitation program. This program included the distribution of seed kits to returning refugees as well as the testing of improved crop varieties to determine which seeds should be included in the kits. It also studied how aid systems could be improved in the future (see Chapter 7).

And then the droughts turned into floods. In early 2000, Cyclone Eline overwhelmed southern Africa. Many of that area's rivers drain into Mozambique, and the Limpopo River Basin became a major disaster area. About 700 people died and half a million were affected, including many thousands displaced from their homes. IITA has been intensively working since then with national institutions and NGOs to restore root crop farming systems that were washed away by the floods.

Chaos in the Democratic Republic of Congo

During the late 1990s, the Democratic Republic of Congo, formerly Zaire, descended into war and chaos. Government forces backed by Angola, Namibia and Zimbabwe battled rebels supported by Uganda and Rwanda. A fragile peace deal is finally raising hopes of an end to this nightmare, but large parts of the country remain unstable.

The conflict is believed to have contributed to the spread of a new strain of the Africa Cassava Mosaic Virus, called the Uganda Variant. Internally displaced people are believed to have transported planting material from one place to another. The cassava crisis could not have struck at a worse time. The impoverished and malnourished refugees

were highly vulnerable to food shortages; an estimated 3 million may have perished during the conflict period, mostly from starvation and disease.

IITA had previously developed cassava lines resistant to the disease that had major impact across East Africa, and beginning in 2000, brought this experience to bear in the more difficult situation of Democratic Republic of Congo. IITA scientists made rapid assessments that confirmed that the Uganda Variant was a spreading epidemic. Within months, proposals were developed, support obtained from USAID for emergency intervention and, in 2001, disease management projects were initiated.

Small initial shipments of plants gave farmers in Democratic Republic of Congo a chance to pick the varieties most suitable for them. From a starting set of 200 genotypes, they selected 10 for rapid multiplication and distribution at the Mvuazi research station. These lines are expected to turn the disaster around for the Democratic Republic of Congo's most important food crop.

Nourishing refugees in Uganda

A brutal insurgency plaguing northern Uganda since 1986 has displaced an estimated 1.4 million people in the Achioli, Teso and Lango sub-regions. Houses have been burned and looted, and civilians have been the victims of atrocities, involuntary conscription and forced labor. The displaced live without shelter or in camps where water, sanitation and health care are inadequate and disease is rampant, with high infant mortality. Security risks limit humanitarian

The devastating Africa Cassava Mosaic Virus (above) can be overcome by new resistant lines from IITA (left).

Photos: ICRISAT

and food aid to the camps; relief convoys have been ambushed. Malnutrition is increasing, particularly among displaced children. When some of the internally displaced try to return home to farm, they lack basic agricultural inputs.

Vitamin A deficiency is one of Africa's most widespread, yet treatable health problems. It is a leading cause of early childhood death and a major risk factor for pregnant and lactating women across Africa. It weakens the immune system, leaving them susceptible to deadly diseases such as measles, malaria, and diarrhea.

Meat and milk are good sources of vitamin A and many fruits and vegetables are rich in beta-carotene, which the human body uses to make vitamin A. But most of these foods are too expensive for African consumers to buy in sufficient quantities and are especially difficult to obtain in times of disaster and conflict.

The Vitamin A for Africa (VITAA) Partnership, led by CIP, is helping to address malnutrition needs in northern Uganda and neighboring countries in eastern Africa. VITAA is tackling this problem through the improvement and dissemination of orange-fleshed sweetpotato. This crop is naturally high in Vitamin A, is familiar to Africans, and is relatively easy to grow.

VITAA is a remarkable partnership of approximately 40 organizations straddling the traditionally-separated sectors of agriculture, health and nutrition. It is convened from CIP's Kampala, Uganda office to coordinate with the regional potato network PRAPACE as well as with ASARECA (Association for Strengthening Agricultural Research in Eastern and Central Africa). Support for VITAA is generously provided by BMZ, the OPEC Fund, the McKnight Foundation, the Micronutrient Initiative, USAID, and the private philanthropic organization--Senior Family Fund.

Through VITAA, more than 850,000 orange-fleshed sweetpotato vine cuttings were delivered to Ugandan farmers in 2003 in the war-torn districts of Lira and Apac. During lulls in the fighting, farmers move beyond the camps to attend to their fields. They depend on extension workers from the James Arwata Foundation (JAF), a local community-based organization and VITAA member, to provide the planting materials, with support from Uganda's National Agricultural Research Organization, PRAPACE, VITAA-CIP, and farmers multiplying vines in Uganda's Soroti district.

Farmers from Luwero, Uganda explain the new orange-fleshed varieties of sweetpotato and the wide range of food products that can be made from them. *Photo: CIP*

Fat is needed in human diet to absorb vitamin A. In emergency situations, as in conditions of chronic poverty, diets of the poor often have insufficient fat. Peanuts, or groundnuts as they are also known, are a poor person's crop that provides a rich source of dietary fat (oil). Working in partnership with Catholic Relief Services (CRS) and the Overseas Development Institute (ODI), a UK-based NGO, ICRISAT undertook a study of seed systems in northern Uganda during a lull in the fighting in 2001, and identified an opportunity to introduce rosette-resistant groundnut varieties in an area where groundnuts are widely grown for food as a complement to starchy staples.

CRS evaluated these materials with displaced farmers, who were provided small plots of church-owned land close to urban centers that are less vulnerable to attack. In 2002, when a rosette epidemic hit the region, the improved varieties stood out like a beacon. These varieties, developed by the BMZ-supported SADC/ICRISAT Regional Groundnut Improvement Project in Malawi, also found their way to Southern Sudan and the Democratic Republic of Congo where farmers have snapped them up. Equally outstanding was IITA's Africa cassava mosaic virus resistant variety TMS 30572.

Angola's Seeds of Freedom

For more than a quarter of a century Angola suffered mightily from a combination of war and drought. The brutal proxy war between the Cold War superpowers also drew in regional combatants. Two to three million people may have died, and 1.2 million were left homeless and hungry. Hundreds of thousands died from or were mutilated by land mines; millions of unexploded devices remain today, impeding farmers' ability to cultivate their fields.

A peace agreement was signed in 1991 between the fighting factions, the Popular Movement for the Liberation of Angola (MPLA)-led Government and UNITA (Union for the Total Independence of Angola), although hostilities resumed later and continued into the next millennium. In the mid-1990s, USAID launched the Seeds of Freedom project to improve household food security and help revitalize the agriculture sector by rebuilding the seed system for high-yielding and adapted varieties of important food crops. World Vision International coordinated the effort, which engaged five CGIAR Centers (CIAT, CIMMYT, ICRISAT, IITA, CIP), four government institutions and eight NGOs.

Seed produced in the first phase included 15 tons of pearl millet (2 varieties), 80 tons of sorghum (3 varieties), 4 tons of beans (4 varieties), 14 tons of maize (3 varieties), 15,000 pathogen-free plantlets of 16 varieties of cassava regenerated from tissue culture, 380 pathogen-tested cuttings of 17 sweetpotato varieties, 1460 mini-tubers of 9 advanced potato clones, and a packet each of 1000 true potato seed (TPS) lines from 6 hybrid progenies.

In the 1996/97 season NGOs distributed 26 tons of seed to farmers (sorghum, millet, maize and beans). A total of 1390 on-farm trials were established and managed by farmers under their own conditions. Data were collected by extension and channeled to the coordinator for analysis and reporting. Usable results were analyzed and farmers' preferences were documented. Minor research infrastructure rehabilitation was carried out.

During 1997-1999, the Project was constrained by a renewal of violence in the country. However, efforts to test and disseminate seeds continue to the extent possible.

Rice in West Africa

West Africa has been plagued by extended wars and low-intensity conflicts in recent decades: in Guinea Bissau (1962-75), Liberia (1989-96), Sierra Leone (1991-97), and most recently in Ivory Coast. Farmers fleeing the Ivory Coast conflict near the border with Liberia, the heart of the upland rice belt, returned only to find their homes and seed stocks looted or burnt. There is an urgent need to build new seed supply systems that farmers can rely upon.

WARDA has helped countries rebuild after conflict by providing infusions of improved seed and by helping restore lost germplasm collections. Seeds being provided in bulk to areas recovering from conflict include the lowland varieties, WITA 4 and WITA 12, identified as superior in wide-scale regional testing using WARDA's participatory varietal selection methodology; and the hardy new NERICA upland rice varieties emerging from innovative wide crosses between the African and Asian rice species *(Oryza glaberrima and O. sativa)*.

Understanding emergency seed interventions

Embedding research/aid organization partnerships into their institutional fabric, ICRISAT and the Overseas Development Institute (ODI), a UK-based NGO established a joint staff position in 2001 based in Nairobi to undertake collaborative research on ways to improve emergency seed interventions. This work also collaborates with FAO's Rehabilitation and Humanitarian Policies Unit (TCER) to examine agricultural rehabilitation in chronic conflict and post-conflict countries (Sierra Leone, Afghanistan and Somalia), and support to the Somalia Aid Coordination Body to revise and expand its Agricultural Sector Strategy for Somalia.

The Humanitarian Policy Group (HPG) at ODI is dedicated to improving humanitarian policy and practice in this challenging, fast-moving and sometimes controversial sector. In addition to its own independent research, the HPG publishes the journal 'Disasters' (in conjunction with Blackwell Publishers), the leading journal in the field of complex emergencies and natural disasters. HPG also manages the Humanitarian Practice Network (www.odihpn.org), which provides a forum for sharing and disseminating information, analysis and experience in humanitarian policy and practice.

ODI also hosts the Secretariat of the Active Learning Network for Accountability and Performance in Humanitarian Assistance (ALNAP). ALNAP is an international, interagency forum working to improve learning, accountability and quality across the humanitarian sector. Through its partnership with ODI, ICRISAT has gained an institutional channel through which it can learn from, as well as influence those working in the humanitarian sector.

Latin America and the Caribbean

Hurricane Mitch

Hurricane Mitch was the worst natural disaster to strike Central America in the past century. It killed more than 10,000 people. Much of the damage was caused not by high winds but by two meters of rain that fell in less than one fateful week in November 1998. Flooding and mudslides damaged an estimated 60% of the combined agricultural land of Honduras and Nicaragua. Bridges and roads were washed away, complicating relief efforts. Rivers, crucial

for irrigation and hydroelectric energy, silted up.

Honduras was hit the hardest, with agricultural losses valued at about $800 million; but the northern mountainous areas of Nicaragua also suffered badly. Maize and beans, the two most important food crops in both countries, suffered huge losses as did other crops like potatoes and plantains. Mitch destroyed about half of the bean crop and a third of the maize in the affected areas. It also wiped out about 80% of the two countries' commercial export crops, such as banana, coffee and tobacco, destroying a crucial source of employment and income in poor agricultural regions. A food crisis loomed.

Small wooden crosses mark the spots where Honduran flood victims were washed away during Hurricane Mitch. Gentle streams became raging torrents, hurling trees, rocks, and villagers' huts down hillsides. *Photo: CIMMYT*

Mitch brought down the roof at the La Lujosa Experiment Station in Honduras when the nearby Choluteca River rose 10 meters. It took out generators, roadways, irrigation systems, farm equipment, a storehouse and hectares of crop trials, leaving a dune-swept expanse. *Photo: CIMMYT*

Bolstered by their success in emergency research-for-development in Rwanda a few years prior, four CGIAR Centers teamed up for a sequel. CIAT, CIMMYT, CIP and IPGRI joined hands with the Directorate of Agricultural Science and Technology (DICTA) in Honduras, the Nicaraguan Institute of Agricultural Technology (INTA), regional research networks, nongovernment organizations (NGOs) and farmer associations to launch Seeds of Hope for Central America, or Seeds of Hope II (SOH-II). Donors underwriting the effort were the Office of Foreign Disaster Assistance of USAID and the Multilateral Programs Branch of CIDA.

The project began with multiplication and targeted distribution of seed in 1999 through networks of researchers, development workers, and farmers. The project's most urgent task was to help multiply large quantities of seed for distribution among small farmers, focusing on bean, maize, potato, and sweetpotato.

Supplies of bean seed were especially hard hit, because the crop is mostly grown in the second season when the hurricane struck. SOH-II, together with national partners and farmer groups in Honduras, organized the multiplication of 175 tons of seed of three popular improved bean varieties. The project provided farmers with seed, fertilizers, and cash to purchase inputs in exchange for a commitment to sell the harvest to the project for distribution. The bean seed was distributed to about 3500 farm families by local and international organizations, notably the Red Cross and the Zamorano School in Honduras.

National researchers' seed stocks, the foundation of the formal seed supply system in these countries, also needed to be rebuilt. DICTA lost major stores of seed. Nearly all its field plantings of improved maize, and most machinery and infrastructure on several key experiment stations were also damaged. Fortunately, INTA came through the storm virtually intact.

Immediately following the hurricane, CIMMYT sent DICTA nearly half a ton of seed of diverse improved varieties and inbred lines chosen for high yield, regional adaptation, and stress tolerance. In addition to high yield potential, the varieties carried valuable traits such as drought tolerance, resistance to foliar diseases and ear rot, and enhanced protein quality.

Nicaraguan Minister of Agriculture Mario De Franco urged that the country "turn disaster into opportunity" by introducing modern high-yielding crop varieties and other innovations. CIP, CIMMYT and Nicaraguan farmers are testing sweetpotato alongside maize, a practice that has helped to reduce soil erosion in China.

Seeds of Hope II brought relief to poor hillside farmers after Hurricane Mitch.
Photo: CIAT

As in Rwanda, regional networks performed a vital role as safety nets for replenishing lost Central American germplasm. Improved bean germplasm was obtained from CIAT's partner, the Collaborative Bean Program for Central America, Mexico and the Caribbean (PROFRIJOL). CIMMYT's network partner was the Regional Maize Program for Central America and the Caribbean (PRM). Both networks have been funded by the Swiss Agency for Development and Cooperation (SDC). (In an interesting example of the safety-net value of regional networks, in 1989 the PRM completely replaced strategic maize seed reserves lost in Panama during the US invasion to oust Manuel Noriega, allowing the national maize program to meet farmers' seed needs within just four months.)

And, in another parallel with the Rwanda experience, the prior existence of a rich knowledge base gained through research paid off unexpectedly when Mitch hit. A digital "Mitch Atlas" developed by CIAT scientists guided relief workers to the areas most in need (see more about this in Chapter 6). The atlas indicates the condition of roads before and after Mitch, relief efforts under way in specific areas, damage to crops, the distribution of poverty, and other information crucial for targeting relief efforts.

Hurricane Michelle

The Caribbean islands are frequently battered by hurricanes. Hurricane Michelle swept through Cuba in November 2001, razing fields of upright crops such as bananas, plantains, yucca and citrus. With its tubers below-ground, sweetpotato survived and provided vital food. This prompted local authorities to launch a program to promote the crop's expansion for food security. The added push from the authorities is expected to increase the island's output by as much as 30%.

Sweetpotato has long been known in Cuba, and is grown on about 60,000 hectares annually. It is easy to cultivate, hardy against a range of stresses, and highly productive. It requires little fertilizer, and as described previously, the orange-fleshed varieties are an excellent source of vitamin A.

CIP and Cuba's Instituto de Investigación de Viandas Tropicales (INIVIT) already had a longstanding research partnership, and more than half of the crop's area was planted with varieties recommended by INIVIT. The partners had also disseminated integrated pest management principles, helping to reduce the damage caused by weevils from 40% to 10% in just five years.

El Niño in Peru

The particularly severe El Niño event of 1997–98 caused Peru's climate to lurch from severe drought to torrential downpours. Potato yields were cut by half in many areas while pests and diseases, especially late blight, surged.

The severe late blight attack took its toll on many potato varieties, including one of Peru's rising stars, 'Canchan-INIA,' developed jointly by CIP and Peru's national potato program and released to farmers in 1990. However, a CIP 'true potato seed' (TPS) hybrid, 'Chacasina', performed well under this stress. 'Chacasina' is a cross between the most popular local variety produced in the central Andes, 'Yungay,' and a CIP late blight–resistant breeding line.

The success of 'Chacasina' continues to rise in Peru. Harvests in more than 100 Peruvian districts where the variety has spread have been exceptional. As a result, the Center has been asked to produce two more similar varieties. Meanwhile, in the aftermath of El Niño, CIP distributed 'Chacasina' to more than 5000 farm families across Peru.

East and South Asia

Cambodia after the Khmer Rouge

Cambodia is a rice-dependent country. So it was natural that the International Rice Research Institute (IRRI) take the lead in bringing CGIAR assistance to that country following the horrific Khmer Rouge genocide of 1971-79. The Cambodian-IRRI-Australia Project (CIAP) was made possible through special funding from the Australian Agency for International Development. As its work progressed, many additional partners joined in, notably World Vision, the German Agency for Technical Cooperation (GTZ), the Canadian International Development Agency (CIDA), Catholic Relief Services and Oxfam.

The situation at the outset of the project in 1988 was grim. A quarter of the country's people had been murdered, especially the educated ones upon whom a recovery depended. Hunger, poverty and desolation permeated the countryside. Villages had been razed and human bones were stacked in the center of most of the major towns. Landmines were still killing and maiming farmers, and the Khmer Rouge, although driven from the capital city, still posed a threat in the countryside.

Agriculture had been likewise devastated. Formerly one of Asia's leading rice exporters, Cambodia's production fell by 84% during the reign of terror. The Khmer Rouge pursued a brutal and disastrous purging of foreign and educated influences. Most of the agricultural scientists were killed or fled the country.

Great personal courage was required of the project leader and his team. A grenade was thrown into the project office early on, the project leader's house was shot at, and a bounty for his life was offered by the Khmer Rouge. One of the project's first locally trained agricultural technicians died when the project vehicle was ambushed and machine-gunned

Ruins of the Toul Koktrap Research Station in Suay Rieng, Cambodia. *Photo: IRRI*

by the Khmer. There was no international peace-keeping force to call upon for protection.

The CIAP team obtained traditional Cambodian varieties from IRRI's gene bank and began growing them for testing, along with launching a training program. They introduced new rice varieties such as early-maturing IR66, providing a quick food crop and leaving time for a second harvest the same season. To achieve the potential of new varieties, the team needed to introduce Cambodians (who were used to low-input rainfed agriculture) to more intensive methods employing fertilizer, water control, and integrated pest management. Postharvest grain handling issues also received attention.

CIAP made a major contribution to relieving intense human suffering (Collis 2002). It was instrumental in transforming Cambodia from a rice deficit country, reflected in widespread hunger and starvation, into a surplus producer by 1995. The dollar value of net benefits over both the terms of the CIAP project (1987-2001) and projected to the year 2020 was estimated as US$1.3 billion (in 2001 dollars), delivering an impressive average annual internal rate of return of 32% on donors' investment (Young et al. 2001).

Timor-Leste

East Timor, a former Portuguese colony, declared its independence in 1975, triggering a long conflict with Indonesia. In August 1999, a UN-sponsored referendum accepted the declaration, but sparked reprisals by those opposing the independence movement. Many lives were lost and crop seeds were stolen or burned, creating an imminent food crisis. Finally, after a UN Transitional Administration was installed to bring calm, a newly-independent Democratic Republic of Timor-Leste was internationally recognized in May 2002.

Many government facilities were destroyed during the East Timor conflict. *Photo: ICRISAT*

The devastated country needed help. Since more than 90% of the population was involved in farming, its first priority was to rebuild agriculture and establish food security. Numerous agencies rushed assistance to the country in the form of seeds, but crop scientists found that much of the seed and plant material provided was not well adapted to the country.

Five CGIAR Centers joined hands to help: CIAT for cassava and beans, CIMMYT for maize, CIP for sweetpotato, ICRISAT for peanuts and IRRI for rice. The Seeds of Life (SOL) Project, launched in the year 2000 during the UN Transitional Administration period, was made possible through support from the Australian Centre for International Agricultural Research (ACIAR). SOL formed a close partnership with the new nation's Ministry of Agriculture, Fisheries and Forestry (MAFF) and helped train its new staff. It also partnered closely with the NGOs-- Catholic Relief Services, World Vision International and Australian Volunteers International. The Memorandum of Understanding that established the partnership was the first such agreement signed by the new government, and the new president of the country, Xanana Gusmão, was an enthusiastic participant at the inaugural planning meeting—demonstrating the priority the new country placed on getting its agriculture moving again.

An initial scoping mission found a wide range of soil types and rainfall patterns across the country. The project team concluded that an appropriately wide range of germplasm should be assembled for testing with the participation of farmers on their own lands. Farmers typically tried 1-3 varieties of a crop using their own management resources. This helped them identify the best materials to be multiplied at the village level for further use, and allowed neighboring farmers to observe as well. Their feedback helped national authorities identify the best varieties for formal release.

Timor-Leste's first President, Xanana Gusmão addressing the United Nations (above), and with the Seeds of Life team at the inaugural planning meeting (below). *Photos: ICRISAT*

Healing Wounds

The project team also advised the government on setting up a central seed multiplication farm to accelerate seed production.

Improved varieties were impressive in the trials, especially when combined with better management techniques. Cassava lines from CIAT yielded almost twice as much as the local varieties, while CIMMYT maize outpaced the local types by 50% and was more lodging-resistant. Groundnut is the most important food legume in Timor-Leste, and varieties provided by ICRISAT proved far more productive than the local varieties in tests across four diverse locations.

Timor-Leste's Prime Minister, Mr Mari Alkatiri cuts the ribbon to inaugurate the Betano Research Station, where the main Seeds of Life activities in the south took place. The entire Cabinet attended this ceremony, underscoring its importance. *Photo: ICRISAT*

Left: Local peanut; right: ICRISAT variety. *Photo: ICRISAT*

At Bacau (a lowland site), farmers were stunned to see the sweetpotato supplied by CIP yielding six times as much as local varieties. They and Timorese leader Xanana Gusmão as well took note because it was previously believed that sweetpotato wouldn't grow well there. In Aileu, a mountain town, the

farmers carried away most of the sweetpotato cuttings. Rather than being perturbed, Project staff saw that as a compliment. Orange-fleshed sweetpotato varieties that could help alleviate vitamin A deficiency—a significant problem on the island, especially for children—will also be introduced.

Drought severely damaged crops in early 2003, and Timor-Leste's Minister of Agriculture wrote to ICRISAT asking for help in reviving sorghum culture, a crop that is well suited to dry conditions and is currently found mainly in the north around Liquiça. It is known as 'tall corn' in the local language, reaching a height of about 4.5 meters. Sorghum is eaten mixed with maize, and is also fed to cattle.

Timor-Leste farmers were amazed to see the six-fold advantage of CIP sweetpotato varieties. *Photo: ICRISAT*

India

The collision of the Indo-Australian and the Eurasian Plates of the earth's crust has given rise to the magnificent Himalaya mountain range of southern Asia. Unfortunately, people sometimes get caught in the middle of this titanic duel.

On 26 January 2001 an earthquake registering 6.9 on the Richter scale struck the state of Gujarat in northwestern India. The epicenter was close to the small desert town of Bhuj. An estimated 20,000 people were killed and 15 million (half the region's people) were affected in some way; hundreds of thousands were left homeless, and the economic basis of the state was ravaged.

To restore critical planting material in this parched area, ICRISAT rushed 500 kilograms of seed of a high-yielding pearl millet hybrid variety to the Gujarat Seed Producers' Association which, with a local NGO (VRTI) distributed it to 350 of the neediest farmers. Due to its location, more quakes are inevitable in the decades to come. To reduce the poverty that underlies vulnerability, ICRISAT is collaborating with the Gujarat Agricultural University and VRTI to multiply and distribute seeds of improved groundnut, sorghum, and pigeonpea. ICRISAT is also planning to assist in the

proposed Fodder Bank for Kutch, which will help meet the demand for high quality fodder in this largely cattle-centered region.

Seed aid was welcome relief in the grim aftermath of the earthquake in Gujarat, India.
Photo: ICRISAT

North Korea

North Korea has suffered greatly from famine in recent years. Three million lives may have been lost. Two-thirds of the potato crop has been lost due to drought caused by El Niño and because of diseases. Potato is the third most important crop in the country after rice and maize.

At the country's request in 1999, CIP came to help establish true potato seed (TPS) technology. World Vision, the Office of Foreign Disaster Assistance of USAID, Potato Production International (a private company based in California), SDC and national program partners from Vietnam and China worked in partnership to introduce the technology.

Central and West Asia and North Africa

Palestine

Palestine faces many difficult problems that require a sustained effort. Chronic conflict aggravates inherent limitations of the agricultural environment: shortage of arable land, water scarcity, and a limited market for local products. Agriculture plays an important role in the Palestinian economy by both feeding the population and providing jobs. Livestock contribute roughly 40% of agricultural income in the West Bank and 25% in Gaza. Activities to strengthen agriculture promote peace through greater economic security.

The capacities of Palestinian agriculture-related agencies and departments (the National Agricultural Research Center—NARC—and the Directorate of Extension and Research) are limited. ICARDA is assisting in the rehabilitation and sustainable development of the Palestinian agricultural sector. Since 1994 ICARDA has worked with the Ministries of Agriculture and Environment and the National Center for Agricultural Research in testing improved crop varieties, capacity-building, and joint project implementation. ICARDA has facilitated many training and conference-attendance opportunities for Palestinian scientists.

Within the framework of the regional initiative for dryland management facilitated by ICARDA, techniques are being promoted that ensure more efficient utilization of water in the Palestinian territories. The project has already tested different water-harvesting techniques and has found two to be exceptionally promising: V-Shaped micro-catchments and permeable rocks. The permeable rocks technique is traditionally used, while the V-shaped micro-catchment technique is new to farmers.

ICARDA is implementing V-shaped micro-catchments and permeable rocks techniques in Palestinian Territories to enhance agrobiodiversity conservation. *Photo: ICARDA*

Iraq

Agriculture in Iraq has suffered because of wars and drought, economic sanctions, and other internal and external factors. Agricultural inputs are scarce and land resources such as irrigation facilities are difficult to maintain. Growing populations and shrinking resources are forcing farmers to follow exploitative production practices. Feed resources have been reduced by overgrazing, cultivation of rangelands for crop and tree production, removal of vegetation for fuel wood, and soil erosion. Veterinary services and vaccines are in short supply. Iraq is in need of substantial humanitarian, rehabilitation, and reconstruction assistance.

Since its inception, ICARDA has worked closely with Iraq, particularly its Ministry of Agriculture and the IPA Agricultural Research Center, Abu Ghraib, Baghdad. ICARDA held its ninth biennial coordination meeting with Iraq in November 2003, in which the partners jointly determined the immediate actions needed to restart agricultural research and rehabilitate the agricultural sector. Priorities include: (i) the multiplication and delivery of high quality seed of adapted varieties, (ii) for the longer term, provision of technical assistance in the development of sustainable agriculture, and (iii) development of a strategy that will ensure a

Coordination meeting between Iraqi and ICARDA scientists, held in November 2003 in Jordan, to develop joint work plans.
Photo: ICARDA

close integration of relief, rehabilitation and development projects. To jump-start seed production, ICARDA provided over 20 tonnes of improved seeds of cereal and legume varieties known to be adapted to Iraq's environmental conditions in 2003. ICARDA and Iraq are implementing a program of large-scale on-farm demonstrations with improved varieties of barley, wheat, chickpea, lentil and vetches under different agroecological conditions during the 2003/2004 cropping season through support from USAID.

Better livestock management options include the introduction of improved breeding stock, practices to enhance fertility and lambing rates, early weaning, on-farm feed production, alternative feed sources, and better management of small ruminants. New varieties of barley, oat, vetch and triticale adapted to harsh environments have been tested and adopted by farmers. Fodder shrubs and cactus are widely used to augment feed resources. Feed-blocks made from agro-industrial by-products have become an integral part of the feed calendar of small ruminants in Iraq, and are produced entirely by the private sector.

Longstanding ICARDA/Iraq collaboration on crop improvement includes joint research, plant genetic resources conservation and capacity building. Improved varieties of barley, spring bread wheat, durum wheat, lentil, and chickpea have been released to Iraqi farmers and are being grown on large areas.

Afghanistan

After years of armed conflict and drought, Afghanistan is struggling to get back on its feet. Afghanistan once produced enough to feed its people and even exported some surplus. A long period of war and four consecutive years of drought have brought the country to its knees. One-third of the population fled during the wars, with Pakistan and Iran sheltering more than 6 million refugees. Less than a third of the population can read or write; the population growth rate exceeds 3% but the average lifespan is just 40-46 years. The great majority are desperately poor, earning less than a dollar a day. Agricultural productivity has declined sharply and food has become scarce.

Only a small part (12%) of Afghanistan's land, mostly in scattered valleys, is suitable for farming. The diverse topography results in tremendous diversity of agriculture. Systems range from arid pastoralism to intensive small-scale irrigated production, to sub-mountainous systems of rainfed cereals, legumes and fruit trees. Because of the dry climate, most of the farmland requires irrigation. Water from springs and rivers is available, but irrigation has been developed on less than a third of the arable land area. In large valleys crop productivity is often constrained by water supply, and conversely in narrow ravines steep slopes limit the quantity of arable land.

Today, with the situation relatively quiet, farmers are returning to their homesteads and villages to take up agriculture again. But getting agriculture back on its feet will not be easy, given the virtual collapse of supporting institutions, the neglect of human resource development and the scarcity of inputs. The country's entire agricultural production system has been disrupted; local seed and crop improvement programs do not

Wheat seed was quickly distributed in many provinces in Afghanistan in 2002 by the ICARDA-led Future Harvest Consortium, and picked up by farmers at local distribution points. *Photo: ICARDA*

function; research stations have been extensively damaged, equipment has been looted and staff members have left the country or do not have the financial means to carry out research and development activities.

To help Afghanistan with these daunting challenges, ICARDA spearheaded the formation of a Future Harvest Consortium to Rebuild Agriculture in Afghanistan during 2001/02, made possible through support from USAID and IDRC as well as the CGIAR core investors (ICARDA 2003b, p. 9). Participating CGIAR Centers include CIAT, CIMMYT, CIP, ICARDA, ICRISAT, IFPRI, ILRI, IPGRI, and IWMI. Non-CGIAR partners include a number of international research and development organizations, the Food and Agriculture Organization of the United Nations (FAO), US universities, several international and local NGOs such as the Overseas Development Institute (ODI) and the Afghan Ministry of Agriculture and Livestock (MOAL).

Two major challenges confront Afghanistan's agriculture today: addressing immediate hunger and food insecurity, and putting the country's agriculture on a sustainable growth path for the longer term. In this chapter we present the emergency actions being engaged by the Future Harvest Consortium; the longer-term activities are addressed in Chapters 6 and 7.

Wheat and maize

Wheat is the most important crop in Afghanistan, covering 80–85% of the farmland or about 4 to 8 million hectares annually. It is the main staple cereal in the diet.

In late 2001 and early 2002, there was worldwide concern about the possibility of starvation in Afghanistan. The 2002 planting season loomed just three months after the Future Harvest Consortium was launched. The Consortium needed to act fast. Fortunately, it had a deep base of experience to draw from; CIMMYT and ICARDA, for example had been evaluating wheat germplasm there with national partners for years.

By early April 2002, 3500 tons of seed of the CIMMYT/ICARDA wheat varieties, 'Inqilab-91' and 'MH 97' were procured by ICARDA in Pakistan and transported by the United Nations World Food Programme to NGOs and village shurahs (community groups) for distribution to farmers. The seed reached an estimated 70,000 farm families in the provinces of Badakhshan, Bamian, Ghazni, Lowgar, Kapisa, Parwan, Wardak, and Uruzgan (ICARDA 2003a, b, p.12). Afghan partners provided critical insights on where the most needy farmers could be found, and worked around the clock to distribute the seed in time. The International Fertilizer Development Center (IFDC) later sup-

plemented the seed with fertilizer distributions through a voucher system. To avoid creating dependency, no inputs were provided free of charge; farmers paid for the seed with wheat grain from their harvest.

"If I had not received this seed, I would not have sown any crop this season. We ate everything we had. Nobody could get a job to earn money and we could not buy seed," said farmer Chariaka Hamidullah from Maidan District. Many ponder the fate of others who were not fortunate enough to get seed. "We received the ICARDA seed and could plant, but another village did not get this seed, and could not plant. We have to help them with what we will harvest," said a farmer in Bagram.

For the autumn 2003 planting, the Consortium arranged the production and delivery of more than 5000 tons of wheat seed. All of this seed was produced locally by leading farmers following a rigorous program to ensure quality, including field inspections, the removal of off-type plants, post-harvest treatment against disease, and proper packaging. The seed reached more than 90,000 farmers in 11 provinces. This high quality, disease-resistant wheat seed produced at least 100,000 tonnes of food in 2003.

CIMMYT's efforts in Afghanistan have recently been strengthened by the Australian Government through AusAid and ACIAR. The project, called Seeds of Strength, is delivering locally-adapted wheat and maize seed that can be sown right away. As a condition of receiving the seed, the farmers are asked to give a portion of the grain they produce to neighbors who did not have access to the seed in the first year of distribution. On-farm participatory testing of the imported seed is identifying the best cultivars, allowing for their local multiplication and distribution. Particular attention has been paid to yellow rust resistance in wheat and to promoting improved agronomy along with improved cultivars.

Through the Seeds of Strength project, CIMMYT distributed seven improved maize varieties along with fertilizer to 500 farmers in seven provinces with the help of a number of national and international NGOs. Three hundred tons of seed of the locally-adapted wheat variety MH-97 were distributed to 9,000 farmers in four provinces in time for 2002 fall planting. A winter wheat called SOLH 02 ('Peace 02') imported from a CIMMYT/ICARDA Winter Wheat Observation Nursery in Turkey and tested by FAO in Afghanistan was also distrib-

Elite wheat seed being multiplied at ICARDA's principal research station for distribution to Afghanistan farmers. *Photo: ICARDA*

uted. The project alleviated the 2002 seed shortage, and a favorable 2003 harvest is expected to boost seed stocks.

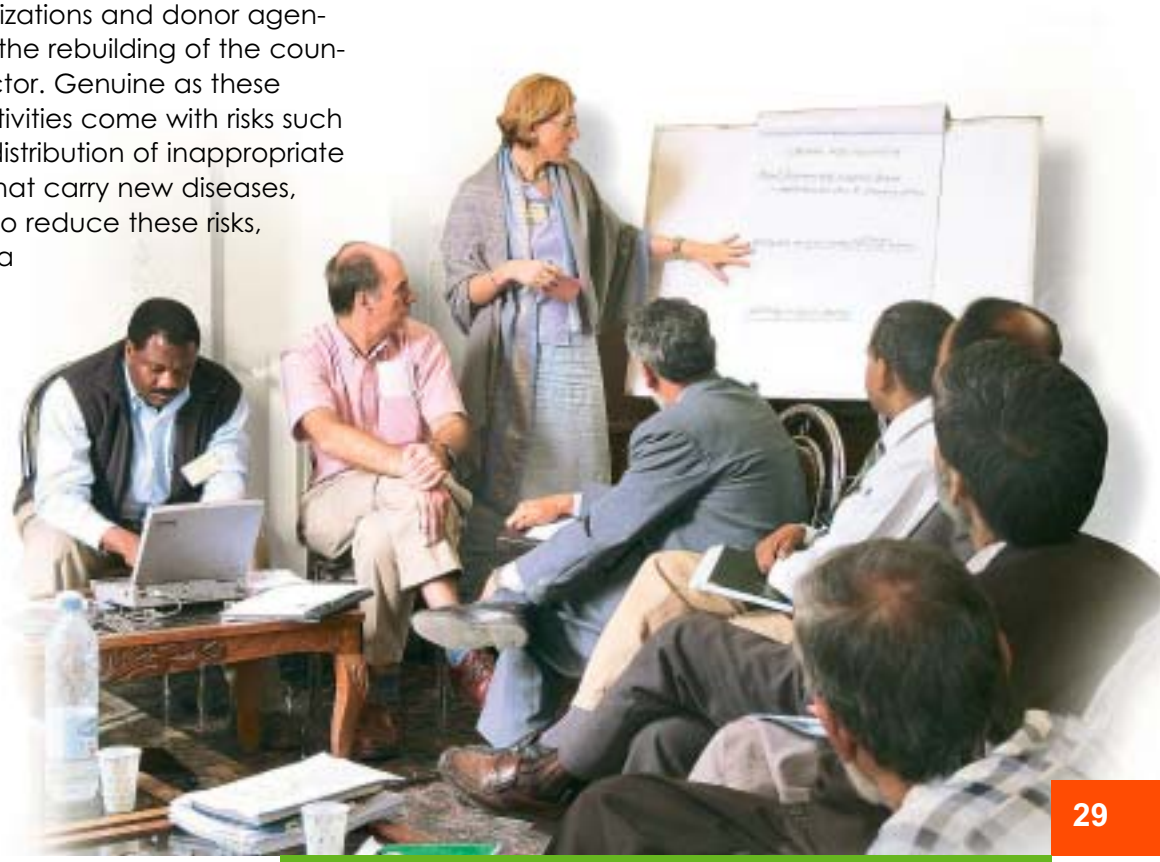
To encourage the formation of seed enterprises, seeds of a large number of varieties of wheat, barley, lentil, chickpea, and vetch have been provided to Afghanistan by ICARDA for evaluation and multiplication in cooperation with farmers (ICARDA 2004). Land race (farmer's traditional) varieties from ICARDA's gene bank are included in the test material. CIMMYT shipped 35 international nurseries to Afghanistan for testing throughout Afghanistan in 2002 and 2003. These materials mark the beginning of a seed sector in Afghanistan.

A code of conduct for seed support

The crisis in Afghanistan has attracted considerable aid interest, and many international and national organizations and donor agencies are assisting in the rebuilding of the country's agricultural sector. Genuine as these efforts are, such activities come with risks such as the import and distribution of inappropriate varieties, or seeds that carry new diseases, pests, and weeds. To reduce these risks, ICARDA organized a meeting of Future Harvest Consortium partners in May 2002 to develop a Code of Conduct for all those involved in seed production and distribution in Afghanistan. The Code is being finalized with support from FAO and is expected to form the basis for a larger national seed policy and regulatory framework for the country.

Pest management saves crop in Helmand, Afghanistan

In the summer of 2002, wheat grown on about 200,000 hectares in Afghanistan was rendered useless after being infested by *Eurygaster integriceps*, an insect commonly known as Sunn pest. This disappointment would have been repeated in spring 2003 if not for the good effort of the Central Asian Development Group (CADG) to save the crop. CADG, a member of the Future Harvest Consortium, was able to save 12.8 million dollars worth of wheat in Helmand Province using Sunn pest management information provided by ICARDA. Sunn pest injects chemicals that cause wheat gluten in the grain to break down. If as little as 2% of the grain in a lot is affected, the entire lot is rendered unsuitable for baking.



Developing a Seed Code of Conduct for Afghanistan. *Photo: ICARDA*

Potato seed

Tuber seed quality, especially the absence of diseases and pests, is vital to the success or failure of a potato crop. CIP initiated an emergency program to speed up the supply of quality potato seed to Afghan refugees returning from Pakistan.

From the outset, the intention was to help Afghanistan's farmers produce their own potato seed rather than import it. In September, project staff received 22 tons of commercial "starter" seed—enough to plant seven hectares. Ninety percent of the shipment was brought in by road from Pakistan through the Khyber Pass, with the remainder coming in as air cargo from India. To ensure that the imported starter seed would be well used, seed production training programs were initiated for staff from Afghanistan's Ministry of Agriculture, local NGOs, and Kabul University. Course graduates, working alongside CIP scientists and researchers from Pakistan, in turn trained a small group of local farmers.

Building a new paradigm in Central Asia and the Caucasus

The collapse of the Soviet Union forced wrenching change on the nations of Central Asia and the Caucasus, or CAC (Central Asia consists of Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan while the Caucasus includes Armenia, Azerbaijan and Georgia). With the disintegration of state-provided inputs, guaranteed product outlets, supporting institutions, infrastructure and policies, the region was thrown into poverty and disarray. Food production fell by 15-45% while populations continued to increase. Agriculture could no longer depend on a few massive state-dominated commodity systems, and needed to reorient and diversify to meet local food needs through a market economy. If nothing was done, a descent into hunger, chaos and eventual conflict appeared likely.

But where to begin? The once-impressive official research and development institutions had collapsed along with the rest of the Soviet structure. Many researchers were earning less than a dollar a day and had almost no operational support or materials to work with.

The CGIAR responded to this major geopolitical development by formally recognizing CAC as target for increased System activity. With its close proximity to CAC and its pre-existing partnerships and experience in the area, ICARDA took the lead during 1995/96 to develop and convene a CAC Consortium. The CAC Consortium now includes nine Centers: CIP, CIMMYT, ICARDA, ICRISAT, IFPRI, ILRI, IPGRI, IRRI, and IWMI.

The Consortium took a systematic approach, first strengthening the partnerships that would be vital for buy-in and progress. They met with CAC leaders and researchers for joint assessments of priorities. With CGIAR approval and funding, the Consortium established a Program Facilitation Unit in Tashkent, Uzbekistan housed in ICARDA's regional office there to enable strong partnerships and communication.

CAC countries and the CGIAR Centers in the Consortium developed joint research proposals and obtained donor support from the Asian Development Bank, IFAD, USAID, and the World Bank to launch their ambitious plans to reinvigorate the agricultural base of the region's eco-

nomy for the long term. The partners currently collaborate under five major themes: productivity of agricultural systems; natural resource conservation and management; conservation and evaluation of genetic resources and biodiversity; socioeconomic and public policy research; and strengthening national programs (Beniwal and Varma 2000).

Livestock are very important to the agricultural economies of the CAC region, with its large steppe areas that are ideal for grazing and herding, and its mountainous areas where sheep and goats can navigate the rough terrain and generate a living for poor rural folk. The region once had highly-developed livestock industries producing wool, pelts, hides and meat. The export channels for these products largely collapsed when the main buyer, the Soviet Union, disintegrated. Through IFAD support, ICARDA has been helping these countries strengthen their feed and livestock systems and identify new market opportunities. Several new crop varieties have been released in CAC countries. For example, from the nurseries provided by the Turkey-CIMMYT-ICARDA wheat project, a promising winter wheat variety 'Dostlik' was released in Uzbekistan in 2002. With support from ICARDA, 1000 tons of seed of this variety was planted in 2003/04 for seed multiplication and distribution to farmers.

As part of the Consortium effort, CIMMYT is contributing technology and training to help rescue national research systems. One project sponsored by the World Bank's International Development Fund in Kazakhstan focuses on developing national strategies to reform the agricultural research system and build up its capabilities. Another, financed by GTZ, aims to help Tajikistan's national program, torn apart by civil war. CIP has expanded its efforts in Asia to include Central Asia and the Caucasus, where potato is an important commodity. Germplasm is being introduced and national scientists are being trained.

Uzbek scientists, development officers and farmers visiting a demonstration site of the new wheat variety 'Dostlik' in Kashkadariya Region, Uzbekistan. *Photo: ICARDA*

Chapter 4

Safeguarding and Restoring Agrobiodiversity

Our fathers planted gardens long ago…
Whose fruits we reap with joy today;
Their labor constitutes a debt we owe…
Which to our heirs we must repay;
For all crops sown in any land…
Are destined for a future man.
—**Arab poet**, **Nizami**

Natural disasters and/or conflicts can seriously damage agrobiodiversity both in the field and in gene banks. Agrobiodiversity can also be under threat when new seeds are imported on a massive scale as urgent emergency aid in crises situations. The CGIAR Centers have been attentive to this issue, applying their research knowledge and tools to gain a better understanding of how agrobiodiversity is threatened in these situations and how it can be protected.

Gene banks: priceless safety nets

With nearly 700,000 accessions of crops, forages and trees in their gene banks, the CGIAR Centers are strategic global assets for the preservation of agricultural biodiversity. Time and again these resources have provided the last safety net against the irreversible loss of valuable germplasm.

Rwandan farmers' amazing bean diversity. *Photo: CIAT*

Every bean has its place in Rwanda

Rwanda is geographically and ecologically diverse, and this is reflected in its crop and varietal diversity. It is an important secondary center of genetic diversity for common bean, with some 600 distinct varieties being grown.

Fortunately, the CGIAR Centers had established a substantial knowledge base on agrobiodiversity issues before the Rwandan conflict—not knowing how valuable this would turn out to be during reconstruction. CIAT, for example, had documented how farmers develop diverse local mixtures of bean varieties suited to their differing agroecological conditions (Sperling et al. 1993; Voss 1992). In addition to helping guide seed restoration activities, this information became a crucial baseline in assessing the effects of the conflict.

Prior to the Seeds of Hope (SOH) Initiative in Rwanda, emergency aid operations typically imported massive shipments of just a few varieties that could be located quickly, without much regard for diversity and adaptation. SOH broke new ground by focusing on farmer's own agrobiodiversity and seed systems (Buruchara et al. 2002). SOH proved that aid agencies can successfully move an impressive range of farmer-appreciated varieties in the heat of a crisis—if they have access to the requisite seed system knowledge and insights into specific sources (for example, regional markets). Careful followup surveys and field trials demonstrated that this approach gave farmers what they really wanted and resulted in higher and more stable yields due to better crop adaptation and disease resistance.

The nimble response of SOH involved a number of timely decisions and actions. An inventory of seed holdings within the national program, ISAR (Institut des Sciences Agronomiques du Rwanda), was urgently carried out before the stations could be looted. One heroic Rwandan field assistant, Alexis Rumaziminsi, kept bean field trials going throughout the war, storing the seed at the Rwerere highland station. Regional network holdings were also updated. As soon as it became possible, the available seed was planted for rejuvenation and multiplication through critical support from World Vision International. During followup impact surveys, seed samples were also collected from farmers as a safety backup measure.

Some 1260 bean samples were collected and characterized in neighboring Uganda. They were compared against holdings in the CIAT gene bank in Cali, Colombia to assess gaps and duplicates. The set has since been returned to Rwanda for further study and use.

Rescuing the rice homeland

Cambodia lies within the swath of Asia where rice first evolved and its diversity is greatest, so degradation of biodiversity due to conflict in this sensitive area is a major concern. In contrast to the quick and resilient outcome observed in Rwanda, agrobiodiversity losses were significant during the long period of Khmer Rouge rule in Cambodia. Farmers grew a wide range of traditional varieties before the Khmer Rouge came to power (Javier 1997). Varietal diversity helps rice farmers reduce diseases and address specialty markets (Zhu et al. 2000). The Pol Pot regime suppressed cultivation of varieties they thought primitive, especially deepwater rice varieties. Many of these have been lost forever.

Instead, farmers were forced to plant exotic varieties from China that did not grow well in Cambodia. Farmers were relocated from one area to another, often carrying their traditional seed with them, which was not necessarily well suited to their new location. They had no backup reserves when the crops they planted did not produce a seed harvest. Farmers

abandoned fields far from their homes because of security concerns. Traditional knowledge of cultivation methods and varietal adaptation was lost on a large scale (Javier 1997).

IRRI held 55 Cambodian rice varieties in its gene bank in 1972. By fortunate coincidence, IRRI collected another 756 accessions in 1973, just as the Khmer Rouge era was getting underway. The CIAP (Cambodia-IRRI-Australia Project) team recognized the agrobiodiversity crisis that the Khmer Rouge had perpetrated, and worked with the Department of Agronomy, Provincial Agriculture Offices and NGOs to rescue traditional varieties as soon as the security situation allowed. A total of 3846 traditional varieties were collected during the 1989-97 CIAP period (Javier et al. 1999). In addition, 1097 accessions of wild rice (*Oryza nivara* and *O. rufipogon*) and their hybrids and progenies with cultivated rice were collected. These precious collections have been repatriated to Cambodia, and will benefit the entire rice-consuming world over time.

A 2001 review investigated the biodiversity impacts of the IRRI-led CIAP Cambodia rehabilitation project (Urwin and Wrigley 2001). In the course of the rebuilding effort, CIAP tapped IRRI's gene bank to restore what native biodiversity it could.

CIAP released a number of varieties particularly suited to the country's different rice-growing environments, which range from the well-drained uplands through various levels of water depth, controlled and uncontrolled, and including deep-water ecosystems. Over its course of work, CIAP recommended 32 different rice varieties for formal seed multiplication and use by Cambodian farmers. Twelve of those were traditional varieties that had been recovered from IRRI's gene bank (Javier 1997).

CIAP promoted low-impact cultivation methods such as integrated nutrient management and integrated pest management (Urwin and Wrigley 2001). These approaches are also likely to have reduced the damage to biodiversity that would otherwise have occurred had less careful policies been followed in the restoration of rice production. For example, low rates of safer pesticides, applied on a needs-only basis help prevent the loss of valuable predatory insects that control insect pest populations.

Safeguarding West Africa's rice

WARDA has helped countries rebuild their rice agrobiodiversity across Africa. Even low-intensity conflict probably had major effects on rice agrobiodiversity, because it altered social cooperation including seed systems (Richards and Ruivenkamp 1997). WARDA, whose gene bank holds 28,000 rice accessions, recognizes the chronic nature of this threat and takes a 'preventive germplasm collection' approach. Data characterizing the collection sites is compiled in a geographical information systems (GIS) database to aid in restoring traditional varieties to their locations of origin as soon as possible.

From 1994 to 2002, about 10,000 rice varieties were restored in West Africa (Liberia and Sierra Leone). In 2002, over 3500 rice varieties/lines were sent to Burundi, the Democratic Republic of Congo, Mozambique and Rwanda. In Côte d'Ivoire, about a thousand cultivars were collected in the year 2000 in an area that was later engulfed in civil war.

Somalia's seed lifeline

Despite the difficult political situation in Somalia, people have to continue with life. ICRISAT has been working with the Somali Agriculture Technical Group (SATG), an association of Somali professionals and friends of Somalia that strives to preserve the country's global resource of knowledge and expertise. An electronic forum has identified the improved sorghum and mung bean varieties that were recommended by researchers and adopted by farmers in the 1980s before the disruption caused by the civil war. These varieties are now being repatriated by SATG and ICRISAT through a wide range of development partners, notably CARE International.

Afghanistan's gene bank looted

Scientists reported in 2002 that looters destroyed Afghanistan's largest crop collection. The collections were stored in plastic jars and hidden in houses in the northern city of Ghazni and the eastern city of Jalalabad. Ironically, the looters took only the plastic containers and left the seed behind, reported Dr Nasrat Wassimi, Executive Manager of the ICARDA Office in Kabul, and Coordinator of the Future Harvest Consortium to Rebuild Agriculture in Afghanistan.

The looters destroyed hundreds of samples of Afghanistan's rich agro-biodiversity heritage. These included samples of wheat, barley, chickpea, lentil, melons, pistachio, almond, pomegranate, other fruits, and pasture crops. Many of the seed samples were of traditional farmer-varieties, bred over generations to prosper under local conditions, and tailored to the tastes of Afghan consumers. Responding to this emergency, ICARDA, ICRISAT and CIMMYT multiplied seed of several crop species, collected from Afghanistan in the past and saved in their gene banks, and repatriated it to Afghanistan.

Guarding the cradle

The Fertile Crescent zone of the Near East is often called 'the cradle of civilization', where many crops are believed to have been first domesticated. They continue today to be a strategic source of agro-biodiversity for many of the crops that humanity depends on. Crops originating in the Fertile Crescent provide about 38% of the human diet globally, especially for the temperate latitudes. Their wild relatives and land races are of enormous importance as a genetic resource.

Turmoil and conflict, high population growth rates, limited arable land resources, droughts and intensive grazing pressures combine to create grave risks to agrobiodiversity in this zone. A GEF/UNDP-funded project is accelerating work to conserve agro-biodiversity in West Asia. It is jointly coordinated by ICARDA, IPGRI and the Arab Centre for Studies of the Arid Zones and Dry Lands (ACSAD).

Begun in 1999, the project is implemented in Jordan, Lebanon, the Palestinian Authority and Syria. It seeks sustainable ways to conserve land races and wild relatives of species of global significance originating from this area including wheat, barley, lentil, onion, several annual forage legumes, olive, fig, pista-

Overgrazed rangeland in Hebron, Palestinian Territories.
Photo: ICARDA

chio, plum, and almond. In the past four years, the project has been able to assess the status of local agrobiodiversity and the factors leading to its degradation, and has demonstrated technological options for its preservation.

The project targets especially troubled areas in Palestine (Jenin and Al-Khalil) where its activities are carried out by the Ministry of Agriculture and the UNDP Programme of Assistance to Palestinian People (UNDP/PAPP). The project has helped in drafting national policy and legislation for agrobiodiversity conservation and is working with the Ministry of Education to include biodiversity conservation in the school curriculum (ICARDA 2002a).

In 2002 the project distributed more than 60,000 thyme (*Thyme vulgaris*), 6,000 Salvia (*Salvia divinorum*), and 12,000 chamomile (*Chamemilum nobile*; *Matricaria recutita*)seedlings to about 120 women farmers. In addition, over 1,200 seedlings of fruit trees were distributed in Sa'eer and Daheria. The project also established nurseries of important indigenous tree varieties that are tolerant to water stress, early-maturing, and economically profitable. These include local land race varieties of olives, figs, almonds, and apricots as well as a promising peach variety from Texas. Through the project, ICARDA repatriated 1,006 accessions of *Aegilops*, barley, durum wheat, primitive wheat, wild *Hordeum* and wild *Triticum* to Palestine for rebuilding their gene bank and for use in breeding.

Iraq also lies within the Fertile Crescent and has been a long-time research partner of ICARDA. Fearing the possibility of war, which did take place in 1991, Iraq's national program provided hundreds of genetic resource accessions to ICARDA in the 1990s for backup safekeeping in its gene bank. The number of accessions of Iraqi origin held in major gene banks outside Iraq is limited; the largest collection is at the USDA (1,113 accessions).

ICARDA holds 1,003 accessions spanning fifteen species and wild relatives. There are 403 accessions in the N. I. Vavilov Scientific Research Institute of Plant Genetic Resources in Russia. ICARDA has made three joint collection missions to Iraq over the last decade, and had re-supplied 1,501 accessions to Iraq for use in its crop improvement programs (ICARDA 2003b, p.28).

Safeguarding Vavilov's legacy

With the collapse of the Soviet Union in 1991, its scientific institutions were thrust into crisis. One of the priceless jewels was the Vavilov Institute, known to every plant breeder as the world's first gene bank, and one of the most extensive and valuable. The Vavilov Institute holds 380,000 accessions of 2,500 species in 19 experiment stations, six of them located outside of Russia.

One important station, known as the Central Asian Branch of the All-Union Research Institute of Plant Industry (CAB-VIR) is located near Botanica in the Kibrai district of Tashkent Region. It has been a focal point for collecting and safeguarding germplasm in the Central Asian region since 1965.

In 1988, ICARDA and CAB-VIR established a partnership that fostered germplasm and scientific exchanges. Following Uzbekistan's independence in 1991, this Branch was renamed as the Uzbek Research Institute of Plant Industry (UzRIPI). The newly-independent country

lacked the resources to adequately support this priceless gene bank; the world was in danger of losing an irreplaceable resource. Storage facilities, records, and the viability of plant accessions were deteriorating rapidly.

ICARDA helped UzRIPI computerize its data, which had previously all been hand-written. It co-organized (with IPGRI) a regional training course on conservation and use of plant genetic resources, emphasizing documentation skills. UzRIPI's current collection of over 35,000 accessions is much safer now as a result of improved documentation (Khalikulov et al. 2000).

ICARDA and UzRIPI also carried out joint collecting missions and evaluation of the new materials. ICARDA helped UzRIPI design upgrades of its seed storage facilities for longer, safer storage. And ICARDA is leveraging this relationship to broaden its collaboration on genetic resources conservation with other nearby countries (Street and Bounejmate 2000).

Recovering from the lost decade

During the 1980s, economic woes thrust many Latin American countries into recession and stagnation, contributing to unrest and conflict. It became difficult for governments to adequately support their national gene banks. Maize originated in Latin America, and vital maize land races throughout the region were at risk. Seed was losing its viability; duplication of gene bank holdings was difficult to afford, so there was little insurance against catastrophic losses. In 1992, CIMMYT helped to remedy this situation by collaborating with gene banks in 13 countries of Latin America to regenerate and share thousands of endangered maize seed collections.

The Latin America Maize Project (LAMP), which drew on support from USAID, USDA, and the private sector has enabled member countries to regenerate more than 10,500 accessions to date. Many of these no longer exist in farmers' fields, so LAMP rescued them from extinction. Their traits have been characterized and seed is available to the world. Duplicates of 7,000 collections are being conserved in CIMMYT's gene bank and at the US National Center for Genetic Resources Preservation. Born out of emergency, LAMP was so successful that it continues to function even today.

Adding value to biodiversity

Poverty can force people to exploit biodiversity to meet their immediate needs rather than protect it for the longer term. In other cases they may recognize no value from biodiversity and it may vanish from neglect, e.g. due to habitat loss. The CGIAR Centers are finding ways to create value from the sustainable management of biodiversity, so that communities will care for these precious resources for the longer term.

Lifting the Solomon Islands

The Solomon Islands have been deeply troubled by ethnic conflict in recent years. The people of Guadalcanal resented settlers from one of the other major provinces, the island of Malaita, who they saw as taking land and jobs from them. Fighting broke out in 1998 on Guadalcanal; about 20,000 people had to flee their homes and return to Malaita.

Thanks to the intervention of the Regional Assistance Mission to Solomon Islands (RAMSI), spearheaded by Australia and New Zealand, peace, hope and business confidence are returning to Solomon Islands. The challenge, however, is to create new livelihoods throughout the country, otherwise the civil unrest and insurgency may re-ignite. Through support from ACIAR, CIDA, the EU, NZAID and the Overseas Fishery Cooperation Foundation of Japan, the WorldFish Center has been developing small-scale aquatic enterprises that can help the poor lift themselves out of poverty.

Healing Wounds

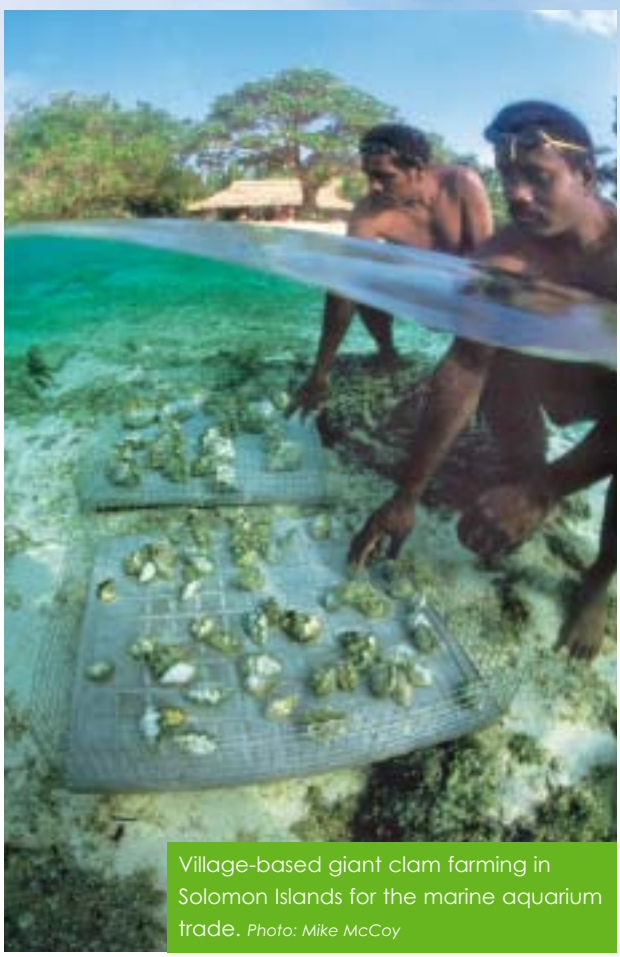
Farming black pearls is the second most important source of foreign exchange in French Polynesia and Cook Islands, a US$200 million per annum industry in French Polynesia. Over the past nine years, WorldFish has transferred the technology for catching and growing the blacklip pearl oyster from Polynesia to Solomon Islands. WorldFish has also operated a demonstration pearl farm to show that high quality black pearls can be produced in Solomon Islands at costs far lower than elsewhere in the region. The establishment of just one major pearl farm in the Western Province of Solomon Islands is expected to provide annual incomes of US$2,000 for at least 100 households.

Pearl farming—a promising new livelihood option in Solomon Islands. *Photo: Mike McCoy*

The tropical marine aquarium trade is a US$300 million per annum industry providing income for thousands of coastal dwellers across Asia, the Pacific and the Caribbean. Most of the colorful fish and invertebrate species are collected from coral reefs. Environmental groups are lobbying consumers to only buy fish from suppliers that use responsible practices, or who culture fish rather than collect them from reefs.

WorldFish has been working with the Department of Fisheries and Marine Resources in the Solomon Islands to find remunerative yet sustainable options to help the islanders benefit from their coral reef biodiversity. They have developed methods for sustainably farming giant clams and corals, and for the sustainable capture and culture of postlarvae of valuable aquarium fish and crustaceans for the aquarium trade. These methods provide farmers with more options and solidify their position at the high-value end of the international aquarium market, where consumers are willing to pay for environmentally responsible products. As villagers come to see the economic value of their biodiversity, they will be more motivated to protect and sustain it.

WorldFish is also working with local communities to add value to wild harvests of sea cucumbers, and to alert them to the dangers of overfishing. During the ethnic tension, when distribution networks for cocoa and copra were dismantled, collection of sea cucumbers, a commodity that can fetch a wholesale price of more than US$70 per kilo, was the only source of income for many coastal communities.



Village-based giant clam farming in Solomon Islands for the marine aquarium trade. *Photo: Mike McCoy*

The cultivation of marine crustaceans can provide the poor with a remunerative income. *Photo: Cathy Hair*

Coral farming in Solomon Islands, a new income-earning opportunity for villages to supply an environmentally-friendly product. *Photo: Jane Harris*

However, sea cucumbers are easy to harvest and stocks have been over-exploited. Also, in their desperation for cash, villagers do not always process sea cucumbers in ways that maximize their value. WorldFish is helping communities identify other livelihood options to allow stocks of sea cucumbers to recover to more productive levels; developing sustainable harvest practices such as catch limits; and training villagers in better processing methods so that they obtain higher prices.

Alternatives to poppy in Afghanistan

Following the departure of the Taliban regime, poppy production in Afghanistan has rebounded to levels that re-establish the country as a leading producer of opium for the illegal drug trade. Poppy earns approximately eight times more income than wheat per unit

Sea cucumbers are marine animals belonging to the phylum Echinodermata, which also encompasses sea urchins and sea stars. Many species of sea cucumbers are processed and traded as 'beche-de-mer' (dried body wall). They are a major source of food and income throughout the Indo-Pacific. *Photos: J-F Hamel & A Mercier (SEVE)*

land area. Farmers grow poppy to offset debt incurred by drought-inflicted losses of other crops. The high value of poppy allows farmers, particularly returning refugees, to raise capital to buy livestock and other inputs. If farmers have other ways to support their families, a transition out of poppy might be possible.

Expanded production of fruits, nuts, vegetables, food legumes, forages and feed grains can enhance farmer incomes in Afghanistan and support food, dairy, meat and hide industries. These alternative crops can create additional employment and market opportunities that the staple grain commodities are unable to provide.

Fruits and nuts hold considerable potential for improving the nutrition and incomes of farm households, and could provide an alternative to poppy cultivation. Efforts are underway through the Future Harvest Consortium to restore grape, fig, olive, pomegranate, almond, mulberry, apricot, peach, orange, lemon, and walnut cultivation.

Afghanistan's gene bank is being restored and local varieties are being evaluated. Afghanistan is the country of origin for over 60 varieties of almonds. There may be considerable value in protecting and developing these unique almond varieties for international markets.

Vegetable seed production at the six agricultural research stations rehabilitated by ICARDA and Future Harvest Consortium partners includes carrots, onions, turnips, tomatoes, and okra. The grain and legume crops at these stations include barley, new wheat varieties, faba bean, chickpea, and mung bean. Improved potato varieties and production practices being introduced by CIP are an important addition to the Afghan agricultural scene.

A new initiative is being launched to build partnerships all along the 'market chain' for high-value export crops that fit Afghanistan's competitive advantages. The Western Afghanistan Agribusiness Program (WAAP), a joint effort of Catholic Relief Services (CRS), ICRISAT and CIAT, funded through USAID's Rehabilitation of the Agricultural Markets Program (RAMP), aims to help small farmers in Herat Province ease their poverty without having to resort to poppy cultivation. WAAP is initially focusing on saffron and cumin. In the first year, gains in economies of scale and collective marketing are projected to increase farm incomes by about 25%.

In the second year, additional gains by connecting more effectively to export markets should rise to about 100% over what farmers are currently receiving from local traders. Based on what is learned, more crops will be added in the future.

Badakshan farmer extracts resin from poppies. Economic alternatives are being explored to replace poppy. *Photo: ICARDA*

Chapter 5

Rebuilding Human and Institutional Capacities

Rarely have so many opportunities and dangers been bound up in a single moment…Lasting peace and security depend on development that eliminates great disparities and great hardships, that binds societies together, and offers hope for the future.
—James Gustave Speth, UNDP, 1994

Human capacities take time to build, but the need for skilled agriculturalists is even more urgent in the aftermath of disasters or conflicts. In crises situations caused by conflict and natural disasters, the Centers realized that they needed to quickly re-establish capacities all the way to the farmer level, working closely with the private, NGO, and government sectors. They had to help save and restore local knowledge, and ensure that knowledge flows did not bypass women and refugees. They had to keep a continuous focus on the immediate bottom line—increasing food security—while also investing in people and institutions for the longer term.

Restoring the knowledge and expertise base

Rwanda

Tragically, the majority of scientists and technicians working in Rwanda's national agricultural research organization, ISAR (Institut des Sciences Agronomiques du Rwanda), were either killed or forced to flee the country during its genocide and civil war in 1994. A large numbers of women were left on their own as heads of households, responsible for all the traditional chores--raising children, fetching firewood, cooking--and now, the entire spectrum

Rebuilding Rwanda's potato research capacity. *Photo: CIP*

of farming as well. In addition to extensive looting of facilities and infrastructure, this devastated the accumulated knowledge and expertise base of the country. When the war ended, a huge, long-term challenge remained. Newly-recruited staff needed to regain the country's lost expertise and knowledge, along with the research materials and infrastructure.

Fortunately, more than a decade of partnership with CGIAR Centers had built up effective regional research networks that now stepped in to help the country recover (Bururchura et al. 2002). The Seeds of Hope (SOH) Initiative played a central role in helping Rwanda tap this reservoir of expertise, materials, and goodwill.

CGIAR Centers, NARS (National Agricultural Research Systems), and the crop commodity networks of the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) all contributed to helping the new Rwandan staff re-start many important research activities, and initiate new ones required to rebuild the country. Through SOH coordination and guidance, new Rwandan researchers gained skills in seed production, plant breeding, statistics, and methods for conducting socio-economic, on-farm, and participatory research, as well as technology dissemination.

ICRAF, for example had been working with Rwanda since 1987, but the changes wrought by genocide and war meant it had to start almost from scratch again in 1997, reshaping its priorities and approaches to fit new realities. It teamed up with national researchers and with NGOs, such as CARE and Trocaire, to launch a collaborative agroforestry program that has provided more than 30 internships. WARDA sent a team of scientists to train national partners on rice breeding, testing, and selection.

ICRAF focused on the masses of returning refugees that were being resettled in communities called '*umudugudu*' scattered throughout the country. It trained students, field technicians and lead farmers (including women) who had the responsibility to rehabilitate the land.

One of those *umudugudu* on a steep, eroded hillside in the Gishamvu commune, about 140 kilometers south of the capital, Kigali, serves as an example. It became home to 60 families, each allotted only a tiny 30 x 30 meter plot. The scene was lifeless, bare and depressing. Wind swept unchecked down the hillside and nothing grew but short grass, a sure sign of impoverished soils. With ICRAF's help, farmers soon began planting trees such as *Calliandra calothyrsus*, *Leucaena diversifolia*, *Grevillea robusta* and to protect and enhance soils and provide fodder, firewood, and plant support stakes for beans, a mainstay of the rural diet. Women traditionally gather fuelwood across Africa so they especially appreciated the fuelwood-producing attributes of agroforestry. Some have also begun cultivating orange, lemon, papaya and passion fruit trees to generate income, while others are producing avocado seedlings for sale.

Hundreds of Rwandan women have received training from the Agroforestry Research Network for East and Central Africa (AFRENA) through funding from the European Union, learning techniques such as grafting and mixing manure with soil. Much of the work is done through seven community-based nurseries that the project helped farmers establish around the country to provide a supply of tree seedlings.

Since human capacity takes a long time to build, many of these support activities continued for years after the war ended. These included follow-through visits to field sites where the re-established research agenda

was being implemented. The continuity provided by the CGIAR Centers and regional research networks has proved vital for reinforcing stability for the longer term.

Afghanistan

Decades of conflict and stagnation in Afghanistan devastated the knowledge and expertise base. Children were separated from the wisdom of their ancestors; professionals left to find jobs in other countries; and those that remained were isolated from peers and progress. Women were especially denied educational opportunities. As international agriculture advanced to meet the demands of the global marketplace, Afghanistan was left far behind.

Now, the central government and its institutions are struggling to gain the confidence of the Afghan people. ICARDA and other partners of the Future Harvest Consortium are upgrading the skills of Afghan researchers, including degree training. The immediate focus was to establish capacities to manage seed systems, identify superior crop varieties, improve soil, water, livestock, rangeland, and integrated pest management, operate and manage research stations, and to improve communications skills. More than 850 Afghan researchers, extension personnel and farmers had been trained by these partners by 2003.

Seed training course in Kabul, offered by ICARDA. *Photo: ICARDA*

Afghanistan's future. *Photo: ICARDA*

Restoring effective water management is seen by the Future Harvest Consortium as key to reinvigorating agricultural production in Afghanistan. More than 100 Afghans have already been trained in water management by Cornell University, the International Center for Biosaline Agriculture (ICBA), the Danish Committee for Aid to Afghan Refugees (DACAAR) and ICARDA. Candidates recommended by DACAAR will return to Afghanistan to be integrated into the agency's rebuilding strategy with an integrated agricultural development objective.

Practical and theoretical sessions of seed potato production training in Bamyan, Afghanistan, organized by CIP, ICARDA, and Solidarite, a French NGO, in August 2004. *Photos: ICARDA*

Potato has a special requirement for virus-free propagation. Clean seed is valuable because it greatly increases yields. The production of virus-free potato seed can be a business enterprise in itself. Training in virus-free seed multiplication has already been conducted for more than 725 Afghans in eight provinces by CIP. Ministry researchers and agronomists have been trained by CIMMYT at both in-country courses and in Turkey and Mexico.

Radio broadcast technology is a key tool for disseminating information across the vast, difficult and sometimes dangerous terrain of Afghanistan. Partly due to the low literacy rate, Afghans depend heavily on radio for information and their connection to other provinces and to the central government.

Through the Future Harvest Consortium and with Afghanistan's Ministry of Agriculture, ICARDA communications experts mounted a five-day workshop in Kabul on agricultural journalism. Radio reporters from 13 provinces visited agricultural research stations and leading farms. Journalism, interview and media production techniques were taught. Participants conducted interviews with agricultural experts and edited a three-minute story that was

recorded on CDs. At the conclusion of the workshop, the reporters were presented with 17 broadcast-ready programs to take back to their home radio stations. The programs, recorded in Dari and Pashto, were entitled "Dialogue in Agriculture." The workshop was a beginning, not an end; the mentoring relationship continues to this day.

Afghanistan's Minister of Agriculture (above, right) and farmers (left) being interviewed for a weekly farm radio program by a Future Harvest Consortium communication expert.

Photos: ICARDA

Iraq

Iraq is a very different case. It has long had a well-trained cadre of agricultural scientists, many with Ph.D. degrees from Europe and the USA. ICARDA trained over 350 Iraqis since collaboration began in the late 1970s. With the chaos of war and the disruption of institutions, this capacity has been scattered and immobilized.

A program called Agricultural Education and Development Project AHEAD), funded by USAID, has been launched to cover workshops, visiting scientists and graduate students. AusAID, through the Australian Center for International Agricultural Research (ACIAR), is considering to launch a three-year project (expected to start in April 2005) in partnership with ICARDA and the Iraqi Ministry of Agriculture to introduce and promote improved varieties of wheat, barley, and pulse and forage legumes among farmers in the dryland cropping regions of northern Iraq; identify, develop and promote improved agriculture systems suited to dryland farming in the country; and develop the capacity of Iraqi scientists to identify and evaluate potentially valuable germplasm and better crop/soil management technologies and promote their adoption by farmers.

With support from the Economic and Social Committee for West Asia of the United Nations (ESCWA), ICARDA has created a database of the expertise of Iraqi nationals around the world. Iraqi nationals can register to help research and development agencies find them for consultancies and full-time positions in Iraq.

Nile Valley and Red Sea countries

ICARDA has fostered a longstanding partnership (since 1979) with Egypt, Eritrea, Ethiopia, Sudan, and Yemen through the Nile Valley and Red Sea Regional Program (NVRSRP). The pioneer investor in NVRSRP was IFAD, later joined by IDRC, the Government of Egypt, the European Union, Italy and the World Bank. The Program has delivered major impacts in improving agricultural production and building human capacities for agricultural development in this troubled zone.

Ethiopia, Eritrea, and Sudan were part of an ICARDA-led study on seed security assessment in drought-prone areas conducted in 1996-1998 to find ways to mitigate food insecurity by restoring or maintaining the food production capacity of farmers in disaster-stricken environments.

With DFID support, ICARDA also created valuable new non-toxic types of grasspea (Lathyrus sativus), known as Gilban in Sudan and Egypt and Guaya in Ethiopia. Grasspea is an extremely hardy legume crop that is often the only edible plant left standing during the frequent droughts and conflicts that ravage the agriculture of this region. It contains a neurotoxin that does not cause harm in small quantities, but when eaten as the staple in the diet, as happens under these types of duress, it can cripple adults (especially males) or cause mental retardation and even death in young children.

Eritrea held great promise in the first five years after gaining independence from Ethiopia in 1993. But another devastating war in 1998 and prolonged drought conditions led to displacement and food insecurity for nearly two-thirds of its population. Since the end of the war in 2000, Eritrea has been trying to rebuild its economy and ensure food security for its 3.5 million people.

Through the NVRSRP, ICARDA is helping Eritrea re-establish agricultural research capacity and increase food production. Major areas of collaboration include disease control in cereals, promotion of conducive seed polices, and building the capacities of Eritrean scientists. For example, a joint seed security assessment in drought-prone areas conducted by ICARDA during 1996-98 led to a project, supported by BMZ/GTZ to raise the efficiency and effectiveness of seed delivery systems for small farmers in West Asia and North Africa. With DANIDA support, ICARDA is working with Eritrea's national agricultural research system on an integrated disease management strategy for cereals. Over the past 20 years, about 90 Eritrean scientists have received training at ICARDA.

An Eritrean researcher from the Department of Agricultural Research records a farmer's views about new barley varieties. *Photo: ICARDA*

Most will recall the terrible drought that hit the Horn of Africa in 1984/85 and filled television screens with images of mass starvation. Since that horror, agriculture in Sudan has improved considerably. Working closely with ICARDA to develop and test new cultivars and management practices, the country is now nearly self-sufficient in wheat and has significantly improved its production of faba bean and chickpea.

Since 1979, ICARDA has partnered with Sudan's Agricultural Research Corporation (ARC) in a wide spectrum of human resource development efforts, such as training, development of linkages, strengthening of facilities for on-farm and on-station research, and access to publications. As of 2003, ICARDA had provided training opportunities to over 400 researchers from Sudan in key areas of agricultural research, including biotechnology, geographical information systems and remote sensing, biometrics, information technology, and information management. Policy makers have also been involved through field visits and briefings on research results.

Cambodia

It would be difficult to imagine a more devastating loss of knowledge and expertise than what Cambodia experienced under the Khmer Rouge. The educated class was ruthlessly exterminated. Human resources for agricultural research were virtually nonexistent when the CIAP project (Cambodia-IRRI-Australia Project) began.

The Australia-supported CIAP project addressed these needs through close partnerships with NGOs and a practical, hands-on approach. Farmer resiliency proved remarkable as rice production rebounded quickly even in the face of severe infrastructure deficiencies and continuing security risks.

Sudanese researchers studying seed systems.
Photo: ICARDA

All told, the CIAP project trained more than 1,600 individuals through approximately 6,000 training opportunities, including 48 B.Sc. and 12 postgraduate degrees. The seeds of a new future had been sown; these trainees generated a wave of training impact. By 2000, CIAP alumni working within the Cambodian Agricultural Research and Development Institute (CARDI) had provided training events for another 35,000 individuals (Raab 2000). Many aid organizations working within Cambodia, such as FAO tapped this new resource to create major impacts through their own development initiatives.

Timor-Leste

Similarly in Timor-Leste, the challenge was to build a new government from scratch. A priority for the Seeds of Life team was to help develop technical capacities within the new Ministry of Agriculture, Fisheries and Forestry (MAFF). They focused on germplasm evaluation, seed production and seed distribution.

Nepal's Tuki

Ten million people in the central mid-hill area of Nepal depend on maize as their staple food crop, but armed insurgency hampers farmers, resulting in chronic shortages. Access to a formal seed sector is difficult, so CIMMYT and the Nepal Agricultural Research Council (NARC) with SDC support have been helping farmers' groups called '*Tuki*' organize their own seed production. A third of the *Tuki* are led by women. Women do most of the farming in the area on plots less than a hectare in size.

The *Tuki* both provide the seed and buy the grain harvested by members, coordinating its sale in the marketplace to ensure stable good prices. They also help members with agronomic and farm management advice and child education. CIMMYT ensures that the *Tuki* have access to the best modern varieties and seed production practices. *Tuki* seed producers receive 50-100% higher prices for seed than they would for grain, and obtain double or triple the average maize yields in the region. Household incomes and nutrition have increased substantially, providing a counterbalance against the insecurity that surrounds them.

Women play a key role in the *Tuki* of Nepal. *Photo: CIMMYT*

Rebuilding research infrastructure

Afghanistan

While the restoration of human capacities is paramount following disasters and conflicts, people need facilities and materials to work effectively. Afghanistan was virtually devoid of agricultural research and development infrastructure when the Taliban were removed. With financial support from USAID through the Future Harvest Consortium and working with staff from the Ministry of Agriculture and Livestock (MOAL), ICARDA and its Consortium partners including FAO, Iranian, Japanese, French and Italian groups have played a lead role in rebuilding six research stations in five Afghan provinces (Kabul, Baghlan, Kunduz, Takhar, and Nangarhar). These stations are now able to develop, test and multiply seed of new crop varieties for distribution throughout the region. Farmers and

Ruined station in Baghlan Province, Afghanistan. *Photo: ICARDA*

seed entrepreneurs visit the stations to select lines best adapted to their needs and learn better management practices.

Seed health and testing laboratories are being renovated at each station along with meteorological equipment to provide accurate weather data. According to the Code of Conduct for Seed agreed upon by the Consortium and the Government of Afghanistan, all seed imported into the country must meet good standards to be certified. The Badam Bagh station in Kabul is now fully equipped with seed health and quality testing facilities. It will serve as Afghanistan's national seed testing and seed health laboratory. These standards will foster safe national and global exchanges of seed.

Rwanda

In Rwanda, the Seeds of Hope project did not have sufficient financial resources to rebuild much of the agricultural infrastructure that had been lost during conflict, but subsequent donor investments greatly assisted the country with this need. SOH was able to help with some of the highest priorities such as the rehabilitation of a tissue culture laboratory at Ruhengeri, greenhouse facilities at Rubona, and a tree center in Ruhande, and the purchase of some second-hand vehicles and computers. ICRAF also helped rebuild a tree seed center at Butare, including both equipment and staffing.

Democratic Republic of Congo

Cassava, the Democratic Republic of Congo's most important staple crop, is vegetatively propagated so disease-free planting material must be used to avoid

Badam Bagh research station near Kabul before (above) and after refurbishing (below).
Photos: ICARDA

spreading pathogens. This requires careful phytosanitary procedures using sterile tissue culture facilities and processes that were disrupted by the country's devastating war. IITA is helping the Democratic Republic of Congo re-establish tissue culture facilities so it can introduce and multiply improved, disease-free clones. Seedlings to initiate the multiplication process are being supplied.

Reinvigorating the market chain

Inputs, services and markets are essential for a sustainable agricultural economy. Across the many rebuilding situations involving the CGIAR Centers, a top objective has been to get the private sector moving again—with special

emphasis on small-scale local entrepreneurism to ensure equitable, bottom-up development.

The refurbished agricultural stations in Afghanistan are serving as launching points for new village seed enterprises being encouraged by the Future Harvest Consortium. The seed testing laboratories being built by the Consortium are invaluable components to the creation of a commercialized seed potato industry. The Consortium members are working with farmers to develop a certification process that will be recognized by seed potato purchasers nationwide. This will create new markets for virus-free potato seed and build farmer confidence in the crop.

These enterprises will help introduce new crops and open new markets, accelerate crop improvement, facilitate information and technology exchanges, and create employment and learning opportunities for Afghan farmers and rural folk.

The tree nurseries established in Rwanda by ICRAF/AFRENA (Agroforestry Research Network for East and Central Africa), and those established by ICARDA/IPGRI/ UNDP/PAPP in the Palestinian Authority (both described in Chapter 4) have stimulated the emergence of small tree seedling enterprises. A wide range of tree species having different advantages enables these village entrepreneurs to meet diverse needs, such as fuelwood, plant staking material, soil fertility rehabilitation, and food production.

Seeds of Hope II in Central America also developed human capacities to launch small-scale seed enterprises. With help from DICTA (Directorate of Agricultural Science and Technology, Honduras) and INTA (Nicaraguan Institute of Agricultural Technology), courses were organized for 60 farmers and technicians from 17 collaborating institutions. The technicians in turn trained another 200 people, half of whom were farmers.

David Montes Romero, a farmer in Honduras said "Now, I know how to treat improved seed. And I've already begun sharing what I've learned with my community." César Romero, president of the Local Committee for Sustainable Development in the Watershed of the Tascalapa River said, "We no longer think about the present but about the future." He and other farmers have decided to form a microenterprise for bean and maize seed production.

Investing in human capacity is innately an act of optimism, because the payoff is long-term and difficult to precisely forecast. The threat of seeing it all washed away due to disaster and conflict has not deterred the CGIAR Centers. They have remained vigorous and innovative under some very difficult situations. It was not uncommon over the past quarter-century to meet scientists training at Centers while their home country had erupted in conflict—in some cases, rescuing them from possible torture and death, preserving a safety net for their country's agricultural future. By building regional and global networks, CGIAR Centers have nurtured a form of insurance that has helped countries recover from some of the worst nightmares that humankind has experienced.

Chapter 6

Reducing Vulnerability to Future Conflicts and Disasters

Natural hazards will always challenge us. But it is within our power to ensure that poverty does not turn hazards into unmanageable disasters.
—Kofi Annan, Secretary General, United Nations, Message on the International Day for Disaster Reduction, 2001

When disaster strikes, the immediate need for relief takes center stage. Yet many are realizing that constantly putting out fires is not the only, or even the best way to handle disasters and conflicts. A recent UNEP Workshop (UNEP 2003) engaging African subregional organizations, the United Nations, other international organizations, and experts in the field concluded that "disaster reduction management is better approached through pre-emptive measures--by prevention and preparedness--rather than by managing the emergency."

In Resolution 58/214 the United Nations predicates its International Strategy for Disaster Reduction by emphasizing that "disaster reduction, including reducing vulnerability to

Severe drought stress on maize in southern Africa. *Photo: CIMMYT*

natural disasters, is an important element that contributes to the achievement of sustainable development" and "recognizing the urgent need to further develop and make use of the existing scientific and technical knowledge to reduce vulnerability to natural disasters, and emphasizing the need for developing countries to have access to technology so as to tackle natural disasters effectively" (UN 2004). World Bank policies on disaster and conflict management now emphasize prevention and post-disaster recovery (World Bank 2004a, 2004b). USAID's Global Development Alliance is built on the strategy that connecting poor countries with market opportunities can spur sustainable development and counteract the hopelessness and instability that lead to conflict.

The CGIAR Centers understand how important long-term investments in vulnerability reduction and prevention are. In fact, disaster prevention provided the original impetus for the creation of the CGIAR System. Catastrophic famine in South Asia, which many thought would be inevitable by the early 1970s was averted when India and Pakistan doubled wheat production between 1966 and 1972. This was made possible by planting fertilizer-responsive, higher-yielding wheat varieties developed by the Rockefeller/Mexico wheat improvement program—the forerunner of the CGIAR. The achievement earned Norman Borlaug a Nobel Peace Prize in 1970 (Hanson et al. 1982).

This chapter describes how the CGIAR Centers have helped countries and regions strengthen their defenses against the risks of conflict and natural disaster; how they are helping the world prepare for the major looming disaster of global warming; and how they are applying strategic science and knowledge management to pre-empt such catastrophes.

Rebuilding nations, strengthening regions

Regional unity to combat drought and promote sustainable development in West Asia and North Africa

The West Asia-North Africa region is plagued by frequent drought crises (De-Pauw 2002). Since 1995, IFAD and the Arab Fund for Economic and Social Development have helped to integrate this zone in a regional approach to drought management. The Mashreq-Maghreb project led by ICARDA has taken an integrated approach to the problem including policy, institutional, and technological issues.

As part of this initiative, drought preparedness in West and North Africa was the subject of an international conference organized by ICARDA and IFPRI in 1998. Participants concluded that there was a vital need for better information and sharper definition of the most vulnerable areas, and for the establishment of holistic national drought management strategies and infrastructure. Emphasis was placed on the need for early-warning and monitoring systems, water resource development, diversification of land use, closer crop-livestock integration, mechanisms for efficient destocking and restocking of animal herds in drought emergencies, the judicious allocation of emergency feed, the examination of crop insurance options, support to community self-help measures, and actions to upgrade the earning capacity of low income people both on- and off-farm.

The pain of drought in the region is illustrated by the severe North African drought of 1994-95. It reduced Morocco's agricultural gross domestic product by 45%. In collaboration with the national program of Morocco, ICARDA demonstrated the potential of com-

puter-based crop growth models under environmental stress to aid in drought planning and response (ICARDA 2000). These models helped to identify times for sowing different crops, define strategies for supplemental irrigation of wheat, quantify the gap between potential crop yields and those currently achieved by farmers, and analyze environmental factors limiting crop production. A climate database was developed, along with a soil map covering most of the agriculturally-productive areas of Morocco. Morocco is now much better prepared to combat drought in the future.

A new future for Afghanistan

The CGIAR's assistance to alleviate the immediate food crisis in Afghanistan has already been described. Strategic longer term assistance focuses on building formal seed systems; soil and water management; livestock, feed, and rangeland improvement; and horticulture. A central objective is to involve Afghan partners closely to create ownership, strengthen their capabilities, and ensure that research priorities and products are appropriate to farmers' interests and means.

As in other rehabilitation settings, information can play a crucial role. Satellite remote sensing and GIS technology is being applied in Afghanistan by ICARDA and Michigan State University, a Future Harvest Consortium member, to assist in rangeland management. Landsat and MODIS images and existing GIS are used to determine and display grass cover, height, and total forage amounts in grass-dominant rangelands in the country. These maps help farmers direct their herds to optimum pastures and reduce overgrazing.

Resolving fundamental productivity problems in the Indo-Gangetic Plain

A vast swath across the Indo-Gangetic Plain of highly-populated South Asia depends on rice and wheat grown in rotation for its food supply. This area includes the troubled border area between India and Pakistan, where continuing low-level conflict has spread fear and insecurity. Nepal and Bangladesh have also endured their share of conflicts and disasters.

This zone had become a showcase for improved agricultural production, thanks to the new wheat and rice technologies introduced during the Green Revolution of the 1970s/80s. But in 1990, studies by IRRI and CIMMYT revealed some worrisome findings. Yields were leveling off or even beginning to decline, suggesting deterioration in the natural resource base under such intensive cropping. What was the cause, and how could it be fixed?

Several CGIAR Centers (ICRISAT, IWMI, and CIP, led by CIMMYT and IRRI) teamed up with these national partners to form the Rice-Wheat Consortium in 1994. Their work was made possible through support from the Asian Development Bank, the government of The Netherlands, the Department for International Development (United Kingdom), the International Fund for Agricultural Development, the United States Agency for International Development, the government of Japan, and the Australian Centre for International Agricultural Research.

The project is succeeding in finding ways to help farmers implement more sustain-

able practices. One approach is known as 'precision farming'—applying inputs only where they are needed, rather than blanketing entire fields with high rates of inputs. A simple leaf color chart is helping farmers determine whether they need to add nitrogen fertilizer, and at what rate. A study found that 175 farmers in India's Haryana State were cutting their fertilizer rates by up to 20%. Controlled-release and deeply-placed fertilizers have increased nutrient efficiency by another 30%. Reducing rates of input usage also saves big money—one of the main attractions that motivates farmers to change.

Other land-saving topics under study include salt and water balances; the cultivation of rice on raised beds; weed management in rice-wheat systems; crop diversification, including potatoes; and the introduction of legume crops into rice-wheat systems. Efforts to improve water use are also paying off. In some cases, water savings of up to 40% have been observed. Techniques such as cultivating rice on raised beds are contributing to these savings.

Long-term partnership pays off in Rwanda

Sometimes the rebuilding of nations is most successful when it begins in advance. Although the Rwandan genocide and civil war took the world by surprise, a decade of prior CGIAR and partner investment made a quick rebound possible (Buruchara et al. 2002). Through the Seeds of Hope project, this prior experience was quickly galvanized. CGIAR and regional network scientists knew about crop agrobiodiversity sources that Rwandan farmers valued, and where to find replacement seed when needed. Regional networks held the knowledge base acquired over years on germplasm characteristics, and were able to quickly restore it to the battered country. The restoration of human capacities in the NARS (National Agricultural Research Systems) succeeded more rapidly because of this steady, long-term approach to development.

Assessment of poverty in Mozambique

Mozambique was in turmoil from 1966 to 1992 due to its independence struggle and an ensuing civil war. It emerged from this long era of conflict as one of the poorest countries in the world. It held its first multi-party elections in 1994, and the new government realized that poverty reduction needed to be at the top of the new agenda. IFPRI was asked to assist the Ministry of Planning and Finance and Eduardo Mondlane University to develop Mozambique's first national poverty assessment and train Mozambican researchers in policy analysis.

The assessment found that almost 70% of Mozambicans lived below the poverty line in 1996-97, and were deprived in such vital areas as health, education, and food security (Simler et al. 2003). The research concluded that reducing poverty hinges on increasing educational levels, stimulating sustainable economic growth, raising agricultural productivity, improving rural infrastructure, and reducing the number of dependents in households through family planning.

These guideposts are invaluable for research and development priority-setting in Mozambique. They also provide valuable guidance for national policy development. By identifying the problems and priorities first, Mozambique has increased the likelihood and speed of a successful recovery.

Building a new Cambodia

The CIAP (Cambodia-IRRI-Australia Project) team knew it had to invest in rebuilding the knowledge base of Cambodian agriculture before it could design appropriate interventions. That knowledge base had been virtually

destroyed in the Khmer Rouge years. CIAP launched a number of baseline surveys and economic assessments. It also developed frameworks for farmer participation in gathering traditional knowledge before it was permanently lost (Raab 2000). This inclusive approach to the recovery and growth of national 'knowledge capital' was a farsighted investment.

This effort quickly paid dividends. When fertilizer aid to Cambodia from Eastern European countries stopped in 1990 with the fall of the Soviet Union, the new set of Western donors came to CIAP to ask for guidance in the types and amounts of fertilizer to provide to the country (Norris 2001). CIAP filled this crucial need at just the right time through technical advice to FAO which was coordinating fertilizer imports. By 1996, the country was strong enough that private sector fertilizer dealers were filling this need.

But the researchers did not stop there. They realized that accurate soil nutrient information was critical for economically efficient rice farming, yet there was no systematic information available on Cambodian soil nutrient status. So they launched a major survey of the nutrient management practices of 1,730 households across the country in 1993. It was followed up by a national workshop in 1995 to devise a new system for classifying rice soils in Cambodia. Broad participation was encouraged, including NGO staff as well as soil scientists, agronomists, land surveyors and other relevant experts.

The resultant Cambodian Agronomic Soil Classification was a landmark achievement that was widely disseminated through publications and followed up with training workshops. It became an important tool used by NGO and government technical staff in assessing rice soils and problems across the country, and a reference point for estimating the likely types and amounts of soil fertility-enhancing amendments that would be most effective in a particular location.

Similar efforts built invaluable knowledge and expertise in integrated pest management. CIAP studies established baseline data and developed means of communicating with farmers to understand their practices and their pest constraints (Jahn et al. 1999). By their nature, pest outbreaks tend to be unpredictable in countries that lack sufficient monitoring skills and tools. CIAP developed those tools and trained NGO and farmer practitioners, resulting in more effective control actions and avoiding dangerously inappropriate pesticides.

Community action is often needed since pest outbreaks need collective action to bring them under control, so this was a special focus of the socio-economic team of CIAP. Major cases included the control of rats (Cox and Mak 1999), rice bug, and army worm outbreaks (Norris 2001). CIAP also helped guide government policy on the control of dangerous and unnecessary pesticide imports.

Perhaps CIAP's most visible legacy will be its success in establishing institutional capacity at the national level. It helped create the Cambodian Agricultural Research and Development Institute (CARDI), inaugurated in November 2000. CARDI has developed into a first-class facility well-staffed by competent and motivated scientists trained largely through CIAP.

In addition to government institution-building, CIAP helped non-governmental organizations. While the government sector was being rebuilt, much of the agricultural extension load was carried by NGOs – estimated at 45% of total technical assistance in 1997 (Norris 2001). NGOs tend to have only local scope and short-term development goals, though. CIAP reinforced them with a broad blanket of training, information, and technical support. NGOs in turn provided CIAP with an 'ear to the ground', feeding back insights from farmer experiences at remote locations all over the country.

Rice production has already increased by 70% since the start of the CIAP program. Now agriculture is diversifying, and living conditions are improving steadily. The rice surpluses since 1995 have been sustained, even allowing the start of a small export trade.

Adapting crops to global warming

The looming threat of global warming can have unprecedented effects on agriculture. This is a major disaster in the making, unless steps are taken to prepare for it and reduce vulnerability. Since new technologies may take a decade or more to be developed, tested and reach the farm, the time to invest in research is now. A wide range of research related to this imperative is underway across the CGIAR Centers. Some selected examples illustrate the kinds of approaches being tried, and their potential.

What are the flies telling us?

Predictions of how global warming will affect integrated pest management are fraught with uncertainty as might be expected. Yet scientists agree that the current balance of insect populations is almost certain to be upset. Some insects react strongly to relatively small changes in temperature and rainfall. Their altered distribution could be one of the first indicators that global warming is taking hold.

Climate change will favor invaders over native species. Pests vulnerable to high temperatures may decline in numbers or move to higher latitudes or altitudes. There could be population explosions in species that respond to higher rainfall or drought by increasing their feeding and/or breeding behavior. New biotypes and species could evolve. Some bio-insecticides cannot tolerate increases in temperature and ultra-violet radiation. Some natural control mechanisms could "decouple" as the populations of pests and predators react differently to changes in rainfall and temperature. Changes in the populations of insect vectors of plant viral diseases may alter disease incidence. Climate could also induce changes in the incidence of fungal diseases.

This wide range of risks implies a need to improve capabilities for detection of early signs of changes in pest pressure. More effective communication with farmers is needed so researchers can learn from farmers' observations on their crops—and both parties can work together to handle problems as they arise.

In a case that might be an example of what to expect from global warming, CIP studied the causes behind the drastic decline in yield of sweetpotato in Peru's Cañete Valley following the El Niño weather phenomenon of 1997/98. Temperatures increased by 3 to 5 degrees while torrential downpours ravaged areas that had suffered from drought for more than a decade, causing an outbreak of harmful pests and diseases such as late blight.

One striking development was the spread of a more aggressive biotype of the whitefly, *Bemisia tabaci*. According to farmers, it arrived during the El Niño year when the climate in this area was hotter and drier than usual. But instead of disappearing when the

weather reverted to normal, the pest apparently adapted to its new environment, where it is now inflicting severe damage. Even worse, another whitefly species, B. afer, had also arrived in the valley. This species is even more aggressive than B. tabaci and is normally restricted to the hotter, drier climates of Africa; it had never been reported before in the Americas.

Models to predict change

Models are powerful tools for analyzing the effects of drought and the potential effects of climate change. They are being developed in several CGIAR Centers to help anticipate the effects of variables such as climate, management choices, and policy interventions. A process-based model for interpolating weather data in highland terrains, for example, has been created by CIP using data collected in Peru. A powerful integrated assessment tool known as the Tradeoff Decision Support System provides a framework for assessing interdependencies in diverse areas, including crop and livestock production, soil productivity, water quality, and human health. The Tradeoff DSS assists politicians, agricultural and environmental research planners, and development specialists in decision- and policy-making.

Joint modeling efforts by CIAT and ILRI suggest a potential 10% decline in maize production in developing countries due to global warming in the coming 50 years if no preventative or coping steps are taken. In southern Africa, CIMMYT coordinates the Risk Management Project, which combines crop modeling with participatory on-farm trial results to help farmers learn how to deal with variable rainfall over years and locations.

Improving the use of scarce water

In poor rainfed areas likely to increasingly suffer from drought due to global warming, farmers will need to use the limited amounts of water that are available more efficiently than ever before. More water will need to be channeled through the plant rather than lost as runoff or percolate down past the root zone. CGIAR Center research has shown that improving soil physical and nutrient conditions can remarkably increase water harvesting and storage in the soil, and make it more accessible by plants.

For example, research at ICARDA and ICRISAT has shown that many sub-tropical and tropical dryland soils are phosphorus-deficient. Correcting this deficiency by adding P fertilizer stimulates root growth, which helps the plants to exploit subsoil moisture reserves. It also hastens crop maturity, avoiding late-season drought. Both yield and yield stability are greatly improved.

Plant breeding for drought resistance

The impact of a current prolonged drought in southern Africa may be a taste of an unwelcome future. Southern Africa has been in the grip of a tenacious drought over the past several years. The subregion is highly dependent on maize for food, but maize requires ample moisture for good production.

Breeding research is making significant advances in increasing the drought tolerance of maize, particularly by reducing the anthesis-silking interval so that more seeds are able to successfully pollinate despite drought stress (Bänziger et al. 2000). This will reduce the risk of maize cultivation in areas where moisture is lim-

iting for the crop. Yields are reduced under drought stress but the new varieties show a 30-50% advantage over previously-grown varieties.

In the excitement over this accelerating impact, though, it is often forgotten that this breakthrough required more than 20 years of drought research by CIMMYT. This is yet another example of the counter-intuitive but important lesson that many emergencies are best handled through long-term investments in research and development.

Left: Maize ears produced under drough stress in southern Africa. Right: Ears of new drought-tolerant maize varieties are larger and have more grains reflecting better pollination. *Photo: CIMMYT*

More than 50 development agencies are accelerating the testing and distribution of the new varieties as part of the Southern African Drought and Low Soil Fertility Project. Cooperating organizations include the German Agency for Technical Cooperation, GTZ, which has decided to supply farmers exclusively with seed tested under project auspices. The initiative is funded by the Swiss Agency for Development and Cooperation (SDC), the Rockefeller Foundation, and the US Agency for International Development (USAID). By early 2004 the new varieties were being grown on an estimated 250,000 ha in southern Africa and 32,000 ha in eastern Africa.

In a similar vein, collaboration with Sudan and other countries involved in the Nile Valley and Red Sea Regional Program, ICARDA has established a Thermo-Tolerance Network to enhance wheat productivity by improving its adaptation to high temperatures.

Breeders will need to apply 'new science' to adapt crops to changing climatic conditions. Drought tolerance will be one of the most important traits. For example, carbon isotope discrimination may be able to identify more water-efficient plants, and its association with molecular markers could lead to more efficient selection for drought-adaptive features in durum wheat (Nachit 1998).

Breeders will break through species barriers in search of drought tolerance genes (Sorrells et al. 2000). Recent advances in GIS and satellite remote sensing have made it possible to associate the distribution of wild relatives of plants with their local climatic environment to spot likely sources of such genes. In one such case, data on 67 climatic and four soil variables generated for 391 germplasm collection sites in Syria successfully identified wild relatives of wheat adapted to drought (Valkoun 2002).

Wide crosses will move such genes into cultivated crop gene pools. Crosses with goat grass, a wild relative of wheat, have for example endowed new CIMMYT varieties with important drought tolerance traits. The new varieties have exhibited up to a 30% yield advantage under drought in two years' tests so far. They have spreading leaves that reduce evaporation of water from the soil surface so that more of the scanty moisture remains available to the plant. Seedlings of these varieties can also be planted deeper where there is more moisture, because they have greater vigor to push their way up through a thicker soil layer.

A drought-tolerant barley developed at ICARDA yielded more than 500 kg/ha under 200 mm annual rainfall at a dry site in Syria in 1999 and 2000, when other barley varieties completely failed. *Photo: ICARDA*

ICARDA, jointly with Syrian farmers, has developed an extremely drought-hardy barley line from a cross between a land race and a wild barley (*Hordeum spontaneum*) line from Palestine (Ceccarelli et al. 2004). It yielded over 500 kilograms per hectare in each of the severe drought years 1999 and 2000 while locally-grown varieties failed to yield anything. This was one of the driest periods in the zone in many decades, and might be a harbinger of things to come if global warming induces climatic change.

To poor farmers in this zone, harvesting 500 kilos means not being forced to sell off the family's livestock or not having to leave farming altogether. Farmers' observations of locally-specific adaptation to drought were key to identifying these super-hardy lines. ICARDA's farmer-participatory approach was catalyzed by support from BMZ/GTZ, IDRC of Canada, DANIDA, the Government of Italy, OPEC Fund and the World Bank; and sustained through the core contributions of the CGIAR Members.

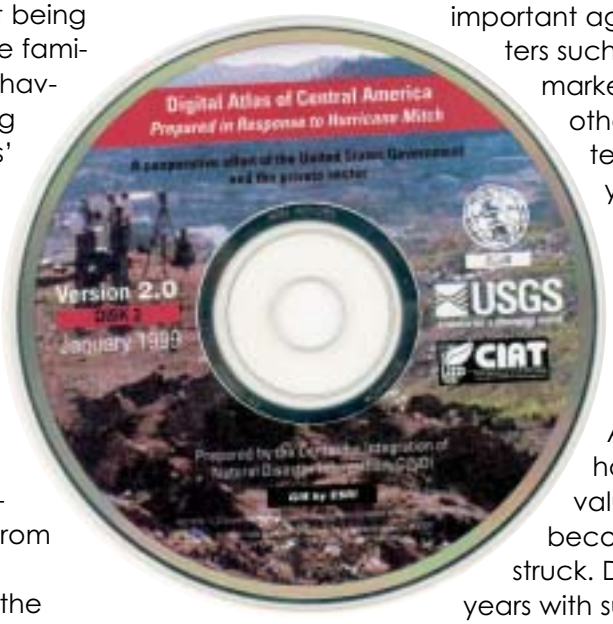
Biotechnology will make it possible to move drought tolerance genes across widely-separated species. Several Centers are attempting to transfer the DREB gene from the Arabidopsis plant into their mandate crops. The DREB gene, provided by JIRCAS (Japan International Research Center for Agricultural Sciences), appears to increase tolerance to drought, salinity, and freezing in some plant species.

Knowledge pays off

CGIAR Centers invest heavily in adding to the world's store of knowledge in ways that may only pay off many years into the future. But when it pays, it pays well. And sometimes the payoff comes sooner than expected.

Geographical information systems (GIS), for example, are vital modern tools for plotting the geographic distribution of important agricultural parameters such as crops, weather, markets, roads, and many other pertinent characteristics. This requires years of painstaking data collection and analysis.

The CIAT scientists who constructed a GIS map for Central America could not have imagined how valuable it would become when disaster struck. Developed over 4 years with support from the



The Mitch Atlas guided relief efforts following Central America's 'Hurricane of the Century'. *Photo: CIAT*

Swiss Agency for Development and Cooperation (SDC) and the Netherlands' Ecoregional Fund to Support Methodological Initiatives, it was perhaps the most comprehensive biophysical and socioeconomic database on Honduras ever compiled. Its formal release, accompanied by a training workshop, was in October 1998, just 3 weeks before Hurricane Mitch—the Storm of the Century—struck.

The database proved invaluable in helping aid agencies gather and integrate information to guide emergency measures. Within a week the GIS data had been matched with satellite images of the devastation. Other key information was quickly added, such as the geographical distribution of important crops, the location of key public and private institutions, and the sites of major drinking water sources. This created a series of maps that emergency workers used to target their assistance. For example, the Atlas ensured that the most needy farmers received seed aid of the right crop varieties for their local areas.

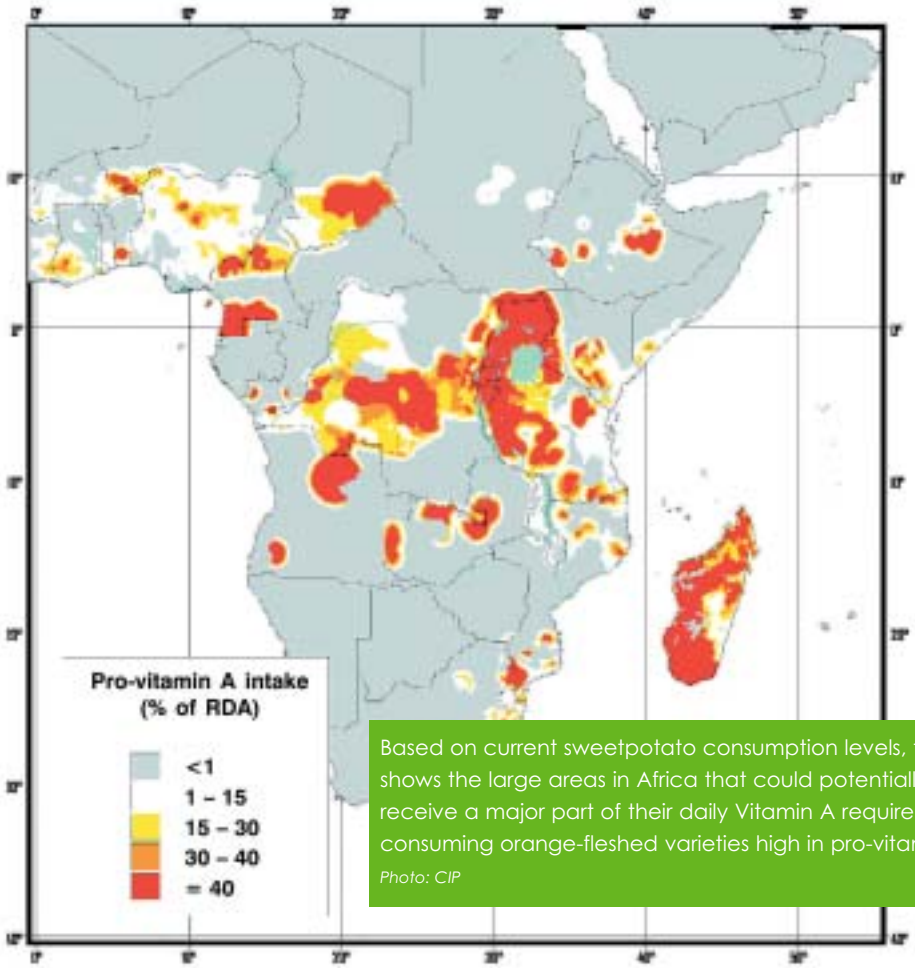
Attacking malnutrition at its roots

Public health agencies have in the past often addressed vitamin A deficiency by providing children with capsules of supplementary vitamin A. The strategy has helped millions but, for financial and logistical reasons, cannot reach everyone, especially the most marginalized and isolated poor. These programs are often interrupted when conflict or disaster strikes. Refugees crowded into camps for the displaced usually cannot access a diverse range of foods necessary for good nutrition, as for example in northern Uganda as discussed in Chapter 3. This is why CIP is working on the long-term challenge of increasing the vitamin A content of sweetpotato through its Vitamin A for Africa (VITAA) Partnership.

To succeed, VITAA had to develop an understanding of the magnitude of the problem, and the potential impacts of the solution. Scientists from the University of Michigan (USA) and CIP estimated that some 50 million children under the age of six stood to benefit. In conflict-prone countries such as Rwanda, Burundi, and Uganda—where sweetpotato production is already high—85 to 95% of the population most in need would receive the "full impact" level of 40% of the recommended daily allowance. Even in countries such as Ethiopia, which is not a major sweetpotato producer, about 30% of the at-risk population would enjoy partial benefits.

Conventional wisdom held that African consumers would not accept orange-fleshed sweetpotato because of its relative moistness and sweetness compared to the drier, white-fleshed types that they were used to. But a study conducted by researchers from CIP and from the International Center for Research on Women (ICRW), a VITAA partner, demonstrated that African women readily accepted orange-fleshed varieties if they were sufficiently high in starch and low in fiber, and when they were introduced through community-level education programs focusing on the health of young children.

Orange-fleshed sweetpotato is high in beta carotene. The body uses beta carotene to synthesize vitamin A. Questions have been raised, though, about the efficiency of this conversion and stability during cooking. Efficacy studies are being carried out by South Africa's Medical and Agricultural Research Councils (MRC-ARC) in coordination with the University of Wisconsin and CIP. In the first study, involving primary school students in a rural area of KwaZulu-Natal Province, daily consumption of 125 grams of boiled sweetpotato contributed nearly 250% of the recommended daily allowance of vitamin A for 4- to 8-year-old children (van Jaarsveld et al. 2003a). In a complementary retention study, MRC-ARC researchers demonstrated that sweetpotato retained 70 to 90% of its beta-



Based on current sweetpotato consumption levels, this map shows the large areas in Africa that could potentially receive a major part of their daily Vitamin A requirement by consuming orange-fleshed varieties high in pro-vitamin A.
Photo: CIP

carotene when boiled (van Jaarsveld et al. 2003b).

To be sustainable, orange-fleshed sweetpotato must attract the interest of rural agro-enterprises so that inputs, markets and other necessary supplies and services become available. VITAA partner organizations are involved in commercializing the new varieties towards this end. In 2002, VITAA's initiative led to the release of a highly nutritious porridge by the Maganjo Millers, a local food processor. The new high-protein, high-beta-carotene product, known as Nutri-Porridge, is made from a combination of orange-fleshed sweetpotato, maize, and peanuts. It is reportedly outselling all of its competitors on the Kampala market and is in high demand. Researchers working for the commercial feed companies UGACHICK and NUVITA in Uganda conducted studies to determine the value of orange-fleshed sweetpotato in commercial animal feeds.

The VITAA case is a particularly compelling example of a growing range of 'biofortification' research being conducted across the CGIAR Centers. A new cross-Center Challenge Programme focused on the topic will pool resources and share expertise across crops. This long-term approach will no doubt pay off in many a future emergency situation.

Fighting Drought-Related Paralysis in Ethiopia

Although the drought-caused famine of 1984-85 in Ethiopia remains well known, the country has suffered less serious but significant droughts in 1987, 1988, 1991-92, 1993-94, 1999, and 2002. When drought hits, all crops fail except one—grass pea (*Lathyrus sativus*). The survival of the poor, therefore, depends on this crop. While harmless to humans in small quantities, a steady diet of grass pea seeds over about a three-month period can cause a neurological disorder that frequently results in irreversible paralysis of the leg muscles. This is because the grass pea seeds, although tasty and rich in protein, contain a neurotoxin called β-N-oxalyl-L-α-B-diaminopropionic acid (B-ODAP). The disorder caused by this neurotoxin has several names, including paraparesis, lathyrism, and neurolathyrism. Under certain conditions, eating grass pea can lead to retardation and death in young children. The African grass pea types contain 0.7% or more of this neurotoxin, much higher than the safe levels (below 0.2%) for human consumption.

A victim of lathyrism in Ethiopia.
Photo: ICARDA

Thousands of people who frequently confront drought and crop failures in Ethiopia face permanent paralysis of the legs from eating grass pea. The poor people know the effects of eating grass pea but live under such desperate conditions that they have no other option but to eat it.

A legume crop—part of the family to which peas and beans belong—grass pea is also grown in Bangladesh, China, India, Nepal, and Pakistan. It is similar in appearance to mung bean, with small green seed.

Researchers at ICARDA recently harvested the first grass pea lines that can be eaten without fear of paralysis. This was accomplished by crossing grass pea from the Middle East—many of which have naturally low toxin levels (average about 0.1%)--with African and Asian varieties. The new ICARDA hybrids contain between 0.02% and 0.04% of neurotoxin, and are perfectly safe for human consumption.

To accomplish that objective, the scientists used a technique known as somaclonal variation to force the plant to mutate and to express genes that were formerly dormant. Among these dormant genes were the genetic codes that controlled the plant's neurotoxins. ICARDA's improved grass pea lines produce 1.5 tons of seed per hectare even with less than 200 mm (8 inches) of rainfall.

ICARDA scientists are now training researchers from Ethiopia and other affected areas to develop locally adapted selections and to begin seed production of the improved varieties.

Funding for ICARDA's grass pea research was provided by DFID.

New, low-neurotoxin grass pea lines developed by ICARDA, safe for human consumption, are now being shared with Ethiopian researchers for testing and release. These lines will both prevent the occurrence of lathyrism and help in fighting drought.
Photo: ICARDA

Chapter 7

Helping Aid Organizations Become More Effective and Efficient

"...investment in the CGIAR has been the single most effective use of official development assistance, bar none. There can be no long-term agenda for eradicating poverty, ending hunger, and ensuring sustainable food security without the CGIAR."
—Report of the Third System Review of the CGIAR

The involvement of CGIAR Centers in rebuilding agriculture in countries affected by conflicts and disasters adds an analytical dimension that can benefit aid organizations. Lessons can be learned from research that helps partners improve each time they tackle a new emergency. This chapter discusses some major lessons learned so far.

Action rooted in understanding

Emergencies require quick action, but too often that action exemplifies Benjamin Franklin's warning that 'haste makes waste'. By building an understanding of the dynamics behind conflict and disaster, aid agencies can be better prepared to act quickly and appropriately. Research can help provide this important baseline knowledge.

Better livestock and health care can play a significant role in sustaining the pastoral way of life. *Photo: ILRI*

The Horn of Africa

Several of the world's poorest, driest, most conflict- and disaster-prone countries are located in the Horn of Africa. This zone is home to societies in transition as well as in turmoil. Traditional pastoralism is under pressure as populations increase and other activities compete for land use, such as urbanization and roads, crop agriculture, communal grazing ranches and wildlife reserves. Greatly aggravating these factors is the increasing frequency of drought. As the drought intervals shorten, pastoralists are squeezed ever tighter. They do not have time to recover and prepare before the next crisis strikes, suffering more each time as they scale down the poverty ladder.

Much relief aid has been provided during and after the frequent crises that hit this zone, but they have tended to be of a simple 'handout' nature that fosters a culture of dependency rather than development (Ndikumana et al. 2002). Seeking to break this pattern, USAID's Office for Disaster Assistance (USAID/OFDA) has been supporting a project appropriately entitled 'Crises Mitigation in Livestock Systems: From Relief to Development' executed by the ASARECA Animal Agriculture Research Network (A-AARNET) and the International Livestock Research Institute (ILRI). USAID is looking to this research-led initiative to place their assistance model for the zone on a more effective long-term trajectory of sustainable development.

The series of studies began by seeking a better understanding of how pastoralists and agro-pastoralists in the Horn of Africa perceive, prepare for, cope with, and recover from drought, animal disease and related disasters. The peoples of this zone are highly dependent on livestock, which provide 20-30% of GDP and up to 70% of the income of typical rural inhabitants.

In a survey of critical areas along the Ethiopia-Somalia border the team began by applying Geographic Information Systems (GIS) technology to construct a detailed picture of the infrastructural, relief-resource, security, and food-security conditions of the zone (Ndikumana et al. 2002). They focused the study further through participatory interaction with pastoralists to understand the social and bio-physical constraints.

They learned how sales of livestock forced by drought can erase years of hard work, because prices tend to drop at these times as large numbers of simultaneous sellers create a situation of distress sales. Migrating herds and herders are plagued by livestock rustling and general insecurity, shortage of human food, and water and pasture for livestock, and occurrence of livestock diseases. Pastoralists traditionally reserve some lands for grazing during drought, but the practice is becoming more difficult as land pressure increases. Even where grazing reserves exist, the movement of herds past the obstacles posed by other land uses (roads, urban areas, farms, nature reserves etc.) is often difficult. Exhausted and malnourished livestock easily fall prey to diseases. During the 1995-97 drought, one-third to one-half of all cattle died across many pastoral communities of southern Ethiopia and northern Kenya (Ndikumana et al. 2002).

Participatory surveys uncover the dynamics of livestock management in the Horn of Africa. *Photo: ILRI*

In a second survey carried out with the additional partnership of USAID's Global Livestock Collaborative Research Support Programme (GL-CRSP) Livestock Early Warning Systems (LEWS), the team focused on how pastoralists traditionally identify the onset of drought, and how they prepare for and cope with it. By building on pastoralists' indigenous knowledge and systems they are comfortable with, the project intends to overcome the limitations of past approaches that imposed solutions from outside that were often not appropriate.

From the rich baseline of information gained through these studies, the A-AARNET/ILRI/LEWS partnership has developed a number of specific recommendations for USAID/OFDA action that could make relief aid more effective than in the past:

- Implement early-warning systems that complement traditional knowledge with scientific meteorological tools.
- Stem the degradation of rangelands through herd size management, employing new policies devised and implemented in partnership with local institutions.
- Improve animal health services and monitor potential epidemic risks.
- Improve dry-season fodder supplies through better agronomic practices in the riverine areas, including improved water management and harvesting.
- Assist in the transition to agro-pastoralism by providing improved cropping technologies, knowledge and skills.
- Diversify livelihoods to include horticultural and non-agricultural options, such as gum tree cultivation, incense production, salt collection, meat, milk and dairy product microenterprises, petty trade and handicrafts, often implemented through micro-credit.
- Improve human health and nutrition, including better prenatal and birth care, child immunization, malaria prevention and treatment, and supplementation of diets with Vitamin A.

USAID/OFDA's progressive vision of evolving from an emergency aid to a sustainable development approach in the Horn of Africa is taking concrete shape through knowledge generated from thorough systems research carried out by ILRI in partnership with ASARECA and others. As this knowledge is implemented, pastoral communities that have in the past been passive recipients of aid handouts will find that the international community has changed its approach to one that empowers them to reduce their own vulnerability by building on their indigenous knowledge, skills and resilience.

Burundi

Burundi, a small and crowded country, has been embroiled in an ethnic civil war for the last decade. Adjusting to the scarcity of farmland, farmers have a long tradition of mixed farming, integrating livestock such as goats and dairy cows with crops. In addition to food and income, animals provide vital manure for maintaining soil fertility for the crops.

Livestock systems in Burundi have been decimated by the conflict. A large proportion of animals perished from disease, starvation and slaughter for emergency food needs. This has shattered one of the underpinnings of sustainable agricultural livelihoods in the country.

As a consequence, A-AARNET and Relief International initiated a project on

restocking of small ruminants in two zones highly affected by the civil war. It was implemented by these two partners in collaboration with the Ministry of Agriculture and the Institut des Sciences Agronomiques du Burundi (ISABU). The impacts of these efforts were subsequently investigated by A-AARNET, which is coordinated by ILRI.

Beset by infrastructural, economic and psychological scars from the war, farmers had become accustomed to passively accepting free donations of animals from donors. Many donated animals were sold to meet emergency food and income needs rather than being used to rebuild herds. Since farmers needed to sell at any price, this perpetuated the cycle of poverty. Aid donors often bought animals for restocking from the same merchant channels, creating an illusion of re-stocking versus a reality of recycling the same animals—with merchants as the main beneficiaries. Collective action by farmers to bypass merchants was made difficult by the breakdown of farmer organizations due to mutual mistrust in the wake of the civil war. The collapse of the animal health sector also contributed to poor survival of re-stocked animals.

These findings led AARNET-ILRI to recommend ways to make re-stocking aid more effective in the future (de Treville 2000). Veterinary services, medicines, good breeding stock and other essential foundations need to be integrated with re-stocking activities. Herds need to be upgraded through careful breeding and better health care. This requires cooperation and interaction among farmer groups, government institutions, and foreign aid providers.

The size and condition of cattle reflect the stress of many challenges faced by herders in East Africa, including drought, insufficient feed sources, encroaching land settlements, and rustling. *Photo: ILRI*

In order to achieve this, farmer groups need to be strengthened. This will also give them power in the marketplace as they share demand/price information and take control over their marketing channels. Such associations will also become conduits for the exchange of inputs, knowledge and techniques for improving herds and for gaining added value from the sale of better-quality by-products such as skins and dairy products.

Donors need to know when their well-intentioned gifts are failing to achieve their desired result or even becoming counterproductive to agricultural development. The case of Burundi illustrates how research into the dynamics of aid processes can identify serious problems and help steer future aid into more effective directions.

The power of diagnostics

Seeds of Hope

It is important that aid interventions properly diagnose the problems and needs of communities under stress from natural disasters and conflicts. From the beginning, the Seeds of Hope (SOH) Initiative implemented a continuous diagnostic process in parallel with its emergency aid actions. These diagnostics provided the guidelines to keep aid activities on track and productive.

The diagnostics measured and monitored the quickly changing seed situation on the ground; evaluated activities soon after they were carried out (such as seed distributions); and guided the next steps on the action

agenda. Providing technical advice to aid agency staff, NARS and NGOs, the researchers' experience helped the aid agencies find sources of needed seed in nearby countries or in distant gene banks; establish conditions for its quick and effective multiplication; and target it to the right environments and to the areas within Rwanda.

The diagnostics helped SOH participants understand the nature, causes and effects of seed aid on farmer welfare and on biodiversity. SOH analyzed whether the aid seed was sown, whether it was adapted to the environment and valued by farmers, and whether and how the seeds were incorporated into farmers' continuing operations in subsequent seasons.

For example, the diagnostics found that good seed of basic food crops continued to be available through local markets despite the war. There were two main reasons for this. First, this war was brutal but relatively short, and shifted among different locations around the country, so that damage was localized and a good portion of the crops in the field could be harvested. Second, a relatively quick restoration of political stability after the war gave farmers confidence to replant their own diverse seeds quickly and, equally important, made it possible for people to come together to buy and sell their seed in their community settings. Such conditions will not always pertain in other conflicts, but where they do, these lessons imply important choices of action (Sperling 1997; Sperling and Cooper 2003). Third, food aid provided by international donors helped farm families avoid having to resort to eating their seed (Sperling 1996).

An important finding from these diagnostics was that while good seed of basic food crops remained available despite warfare, many could not afford to buy it. In other words, the problem was one of access, not availability. Poverty was severe in Rwanda before the war but was exacerbated by the conflict, with those on the lowest rungs of society suffering the most.

The lesson from this experience was that rather than giving away free seed, aid monies in such a situation might be better invested in bolstering local seed systems. One innovative way of doing this, pioneered by Catholic Relief Services, is to provide the needy with seed vouchers to purchase the seed locally that they need and want (Sperling and Cooper 2003). NGOs can organize seed fairs where buyers and sellers meet and vouchers are accepted, providing one-stop access to a wide range of diversity while ensuring that the vouchers are applied to the intended purpose of seed relief.

A third major finding from the diagnostics was that, in contrast to the resilient supply of seed of basic food crops, seed of new cash-generating crops and of new varieties such as potato and the new climbing bean types was seriously impeded by the conflict. Such new enterprises are key to longer term agricultural growth and poverty reduction in the smallholder sector. These new materials and the young industries supporting them were still being nurtured by the state sector and international agencies. Since these agencies and their infrastructure were hard hit or could not function effectively during the war, the flow of these newer types of seed dried up, along with the inputs needed to cultivate them.

This illustrates the need to target aid differently for different crop and variety sectors. Intervention to help fledgling new-crop enterprises would be appropriate to prevent major setbacks in agricultural growth and development. Such interventions could include seed and input supplies, infrastructure and training—perhaps carried on in neighboring countries as long as the conflict rages, followed by transfer into the country as soon as possible.

Lessons learned from diagnostic research during emergency aid operations can make seed aid more effective and efficient in the future. These gains probably more than compensate for the relatively small cost of including a research component within aid operations.

Afghanistan

The power of diagnostics is well illustrated by the needs assessments carried out by the Future Harvest Consortium in post-Taliban Afghanistan. They covered four main areas: soil and water management; livestock and rangelands; seed systems and crop improvement; and horticulture. Armed only with penetrating questionnaires, survey teams visited every province, talking to thousands of farmers. When asked if Afghan farmers were reticent or suspicious about the questions, Joachim Mueller, a survey team member said, "After a short period and with the aid of abundant tea, in all cases we achieved good participation."

The hard-won needs assessments data were studied at a workshop held at ICARDA in 2002 by representatives from the Afghanistan Ministry of Agriculture and Livestock (MOAL), United States universities, NGOs, FAO, the private sector, and participating CGIAR Centers.

The soil and water needs assessment identified potential for expanding irrigated crop land. Afghan farmers need more information on effective management of water resources and use of fertilizer, which dropped off precipitously in the 1980s. The greatest constraints listed by the soil and water assessment team were the lack of credit for farmers, nutrient deficiency, seeds, and water (ICARDA 2002b). The farmers expressed great concern over locusts, which did plague their crops in the following growing season.

The crop improvement and seed survey report stated that in normal times Afghan households were able to produce about 86% of their food needs, but drought had caused considerable shortfalls recently (ICARDA 2002c). Debt insecurity averaged about US$800 per household with very little capacity for repayment. Increased crop productivity at the household level could considerably reduce rural poverty and hunger (Kugbei 2004). The survey identified that improving farmers' access to irrigation water, quality seed of crop varieties, and fertilizer was of utmost importance.

Afghan farmers participating in the livestock and rangelands needs assessment. *Photo: ICARDA*

The assessment report also stated that the focus in seed should be on quality enhancement and not on quantity, since households meet a high proportion of their seed needs from sources within their communities including own production and other farmers. Alternative seed systems should be developed within these communities to produce high quality seed and make it available to local farmers.

The livestock, feed and rangelands assessment recommended six project ideas with potential for short- and long-term impact. The ideas include institutional strengthening/human capacity building; improving dairy production; integrated small-ruminant production; integrated animal health management; animal power for tillage and transport; and village women's poultry production. Development assistance should help restore marketing structures and encourage the export of goods such as carpets, for which Afghanistan has a comparative advantage (Thomson et al. 2003).

The horticulture and marketing assessment pointed out that in the past, horticulture provided 30-50% of Afghanistan's export earnings and presents the best potential for replacing poppy production. However, global competition is increasing for traditional Afghan horticultural crops and global preferences are also changing, rendering many of the Afghan cultivars and practices less competitive. The rebuilding of the country's horticulture will provide a critical source of nutrients, employment opportunities, and significant income at the farm level and foreign exchange at the national level.

The report's recommendations included conserving existing genetic resources; conducting a market analysis to identify trade opportunities and establish the framework for a viable, horticultural sector; and developing human resource programs as well as programs to enhance horticultural production capacity, quality, and postharvest handling systems (ICARDA 2003c).

The Afghanistan case shows how the power of diagnostics, leveraging CGIAR Center expertise, can help aid agencies identify key development needs in a quick, focused, and practical way.

Aid made smart and targeted

Research and development need not occur separately or sequentially. The Seeds of Hope (SOH) project crossed conventional institutional divides to show that a blend of these elements can deliver 'smart aid'.

Aid agencies had in past emergencies typically relied on massive seed shipments from abroad, often of insufficiently-tested, maladapted varieties. SOH helped them understand how risky this was, and the damage that could follow when farmers' seed stocks are replaced by varieties that are not resistant to local diseases, pests and stresses or suited to local market demands.

Rather than the one-size-fits-all approach, SOH identified and multiplied many local and improved varieties, and provided seed to just those areas where it was adapted and needed. Since the conflict shifted to different parts of the country over time, SOH partners participated in regular weekly seed meetings

so that researchers, donor agencies and NGOs could share information on seed needs and priorities. This knowledge was documented in technical bulletins summarizing critical issues and recommended actions.

Donors carried this lesson forward to the Greater Horn of Africa. They had become concerned about the effectiveness of traditional emergency seed relief operations and the dependency that 'free giveaways' appeared to be creating there. They asked ICRISAT to assess the situation and provide recommendations. With USAID Office of Foreign Disaster Assistance and European Union support, ICRISAT partnered with Catholic Relief Services and ODI to investigate seed relief cases in southern Sudan, northern Uganda, Somalia, and later in Mozambique. USAID/OFDA also funded CIAT (partnering with CRS, CARE and a range of African NARS) to compare and contrast different kinds of seed aid interventions in seven African countries, as well as to develop better Seed System Security Assessment (SSSA) tools in order to prepare an appropriate relief and recovery response from the beginning.

In all cases, the researchers were impressed by the resilience of traditional seed systems compared to the formal sector (Sperling and Longley 2002). They concluded that seed donations, albeit well intentioned, could be destructive in the medium and long term because they tended to compete with the farmers' traditional seed exchanges. They recommended that focus be shifted towards strengthening local seed systems so they could supply seed during tough times, rewarding local seed producers rather than displacing them (Jones et al. 2002; Longley et al. 2001). To ensure that the poor also benefit from growth opportunities, local seed systems should also link to the formal seed sector in appropriate ways (Rohrbach and Kiala 2000).

This lesson had to be re-learned, though, following the devastating flood of February 2000 in Mozambique. The government became concerned that the repeated distribution of free seed was undermining the development of the seed trade, and as a result was pleased when ICRISAT proposed to undertake research to test alternative seed interventions. Mozambique is now implementing the Seed Fair approach (see next section) and is supporting ICRISAT to institutionalize a seed needs assessment methodology developed under the project (Longley et al. 2002). These investigations are also being extended to Zimbabwe through support from DFID and FAO.

These cases show how research can make relief smarter, better-targeted, and less likely to cause unintended negative consequences. By helping steer aid along the most appropriate and effective course, research can make all the difference in project success.

References

Bänziger, M., Mugo, S. and Edmeades, G. O. 2000. Breeding for drought tolerance in tropical maize–conventional approaches and challenges to molecular approaches. Pp. 69-72 in Ribaut, J. M. and Poland, D. (eds.), Molecular Approaches for the Genetic Improvement of Cereals for Stable Production in Water-Limited Environments. A Strategic Planning Workshop held at CIMMYT, El Batan, Mexico, 21-25 June 1999. Mexico D.F.: International Center for Maize and Wheat Improvement.

Beniwal, S.P.S. and Varma, S. 2000. Transforming agriculture in Central Asia and the Caucasus. ICARDA Caravan 13:8-11. Aleppo, Syria: International Center for Agricultural Research in the Dry Areas.

Brennan, J. P., Aw-Hassan, A. and Nordblom, T. 2003. Influence of spillovers to Australia on impacts of the International Center for Agricultural Research in the Dry Areas. Food Policy 28:471-485.

Brown, M. E. (ed.) 1996. The International Dimensions of Internal Conflict. London: MIT Press.

Brundtland Commission, 1987. Our Common Future. Oxford: Oxford University Press, for World Commission on Environment and Sustainable Development.

Buruchara, R.A., Sperling, L., Ewell, P. and Kirkby, R. A. 2002. The role of research institutions in seed-related disaster relief: Seeds of Hope experiences in Rwanda. Disasters (United Kingdom) 26(4):288-301.

Carter, Jimmy 1999. First Step Towards Peace is Eradicating Hunger. New York: International Herald Tribune. Thursday June 17, 1999. http://www.futureharvest.org/news/jimmycarter.shtml

Ceccarelli, S., Grando, S., Baum, M. and Udupa, S. M. 2004. Breeding for drought resistance in a changing climate. In S.C. Rao and J. Ryan (eds.), Challenges and Strategies for Dryland Agriculture. CSSA Spec. Publ. 32. Madison, Wisconsin USA: American Society of Agronomy and Crop Science Society of America.

Coghlan, A. 2003. Heatwave's warning for the future of farming. New Scientist 179 (2409, 23 August): 5.

Collier, P. and Hoeffler, A. 1998. On economic consequences of civil war. Oxford Economic Papers 50: 563-573. Oxford: Oxford University Press.

Collier, P. 1999. On the economic consequences of civil war. Oxford Economic Papers 51: 168-183. Oxford: Oxford University Press.

Collis, B. 2002. Rebuilding Cambodia's killing fields. Rice Today 1 (1):14-19. Los Baños, The Philippines: International Rice Research Institute.

Cox, P. G. and Mak, S. 1999. Participatory farmer research for the management of rats in Cambodia. In Cambodian Journal of Agriculture 2(1). Phnom Penh: Cambodian Society of Agriculture.

Delaney , P., Kaul, A. and Miller, C. 2003. Weathering natural disasters—refocusing relief and development through improved agricultural and environmental practices. Washington DC: Future Harvest Foundation and Care. http://www.futureharvest.org/pdf/Weathering_Nat_Disas1.pdf

De-Pauw, E. 2002. Drought in WANA: Six frequently asked questions. ICARDA Caravan 17:6-10. Aleppo, Syria: International Center for Agricultural Research in the Dry Areas.

de Soysa, I. and Gleditsch, N. P. 1999. To cultivate peace—agriculture in a world of conflict. PRIO Report 1/99. Oslo: International Peace Research Institute.

de Treville, D. 2000. The role of restocking in crisis mitigation—the case of Burundi. Draft final report submitted to AARNET-ILRI by Relief International-Burundi. Addis Ababa, Ethiopia: International Livestock Research Institute.

Fan, S., Hazell, P. and Haque, T. 2000a. Targeting public investments by agro-ecological zone to achieve growth and poverty alleviation goals in rural India. Food Policy 25:411-428.

Fan, S., Zhang, L. and Zhang, X. 2000b. Growth and poverty in rural China: The role of public investments. Environment and Production Technology Division Discussion Paper No. 66. Washington, D.C.: International Food Policy Research Institute.

Freeman, P. K., Keen, M. and Mani, M. 2003. Being prepared. Finance & Development 40(3):42-45. International Monetary Fund.

Hanson, H., Borlaug, N.E. and Anderson, R.G. 1982. Wheat in the Third World. Boulder, Colorado, USA: Westview.

Hazell, P. and Haddad, L. 2001. Agricultural research and poverty reduction. Food, Agriculture, and the Environment Discussion Paper 34. Washington, DC: International Food Policy Research Institute. http://www.ifpri.org/2020/dp/2020dp34.pdf

ICARDA 2000. ICARDA Annual Report for 1999. Pp. 28-30. Aleppo, Syria: International Center for Agricultural Research in the Dry Areas.

ICARDA 2002a. Newsletter of the GEF/UNDP Conservation and Sustainable Use of Dryland Agrobiodiversity project. Dryland Agrobio 10-11:1-2, 7-8, July-December 2002. Aleppo, Syria: International Center for Agricultural Research in the Dry Areas.

ICARDA 2002b. Needs Assessment on Soil and Water in Afghanistan. Aleppo, Syria: International Center for Agricultural Research in the Dry Areas. http://www.icarda.org/Afghanistan/PDF/NA_SoilWater.pdf

ICARDA 2002c. Afghanistan Seed and Crop Improvement Situation Assessment. Aleppo, Syria: International Center for Agricultural Research in the Dry Areas. http://www.icarda.org/Afghanistan/NA/fcontent.htm

ICARDA 2003a. ICARDA Annual Report for 2002. Aleppo, Syria: International Center for Agricultural Research in the Dry Areas.

ICARDA 2003b. Review of agriculture in the dry areas. ICARDA Caravan 18/19. Aleppo, Syria: International Center for Agricultural Research in the Dry Areas.

ICARDA 2003c: Needs Assessment on Horticulture in Afghanistan. Aleppo, Syria: International Center for Agricultural Research in the Dry Areas. http://www.icarda.org/Afghanistan/PDF/NA_Horticulture.pdf

ICARDA. 2004. Rebuilding Agriculture in Afghanistan. ICARDA/USAID/Ministry of Agriculture and Livestock, Afghanistan. Leaflet No. ICARDA 13/May 2004. Aleppo, Syria: International Center for Agricultural Research in the Dry Areas.

Jahn, G. C., Chanthy, P., Sophea, P., Bunnarith, K. and Nel, C. 1999. Pest management and rice production practices of farmers in upland and deepwater rice ecosystems of Cambodia. Cambodia-IRRI-Australia Project Baseline Survey Report No. 7. Phnom Penh: Cambodian Agricultural Research and Development Institute.

Javier, E. 1997. Rice ecosystems. Pp. 39-81 in Rice production in Cambodia. Nesbitt, H. J. (ed.) Manila, Philippines: International Rice Research Institute.

Javier, E., Sarom, M., Hel, P. K., Hak, K. L., Puthea, S., Sovith, S., Makara, A., Yadana, H., Sophal, S., Vathany, T., Sidhu, G. S., Mishra, D. P., Sahai, V. N., Chaudhary, R. C. and Ledesma, D. R. 1999. Rice Germplasm Catalog of Cambodia III. Phnom Penh: Cambodia-IRRI-Australia Project.

Jones, R. B., Bramel, P., Longley, C. and Remington, T. 2002. The need to look beyond the production and provision of relief seed: experiences from Southern Sudan. Disasters 26(4):302-315.

Khalikulov, Z., Movlaynova, R., Konopka, J., Khodjaev, P., Street, K. and Abdullaev, F. 2000. Nurturing the Vavilov legacy. ICARDA Caravan 13:14-15. Aleppo, Syria: International Center for Agricultural Research in the Dry Areas.

Kugbei, S, Gregg, B. R., Wassimi, N. and van Gastel, A. J. G. 2004. Socioeconomic features, food security status and seed needs of farming households in Afghanistan. Journal of New Seeds Vol 6(4). In Press.

Lewis, A. 2003. Revitalizing the drive for rural infrastructure. IFPRI Forum Sept. 2003:1-12. Washington DC: International Food Policy Research Institute. http://www.ifpri.org/pubs/newsletters/ifpriforum/IF200309.htm

Lipton, M. 2002. What productive resources do the poor really need to escape poverty? Pp. 66-71 in Sustainable Food Security for All by 2020: Proceedings of an International Conference, Sept. 4-6, 2001, Bonn, Germany. Washington, D.C.: International Food Policy Research Institute. http://www.ifpri.org/pubs/books/2020conpro/ch09.pdf

Longley, C., Jones, R., Ahmed, M. H. and Audi, P. 2001. Supporting local seed systems in southern Somalia: a developmental approach to agricultural rehabilitation in emergency situations. AgREN paper No. 115. London: Overseas Development Institute. http://www.odi.org.uk/agren/papers/agrenpaper_115.pdf

Longley, C., Dominguez, C., Saide, M. A. and Leonardo, W. J. 2002. Do farmers need relief seed? A methodology for assessing seed systems. Disasters 26 (4): 343-355.

Meinzen-Dick, R., Adato, M., Haddad, L. and Hazell, P. 2003. Impacts of agricultural research on poverty: findings of an integrated economic and social analysis. Environment and Production Technology Division Discussion Paper no. 111. Washington, D.C.: International Food Policy Research Institute.

Messer, E., Cohen, M. and D'Costa, J. 1998. Food from peace: breaking the links between conflict and hunger. Food, Agriculture and the Environment Discussion Paper 24. Washington DC: International Food Policy Research Institute.

Nachit, M. M. 1998. Associations of grain yield in dryland and carbon isotope discrimination with molecular markers in durum (*Triticum turgidum* L. var *durum*). Pp. 218-224 in Vol. 1 of Slinkard, A. E. (ed.), Proceedings of the Ninth International Wheat Genetics Symposium, Saskatoon. Canada: University of Saskatchewan - University Extension Press.

Ndikumana, J., Kamidi, R., Desta, S., Marambii, R., Abdi, A. I. and Shori, R. 2002. Assessment of possible USAID/OFDA-led activities for increasing resilience of pastoral communities in the Greater Horn of Africa. Addis Ababa, Ethiopia: International Livestock Research Institute and ASARECA Animal Agriculture Research Network.

Norris, C. 2001. CIAP-NGO impact study. Phnom Penh: Cambodian Agricultural Research and Development Institute.

Parry, M. L. 2002. Turning up the heat: how will agriculture weather global climate change? Pp. 117-123 in Sustainable Food Security for All by 2020: Proceedings of an International Conference, Sept. 4-6, 2001, Bonn, Germany. Washington, D.C.: International Food Policy Research Institute. http://www.ifpri.org/pubs/books/2020conpro/ch15.pdf

Raab, R. 2000. Impact of CIAP's human capital development and information dissemination efforts, 1987-1999. Phnom Penh: Cambodian Agricultural Research and Development Institute.

Raitzer, D. A. 2003. Benefit-cost meta-analysis of investment in the international agricultural research centres of the CGIAR. Rome: CGIAR Science Council Secretariat, Food and Agriculture Organization of the United Nations. http://www.cgiar.org/pdf/bcmeta.pdf

Richards, P. and Ruivenkamp, G. 1997. Seeds and survival: crop genetic resources in war and reconstruction in Africa. Rome: International Plant Genetic Resources Institute.

Rohrbach, D. and Kiala, D. 2000. Development options for local seed systems in Mozambique. ICRISAT Socioeconomics and Policy Program - Working Paper Series no. 5. Bulawayo, Zimbabwe: International Crops Research Institute for the Semi-Arid Tropics.

Sachs, J. D. 2002. The essential ingredient. New Scientist Aug. 17:52-55.

Sen, A. 1987. Food and freedom. Sir John Crawford Memorial Lecture. Washington DC: Consultative Group on International Agricultural Research. http://www.worldbank.org/html/cgiar/publications/crawford/craw3.pdf

Simler, K. R., Mukherjee, S., Dava, G. L. and Datt, G. 2003. Rebuilding after war: micro-level determinants of poverty reduction in Mozambique. IFPRI Research Report Abstract 132. Washington D.C.: International Food Policy Research Institute. http://www.ifpri.org/pubs/abstract/132/ab132.pdf

Sorrells, M. E., Diab, A. and Nachit, M. 2000. Comparative genomics of drought tolerance. Pp. 191-201 in Royo, C., Nachit, M. M., Di Fonzo, N. and Araus J. L. (eds.), Durum Wheat Improvement in the Mediterranean Region: New Challenges. Proceedings of a Seminar by CIHEAM, Centre UdL-IRTA, CIMMYT and ICARDA, Zaragoza, Spain 12-14 April 2000.

Sperling, L. 1996. Executive summary and reflections of Seeds of Hope socio-economic analyses in Rwanda: The impact of war on agricultural production. SOH Assessment Document 10, August 1996. CIAT, Cali, Colombia: Report submitted to the International Development Research Centre, Ottawa, Canada.

Sperling, L. 1997. The effects of the Rwanda war on crop production and varietal diversity: a comparison of two crops. In L. Sperling (ed.). War and Crop Diversity. AgREN Network Paper 75. UK: DFID.

Sperling, L. and Longley, C. 2002. Editorial: Beyond seeds and tools: Effective support to farmers in emergencies. Disasters (Special Issue) 26(4) December 2002.

Sperling, L. and Cooper, D. 2003. Understanding seed systems and strengthening seed security: a background paper. In Effective and Sustainable Seed Relief: A Stakeholder Workshop, 26-28 May 2003. Rome: Food and Agriculture Organization of the United Nations.

Sperling, L, Loevinsohn, M. E. and Ntabomvura, B. 1993. Rethinking the farmer's role in plant breeding: local bean experts and on-station selection in Rwanda. Experimental Agriculture 29:509-519.

Speth, J. G. 1994. Towards sustainable food security. 1993 Sir John Crawford Memorial Lecture. Washington DC: Consultative Group on International Agricultural Research. http://www.worldbank.org/html/cgiar/publications/crawford/craw9.pdf

Street, K. and Bounejmate, M. 2000. The hunt for green gold in Central Asia and the Caucasus. ICARDA Caravan 13:12-13. Aleppo, Syria: International Center for Agricultural Research in the Dry Areas.

Thomson, E., Barker, T. and Mueller, J. 2003. Drought, livestock losses and the potential for feed production from arable land in Afghanistan: A case study of 183 villages with mixed crop/livestock farming systems. Integrated Natural Resource Management Research Report Series No. 5. Aleppo, Syria: International Center for Agricultural Research in the Dry Areas.

UN 1995. An Agenda for Development. New York: United Nations.

UN 2000. United Nations Millennium Declaration. General Assembly Resolution 55/2 of 8 September 2000. New York: The United Nations.

UN 2001. Road map towards the implementation of the United Nations Millennium Declaration. Report of the Secretary General. General Assembly document A/56/326, 6 September 2001. New York: The United Nations.

UN 2004. International strategy for disaster reduction. Resolution 58/214 adopted by the General Assembly. Distributed 27 February 2004. New York: the United Nations.

UNEP 2003. Africa Regional Workshop on Environmental Disasters, 28-30 July 2003. Workshop Report. Nairobi: United Nations Environment Programme.

Urwin, N. and Wrigley, T. 2001. Environmental impact assessment of the Cambodia-IRRI-Australia Project. Phnom Penh: Cambodian Agricultural Research and Development Institute.

Valkoun, J. 2002. Collecting and conserving genetic resources to meet future needs. ICARDA Caravan 17: 28-30. Aleppo, Syria: International Center for Agricultural Research in the Dry Areas.

van Jaarsveld, P., Faber, W. M., Tanumihardjo, S. A., Lombard, C. J. and Spinner Benadé A. J. 2003a. The efficacy of orange-fleshed sweetpotato to improve vitamin A status of children 5–10 years of age. Final Report to the Micronutrient Initiative. National Programme for Women and Child Health, Nutritional Intervention Research Unit (NIRU), Medical Research Council, South Africa.

van Jaarsveld, P., Wet, M. De, Armes, E. and Rodriguez-Amaya, D. 2003b. Evaluation of the retention of ß-carotene in boiled, mashed orange-fleshed sweetpotato. Poster presented at 21st IVACG—International Vitamin A Consultative Group International Meeting: Improving the Vitamin A Status of Populations, Marrakech (Morocco), 3–5 February.

Voss, J. 1992. Conserving and increasing on-farm genetic diversity: farmer management of varietal bean mixtures in Central Africa. Pp. 34-51 in Moock, J.L. and Rhoades, R.E. (eds.), Diversity, Farmer Knowledge and Sustainability. Ithaca and London: Cornell University Press.

Weiner, T. 2004. Life is hard and short in Haiti's bleak villages. New York Times, March 14, 2004.

World Bank 2000-2001. World Development Report 2000-2001. Washington, DC: The World Bank.

World Bank 2004a. About the Conflict Prevention and Reconstruction Unit. Washington D.C.: The World Bank. http://lnweb18.worldbank.org/ESSD/sdvext.nsf/67ByDocName/AboutUs

World Bank 2004b. Natural disasters: promoting a proactive approach. World Bank website. Washington, DC: The World Bank. http://www.tinyurl.com/ypwzq

Young, D., Raab, R., Martin, R., Sin, S., Leng, B., Abdon, B., Mot, S. and Seng, M. 2001. Economic impact assessment of the Cambodia-IRRI-Australia Project. Phnom Penh: Cambodian Agricultural Research and Development Institute.

Zhu, Y., Chen, H., Fan, J., Wang, Y., Li, Y., Chen, J., Fan, J., Yang, S., Hu, L., Leungk, H., Mewk, T. W., Tengk, P. S., Wangk, Z. and Mundtk, C. C. 2000. Genetic diversity and disease control in rice. Nature 406: 718-722.

Acronyms

A-AARNET	ASARECA Animal Agriculture Research Network
ACIAR	Australian Centre for International Agricultural Research
ACSAD	Arab Centre for Studies of the Arid Zones and Dry Lands
AfDB	African Development Bank
AFRENA	Agroforestry Research Network for East and Central Africa
ALNAP	Active Learning Network for Accountability and Performance in Humanitarian Assistance
ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa
AsDB	Asian Development Bank
AusAID	Australian Government Overseas Aid
BMZ	Federal Ministry for Economic Cooperation and Development (Germany)
CAB-VIR	Central Asian Branch of the All-Union Research Institute of Plant Industry
CAC	Central Asia and the Caucasus
CADG	Central Asian Development Group
CARDI	Cambodian Agricultural Research and Development Institute
CGIAR	Consultative Group on International Agricultural Research
CIAP	Cambodia-IRRI-Australia Project
CIAT	International Center for Tropical Agriculture
CIDA	Canadian International Development Agency
CIMMYT	International Center for Maize and Wheat Improvement
CIP	International Potato Center
CRS	Catholic Relief Services
DACAAR	Danish Committee for Aid to Afghan Refugees
DANIDA	Danish International Development Agency
DFID	Department for International Development (UK)
DICTA	Directorate of Agricultural Science and Technology (Honduras)
DSS	Decision support system
EARRNET	East African Root Crops Network
ESCWA	Economic and Social Committee for West Asia of the United Nations
ESRI	Environmental Systems Research Institute
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
GIS	Geographic information systems
GL-CRSP	Global Livestock Collaborative Research Support Programme (USAID/Texas A&M University)
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit
HPG	The Humanitarian Policy Group at ODI
ICARDA	International Center for Agricultural Research in the Dry Areas
ICBA	International Center for Biosaline Agriculture
ICRAF	World Agroforestry Centre
ICRISAT	International Crops Research Institute for the Semi-arid Tropics
ICRW	International Center for Research on Women
IDRC	International Development Research Centre (Canada)
IFAD	International Fund for Agricultural Development
IFDC	International Fertilizer Development Center
IFPRI	International Food Policy Research Institute
IITA	International Institute of Tropical Agriculture
ILRI	International Livestock Research Institute
INIA	Instituto Nacional de Investigación Agraria, Peru
INIVIT	Instituto de Investigación de Viandas Tropicales (Cuba)

INTA	Nicaraguan Institute of Agricultural Technology
IPGRI	International Plant Genetic Resources Institute
IPPCC	Intergovernmental Panel on Climate Change
IRRI	International Rice Research Institute
ISAR	Institut des Sciences Agronomiques du Rwanda
ISABU	Institut des Sciences Agronomiques du Burundi
IWMI	International Water Management Institute
JAF	James Arwata Foundation, Uganda
JIRCAS	Japan International Research Center for Agricultural Sciences
LAMP	Latin America Maize Project
LEWS	Livestock Early Warning System (GL-CRSP subproject)
MAFF	Ministry of Agriculture, Fisheries and Forestry (East Timor)
MOAL	Ministry of Agriculture and Livestock, Afghanistan
MODIS	Moderate Resolution Imaging Spectroradiometer
MPLA	The Popular Movement for the Liberaton of Angola
MRC-ARC	Medical and Agricultural Research Councils (South Africa)
NARS	National Agricultural Research Systems
NEPAD	New Partnership for Africa's Development
NGO	Non-governmental organization
NVRSRP	Nile Valley and Red Sea Regional Program (ICARDA)
NZAID	New Zealand's International Aid and Development Agency
ODI	Overseas Development Institute (UK)
OPEC	Organization of the Petroleum Exporting Countries
PRAPACE	Research Network on Potato and Sweetpotato in East and Central Africa
PRM	Regional Maize Program for Central America and the Caribbean
PROFRIJOL	Collaborative Bean Program for Central America, Mexico, and the Caribbean
R4D	Research for Development
RAMP	Rehabilitation of the Agricultural Markets Program, USAID
RAMSI	Regional Assistance Mission to Solomon Islands
RESAPAC/ ECABREN	East and Central African Bean Research Network
SADC	Southern African Development Community
SATG	Somali Agriculture Technical Group
SDC	Swiss Agency for Development and Cooperation
SOH	Seeds of Hope Initiative (Rwanda)
SOH-II or SOH-CA	Seeds of Hope for Central America
SOL	Seeds of Life project (Timor-Leste)
SSS	Service Semencier Selectionnees
SSSA	Seed System Security Assessment
TPS	True Potato Seed
TCER	FAO's Rehabilitation and Humanitarian Policies Unit
UNDP	United Nations Development Programme
UNDP/PAPP	UNDP Programme of Assistance to Palestinian People
UNEP	United Nations Environment Programme
UNITA	Union for the Total Independence of Angola
USAID	United States Agency for International Development
USAID/OFDA	USAID Office for Disaster Assistance
USDA	United States Department of Agriculture
USGS	US Geological Survey
UzRIPI	Uzbek Research Institute of Plant Industry
VITAA	Vitamin A for Africa Partnership
VRTI	Vivekanand Research and Training Institute
WARDA	The Africa Rice Center
WAAP	The Western Afghanistan Agribusiness Program
WVI	World Vision International

The CGIAR Centers

CIAT
Centro Internacional de Agricultura Tropical (International Center for Tropical Agriculture)
www.ciat.org
Headquarters: Cali, Colombia
Founded: 1967
Joined the CGIAR: 1971
Mission: To reduce hunger and poverty in the tropics through collaborative research that improves agricultural productivity and natural resource management.

CIFOR
Center for International Forestry Research
www.cifor.org
Headquarters: Bogor, Indonesia
Founded: 1993
Joined the CGIAR: 1993
Mission: To contribute to the sustained well-being of people in developing countries, particularly in the tropics. This is achieved through collaborative, strategic and applied research and by promoting the transfer and adoption of appropriate new technologies and social systems for national development.

CIMMYT
Centro Internacional de Mejoramiento de Maïz y Trigo (International Maize and Wheat Improvement Center)
www.cimmyt.org
Headquarters: Mexico City, Mexico
Founded: 1966
Joined the CGIAR: 1971
Mission: CIMMYT acts as a catalyst and leader in a global maize and wheat innovation network that serves the poor in developing countries. Drawing on strong science and effective partnerships, CIMMYT creates, shares, and uses knowledge and technology to increase food security, improve the productivity and profitability of farming systems, and sustain natural resources.

CIP
Centro Internacional de la Papa (International Potato Center)
www.cipotato.org
Headquarters: Lima, Peru
Founded: 1971
Joined the CGIAR: 1973
Mission: To reduce poverty and achieve food security on a sustained basis in developing countries through scientific research and related activities on potato, sweetpotato, and other root and tuber crops and on the improved management of natural resources in the Andes and other mountain areas.

ICARDA
International Center for Agricultural Research in the Dry Areas
www.icarda.org
Headquarters: Aleppo, Syrian Arab Republic
Founded: 1977
Joined the CGIAR: 1977
Mission: To improve the welfare of poor people and alleviate poverty through research and training in dry areas of the developing world, by increasing the production, productivity and nutritional quality of food, while preserving and enhancing the natural resource base.

ICRISAT
International Crops Research Institute for the Semi-Arid Tropics
www.icrisat.org
Headquarters: Patancheru, Andhra Pradesh, India
Founded: 1972
Joined the CGIAR: 1972
Mission: To help developing countries apply science to increase crop productivity and food security, reduce poverty, and protect the environment. ICRISAT focuses on the farming systems of the semi-arid tropical areas of the developing world, where erratic rainfall, low soil fertility, and extreme poverty are formidable constraints to agricultural development.

IFPRI
International Food Policy Research Institute
www.ifpri.org
Headquarters: Washington, DC, United States of America
Founded: 1975
Joined the CGIAR: 1980
Mission: To identify and analyze policies for sustainably meeting the food needs of the developing world. Research at IFPRI concentrates on economic growth and poverty alleviation in low-income countries, improvement of the well-being of poor people, and sound management of the natural resource base that supports agriculture. IFPRI seeks to make its research results available to all those in a position to use them and to strengthen institutions in developing countries that conduct research relevant to its mandate.

IITA
International Institute of Tropical Agriculture
www.iita.org
Headquarters: Ibadan, Nigeria
Founded: 1967
Joined the CGIAR: 1971
Mission: IITA's mission is to enhance the food security, income, and well-being of resource-poor people in sub-Saharan Africa by conducting research and related activities to increase agricultural production, improve food systems, and sustainably manage natural resources, in partnership with national and international stakeholders.

ILRI
International Livestock Research Institute
www.ilri.org
Headquarters: Nairobi, Kenya
Founded: 1995
Joined the CGIAR: 1995
Mission: The International Livestock Research Institute (ILRI) works at the crossroads of livestock and poverty, bringing high-quality science and capacity-building to bear on poverty reduction and sustainable development for poor livestock keepers and their communities.

IPGRI
International Plant Genetic Resources Institute
www.ipgri.org
Headquarters: Maccarese, Rome, Italy
Founded: 1974
Joined the CGIAR: 1974
Mission: IPGRI aims to conserve and use the genetic variation in plants to create crop varieties that are more productive, stronger, and more nutritious. These varieties contribute to better agriculture that can help sustain families, build prosperity, improve health, and renew the earth.

IRRI
International Rice Research Institute
www.irri.org
Headquarters: Los Baños, Philippines
Founded: 1960
Joined the CGIAR: 1971
Mission: To improve the well-being of present and future generations of rice farmers and consumers, particularly those with low incomes.

IWMI
International Water Management Institute
www.cgiar.org/iwmi
Headquarters: Battaramulla, Sri Lanka
Founded: 1984
Joined the CGIAR: 1991
Mission: Improving water and land resources management for food livelihoods and nature.

WARDA
West Africa Rice Development Association
www.warda.org
Headquarters: Bouaké, Côte d'Ivoire
Founded: 1970
Joined the CGIAR: 1975
Mission: WARDA's mission is to contribute to poverty alleviation and food security in Africa, through research, development and partnership activities aimed at increasing the productivity and profitability of the rice sector in ways that ensure the sustainability of the farming environment.

World Agroforestry Centre

www.worldagroforestrycentre.org
Headquarters: Nairobi, Kenya
Founded: 1977
Joined the CGIAR: 1991
Mission: To improve human welfare by reducing poverty, improving food and nutritional security, and enhancing environmental resilience in the tropics.

World Fish Center

www.worldfishcenter.org
Headquarters: Penang, Malaysia
Founded: 1977
Joined the CGIAR: 1992
Mission: To promote sustainable development and use of living aquatic resources based on environmentally sound management.