AFRICA HUMAN DEVELOPMENT SERIES

Building Science, Technology, and Innovation Capacity in Rwanda

Developing Practical Solutions to Practical Problems

Alfred Watkins and Anubha Verma, Editors

THE WORLD BANK

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1 2 3 4 5 10 09 08 07

ISBN: 978-0-8213-7356-9 eISBN: 978-0-8213-7357-6
DOI: 10.1596/978-0-8213-7356-9

Library of Congress Cataloging-in-Publication Data

Watkins, Alfred J.
Building science, technology, and innovation (STI) capacity in Rwanda : developing practical solutions to practical problems : Government of Rwanda-World Bank technical assistance program overview and detailed summaries of six needs assessments and action plans / compiled By Alfred Watkins & Anubha Verma.
p. cm.
Includes bibliographical references.
1. Technical education—Government policy—Rwanda. 2. Science—Study and teaching—Government policy—Rwanda. 3. Technology and state—Rwanda. 4. Technical assistance—Rwanda. 5. Rural development projects—Rwanda. I. Verma, Anubha. II. World Bank. III. Title.
T166.R95W38 2007
338.967571'07—dc22

2007040465

Cover photo by: Alfred J. Watkins at the Maraba Coffee Cooperative, Butare, Rwanda.
Cover design: Naylor Design, Inc.

Contents

FOREWORD ix

ACKNOWLEDGMENTS xiii

ABBREVIATIONS xv

EXECUTIVE SUMMARY xvii

CHAPTER 1 : OVERVIEW AND SUMMARY OF RESULTS 1

Current Social and Economic Situation 2
Improving the Lives of the Rural Poor, Reducing Poverty, and Achieving the MDGs 4
Creating Wealth and Diversifying the Economy 6
Government Commitment to STI Capacity Building 8
Methodology and Design of the STI Capacity-Building Program 11
Lessons Learned 15
Implementation Issues 21
Notes 22

CHAPTER 2 : THE FOOD-PROCESSING INDUSTRY 25

Situation Analysis/Needs Assessment 25
Standardization and Quality Management 27
Human Resource Constraints 27
Markets for Processed Foods 28
Development Potential for the Food-Processing Industry 29
Recommended Strategies 30
Educating and Training People 32
Developing Business Development Services 33
Improving Transport and Packaging 34
Conducting Market Research and Feasibility Studies 34
Adopting Complementary Measures 35

CHAPTER 3 : VALUE-ADDED EXPORTS 37

Situation Analysis/Needs Assessment 37
Recommended Public–Private Partnerships for Capacity Building in Value-Added Enterprises 40
Public–Private Partnership for Technical and Vocational Training 40
Public–Private Grant Facility for Enterprise-Based Training 41
Establishing a Public–Private Technology Information Service 42
Establishing a Matching Grant Program for Investment in Productive Technologies 43
Creating a Public–Private Organic Production and Research Association 43
Building Capacity for Organic Production and Certification 45
Public–Private Instruments for Capacity Building in Design and Product Development 45
Notes 46

CHAPTER 4 : DEVELOPMENT AND DIFFUSION OF APPROPRIATE TECHNOLOGIES 47

Situation Analysis/Needs Assessment 47
Agencies and Institutions Responsible for Promoting Appropriate Technology 51
Factors Hampering the Development and Transfer of Appropriate Technology 54
Recommended Strategies 55
Building Capacity at CITT 56
Building Capacity at IRST 58
Building Capacity at Vocational Training Centers 59
Establishing a Technology Development Fund 60
Notes 62

CHAPTER 5 : DELIVERY OF CLEAN DRINKING WATER 63

Situation Analysis/Needs Assessment 63
Recommended Strategies 65
Training Local Water Technicians 65
Training District- and National-Level Managers 68
Building Capacity at KIST 68
Building Capacity at NUR 69
Building Capacity at ISAE 70

CHAPTER 6 : GEOSCIENCES AND GEOTHERMAL ENERGY 71

Strategy A: Fast-Track "Urgent" Plan for Geothermal Resource Assessment and Pilot Power Generation 72
Institutional Set-Up 74
Capacity Building through Hands-On Training 74
Strategy B: Long-Term Institution/Capacity Building for Geothermal Energy and Geoscience Development: The Rwanda Geoscientific Center 75
Required Capacity-Building Efforts 80
Notes 82

CHAPTER 7 : CLIENT-FOCUSED AGRICULTURAL RESEARCH AND OUTREACH 83

Situation Analysis/Needs Assessment 83
Weaknesses in the Performance of the Agricultural Research and Technology Transfer System 85
Weaknesses in the Public Research and Technology Transfer System 86
Weaknesses in Private Sector Participation 88
Weaknesses in the Agricultural Education and Training System 88
Recommended Strategies for Capacity Building 89
Strengthen the Key Components of the Agricultural Research and Technology Transfer System 89
Empower the Beneficiaries of Agricultural Research and Outreach 90
Promote the Profitability of Agriculture and Private Sector Participation 91
Improve ISAR's Institutional Performance 93
Improve Coordination, Methods, and Performance Standards for Agricultural Research and Technology Transfer 94
Develop and Manage Human Resources 95
Build Capacity at ISAE and NUR 96
Notes 97

APPENDIXES

APPENDIX 1 : Background Documents **99**

APPENDIX 2 : Sample Terms of Reference for the Needs Assessment and Action Plan Studies **101**

APPENDIX 3 : Public Institutions Involved in STI Capacity-Building Action Plans **105**

BIBLIOGRAPHY **107**

INDEX **109**

BOX

Box 1.1: Improving Institutional Capacity and Building an Innovation Culture 20

FIGURES

Figure 1.1: Enterprise-based Model of STI Capacity Building 8
Figure 1.2: Cross-cutting Nature of STI Capacity Building 16
Figure 1.3: STI Capacity Building Cuts Across Traditional Silos of Development 17
Figure 1.4: Capacity-building Needs at Various Skill Levels 18
Figure 5.1: Access to Clean Drinking Water and Sanitation, 2000–20 63
Figure 7.1: STI System for Agricultural Research and Technology Transfer (ARTT) in Rwanda 84

TABLES

Table 4.1: Status of Appropriate Technologies in Rwanda 48
Table 5.1: Recommended Capacity-Building Activities in the Water and Sanitation Sector 66
Table 5.2: Projected Number of Workers Needed to Handle Basic Water Supply and Management Tasks 67
Table 3A.1: Public Institutions Involved in STI Capacity-Building Action Plans 105

Foreword

In 2003, Rwanda emerged from its first democratic elections with a new government entrusted with meeting the challenges of building an economy based on science, technology, and innovation (STI) and making Rwanda a technology hub in Sub-Saharan Africa. Together with other science- and technology-oriented ministries, the Ministry of Education, Science, Technology and Scientific Research was charged with implementing this vision—even if it meant breaking down bureaucratic barriers, doing the unusual, and formulating and implementing ambitious STI policies.

Rwanda's commitment to STI capacity building starts at the very top. The president of Rwanda, His Excellency Paul Kagame, was the first to stress the importance of making science and technology an instrument for Rwanda's economic and social development. During his January 2004 address to the diplomatic corps, he outlined the following ambitious goal: "We will continue to invest in our people and strive to open up the frontiers of science, technology, and research as we broaden our trade links with our neighboring countries and beyond."

President Kagame has not wavered from this initial vision. In his speech to the U.K. Royal Society in September 2006, he stated: "We in Africa must either begin to build our scientific and training capabilities or remain an impoverished appendage to the global economy." In his January 2007 address to the Eighth African Union Summit, he emphasized that building science and technology capacity is synonymous with economic transformation. STI capacity building, he explained, "is about applying science and technology holistically—in all levels of education and training, in commercializing ideas, in developing business and quickening the pace of wealth-creation and employment-generation, in enabling government to provide better services, and indeed in providing basic tools to society at large for self- and collective betterment."

Rwanda has sought to implement this vision in three stages. The first stage entailed developing a national STI policy. With significant support from development partners, this stage was implemented as follows:

- September 2004, with support of the World Bank: Appointment of a science and technology adviser in the office of the Minister of Education, Science, Technology and Scientific Research
- November 2004, with support of the Department for International Development (DFID) and the United Nations Educational, Scientific and Cultural Organization (UNESCO): Preparation of a concept paper entitled "Preparatory National Integrated Innovation Framework for Rwanda"
- December 2004–April 2005: Preparation of a first draft of the national STI policy, followed by extensive consultation with key stakeholders
- May 2005, with support of DFID: Review of the draft documents at the National Science and Technology Conference in Butare, opened by President Kagame and, on behalf of Rwanda's development partners, Jeremy Macadie, the British Ambassador to Rwanda
- July 2005: Approval of the national STI policy by the Rwandan cabinet. The policy was subsequently published, with the support of UNESCO and the United Nations University.

The goals of Rwanda's national STI policy are to (a) promote sustained growth of GDP; (b) improve the quality of life and raise the standards of living of the citizens of Rwanda; (c) improve skills and knowledge among the population; (d) maintain the viability of and enhance opportunities for growth in rural areas; and (e) integrate technical education with commerce, industry, and the private sector. To achieve these goals, policies are needed that promote knowledge acquisition, knowledge creation, knowledge transfer, and a culture of innovation.

Approving and publishing the national STI policy was only the first step in realizing President Kagame's vision of transforming Rwanda into a knowledge society. The crucial second step was converting this policy into detailed, specific programs. This is where the World Bank has played a crucial role. The World Bank Science and Technology Program Unit, working hand in hand with the Ministry for Science, Technology and Scientific Research, prepared a series of Needs Assessment and Action Plans (NAAPs) for STI capacity building. These studies provided the roadmap for integrating STI capacity building into Rwanda's Economic Development Poverty Reduction Strategy. The NAAPs are based on the premise that by embarking on a concerted effort to build STI capacity, Rwanda will

greatly enhance its prospects of achieving the growth, poverty reduction, wealth creation, and export diversification objectives that form part of the Government's vision. I am delighted to be associated with the publication of this volume, which summarizes the results of the second phase of Rwanda's STI capacity-building effort.

Phase 3 will entail implementing these recommendations, through a partnership between the Government of Rwanda on the one hand and the World Bank and many other development partners on the other. As we enter this third phase, I am confident that, working together, we will succeed in meeting the goal of a prosperous Rwanda, transformed into a technology-led, knowledge-based economy.

Professor Romain Murenzi
Minister in the President's Office of Science,
Technology and Scientific Research

Acknowledgments

This report was compiled by a team of Human Development Network staff and consultants led by Alfred Watkins, the World Bank's science and technology program coordinator, and Anubha Verma, a science, technology, and innovation (STI) specialist at the Bank. The individual Needs Assessment and Action Plans (NAAPs) were prepared by the following expert teams:

- Food-processing: David Poston, Dominique Nkunda, and Jean Claude Nkuri
- Value-added exports: David Poston and Ignace Habimana
- Development and diffusion of appropriate technologies: Gerard Hendriksen, Rebecca Ruzibuka, and Theogene Rutagambwa
- Delivery of clean drinking water: Philippe Lothe and Jean Claude Nkuri
- Geosciences and geothermal energy: Steve Hirsch, Anis Abdallah, and Jean de la Paix Ngizimana
- Client-focused agricultural research and outreach: Clessensio Tizikara, David Wilcock, and Pierre Celestin

Frans Doorman worked with the editors to prepare the summaries of the NAAPs that appear in this report. Along the way, he also contributed many useful observations on all facets of this report and the underlying technical assistance program. Yaw Ansu, director of the Human Development Department in the World Bank's Africa Region, initially requested that this work be undertaken; he provided support at every step of the process. Jee-Peng Tan, adviser in the Human Development Department of the World Bank's Africa Region, helped guide the overall work program and provided funding from the Norwegian Post-Primary Education Trust Fund. Ruth Kagia, director of the Education Department in Human Development Network, provided support and expert guidance for the

work in Rwanda as well as for the overall science, technology, and innovation program.

World Bank colleagues in the Rwanda Country Department, led by the country director, Pedro Alba, provided strong support for the overall program. Colleagues in the agricultural and rural development, education, energy, and water sectors provided support and offered detailed guidance and assistance on the design of individual studies. This study also benefited from the intellectual support, guidance, comments, and assistance from colleagues at the Department for International Development (DFID), the Japan International Cooperation Agency (JICA), Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ), the Swedish International Development Agency (SIDA), and the United Nations Industrial Development Organization (UNIDO). A wide range of government ministers, public officials, university rectors, and private entrepreneurs—who met with the project team on numerous occasions and were generous with their time, advice, comments, and support—also wholeheartedly supported this work.

Last, but by no means least, a deep debt of gratitude is owed to Professor Romain Murenzi, minister in the President's Office of Science, Technology and Scientific Research, and Michael Hughes, adviser to Minister Murenzi, for their hands-on support, guidance, and friendship.

ABBREVIATIONS

ARGeo	East African Rift Valley Geothermal Program
ARSC	Centre for Applied Sciences Research
BGR	Federal Institute of Geosciences and Natural Resources
CITT	Centre for Innovation and Technology Transfer
COFORWA	Compagnons Fontainiers du Rwanda
CSIR	Council for Scientific and Industrial Research
DFID	Department for International Development
EAV	*école agro-veterinaire*
ETO	*école technique officielle*
GAR	Geothermal Association of Rwanda
GDA	Geothermal Development Associates
GIS	Geographic Information System
IRST	Institute for Scientific Research and Technology
ISAE	Institut Supérieure d'Agriculture et d'Elevation
ISAR	Agricultural Sciences Institute of Rwanda
KIST	Kigali Institute of Science, Technology and Management
MINAGRI	Ministry of Agriculture
MINICOM	Ministry of Industry and Commerce
MININFRA	Ministry of Infrastructure
MINISTR	Ministry of Science, Technology and Scientific Research
NAAP	Needs Assessment and Action Plan
NARB	National Agricultural Research Board
NGO	nongovernmental organization
NIS	National Institute of Statistics
NSTIP	National Science, Technology and Innovation Policy
NUR	National University of Rwanda
PHAST	Participatory Hygiene and Sanitation Transfer
R&D	research and development
RADA	Rwanda Agriculture Development Authority
RARDA	Rwanda Animal Resources Development Authority
RBS	Rwanda Bureau of Standards
REMA	Rwanda Environmental Management Authority
RGC	Rwanda Geoscientific Center
RGMA	Rwanda Geology and Mining Authority
RHODA	Rwanda Horticulture Development Authority
RIEPA	Rwanda Investment and Export Promotion Agency
ROPRA	Rwanda Organic Production and Research Association
RPSF	Rwandan Private Sector Federation
RTTP	Rural Travel and Transport Program

SME	small and medium-size enterprise
STI	science, technology, and innovation
STIR	Science, Technology and Innovation for Results
TDF	technology development fund
TOR	terms of reference
TVET	technical and vocational education and training
VTC	vocational training college

Executive Summary

In August 2006, the World Bank and Government of Rwanda began work on a Science, Technology and Innovation (STI) Capacity-Building Technical Assistance Program. The objective was to help Rwanda build the STI capacity it needs to identify, design, and implement practical solutions to a series of everyday practical economic and social development problems. These problems fall into two broad categories: (a) improving the lives of the rural poor, reducing poverty, and achieving the Millennium Development Goals (MDGs) and (b) generating wealth, diversifying the economy, and supporting private sector initiatives to produce and sell value-added, natural resource (mostly agricultural) exports.

Rwanda is recovering from an unprecedented genocide and is making impressive development strides. The economy grew at an average annual rate of almost 10 percent a year between 1995 and 2005. The Government of Rwanda has introduced market reforms and privatized many state-owned enterprises. Economic and political governance has improved dramatically. The government has introduced measures to promote reconciliation and peace. Poverty and mortality rates are down significantly, while immunization and literacy rates have risen substantially. These results are impressive. But growth is beginning to slow, as the natural rebound effects from the depths of the genocide begin to wear off. And Rwanda still has a long way to go before it achieves the MDGs and raises per capita incomes even to lower-middle-income levels.

With this in mind, the Government's Vision 2020 Statement, its National Science, Technology and Innovation Policy (NSTIP), and related policy documents identify two critical development challenges. The first involves improving the quality of life, raising the standard of living, and meeting such everyday needs of the rural poor as increasing access to clean water, food security, and electricity. This challenge also involves increasing the productivity of farmers engaged in subsistence agriculture.

Achieving these objectives would provide a major boost to national welfare and would go a long way toward helping Rwanda achieve the MDGs.

The second challenge involves generating wealth and boosting income levels through higher-value jobs. With a per capita income of only $0.71 a day, Rwanda needs to boost per capita income by 40 percent just to lift people above the $1 a day poverty line. Put differently, if Rwanda hopes to become more prosperous, it must find ways to reduce the ranks of the rural poor, not merely develop technologies that make life more tolerable for them. Reducing the ranks of the poor must entail creating more-productive, higher-paying jobs outside or alongside subsistence agriculture; developing new, higher-value-added exports; and improving the quality of science and technical education at all levels.

Both challenges entail building STI capacity. Rwanda cannot hope to achieve the MDGs if it does not have the scientific, engineering, and technical/vocational capacity to handle such mundane but vital tasks as delivering clean drinking water to a rural village or preventing food from rotting shortly after it is harvested. Rwanda cannot hope to prosper in an increasingly competitive global economy and open trading system if it does not build the appropriate science, technology, innovation-entrepreneurial, engineering, and technical/vocational capacity to produce more value-added goods and services.

Fortunately, much of the science, engineering, and technical knowledge needed to achieve these objectives already exists and is widely used outside Rwanda. Unfortunately, this knowledge is not being applied in Rwanda. From this perspective, therefore, the STI capacity-building challenge is to train farmers, entrepreneurs, engineers, technicians, scientists, and teachers to find the appropriate knowledge, import it, adapt it to local conditions, and use it to solve local problems and produce and market higher-value, more knowledge-intensive goods and services.

To meet these challenges, Rwanda will need to improve the quality of its applied engineering and scientific research institutes as well as its technical and vocational education. It will also have to focus more of its teaching and research efforts on training Rwandans to use this knowledge to develop, produce, and deploy such simple, low-cost technologies as more efficient wood burning stoves; manual irrigation pumps; food-processing and storage equipment; more efficient, low-cost construction materials and methods; and nonelectrical refrigeration and food-cooling equipment.

Enterprises will not be able to exploit the competitive opportunities generated by appropriate technologies if local enterprises do not have the

organizational and managerial skills and the technical competence to build businesses around these technologies and their workers do not have the skills to use new technology to perform more complex tasks. Rwanda suffers from a shortage of skilled technicians and craftspeople. At the same time, graduates from the few technical and vocational schools that do exist are having difficulty finding jobs, apparently because graduates do not receive appropriate training. STI capacity building, therefore, needs to encompass innovative ways of delivering and financing technical and vocational education.

To begin this process, the Government of Rwanda and the World Bank, with financial support primarily from the Norwegian Post-Primary Education Trust Fund, embarked on a two-stage STI capacity-building program. The first stage involved assembling teams of Rwandan and international experts to prepare a series of STI capacity-building needs assessments and action plans (NAAPs). This stage is expected to be followed by a second stage, in which the Bank and donors finance the implementation of the recommendations in the NAAPs.

Following several months of detailed consultation with government officials, university rectors, directors of national training institutions, bilateral donors, private sector support organizations, industry associations, entrepreneurs, nongovernment organizations (NGOs), and other stakeholders, it was agreed that the technical assistance program should focus on the preparation of a series of NAAPs in six high-priority areas, as defined in Rwanda's Vision 2020 Statement and NSTIP: food-processing, value-added exports, development and diffusion of appropriate technologies, delivery of clean drinking water, geosciences and geothermal energy, and client-focused agricultural research and outreach.

Each NAAP attempts to answer three broad questions: What is Rwanda's current capacity? What capacity does Rwanda need? What specific policies and programs are needed to build this capacity? The NAAPs did not ask if there would be demand for this capacity once it was created. Conducting an analysis of market demand for such items as processed food or electricity generated from geothermal energy was beyond the scope of these STI capacity-building studies. Nevertheless, demand is important, and the NAAPs did not simply assume that demand would automatically be present if the requisite capacity were developed. On the contrary, the expert teams relied on published reports that covered demand-side issues extensively (see appendix 1). Consultations and interviews with agencies and institutions in Rwanda (identified in appendix 3) helped refine the demand-side aspects of a given sector.

Several broad principles for building STI capacity emerged from the NAAPs and related work:

- STI capacity building should focus on finding practical solutions to practical problems. Especially for small countries like Rwanda that are at an early stage of the development process, broad, unfocused efforts to build science in general will probably not have the desired developmental impact.
- STI capacity building is a cross-cutting issue with a direct impact on such diverse programs as private sector development, rural and agricultural development, eRwanda, infrastructure and sustainable energy development, and education, among others. It would be difficult, for example, to improve agricultural productivity and raise the cash incomes of rural farmers without training them to employ modern cultivation techniques and to utilize more knowledge-intensive inputs. Thus, training farmers—and training extension agents to train farmers—can be classified as both STI capacity building and agricultural development.
- Because STI capacity building is a cross-cutting issue, something as seemingly simple as developing a food-processing industry or improving the competitiveness of the food-processing industry requires coordinated action across a large number of ministries and agencies. Failure to coordinate and integrate actions and policies across disparate sectors runs the risk that the capacity-building program will not achieve its objectives and that the money invested by other agencies and organizations will not produce the desired result. Although the program may produce voluminous outputs, there will be a paucity of satisfactory outcomes.
- Individual sector reforms are necessary, but by themselves, they will not lead to the emergence of a food-processing industry or help Rwanda to deliver clean water to rural villages. Sector reforms must be complemented by a problem-solving approach that cuts across sectors and builds coherent, integrated capacity in all required areas.
- STI capacity building is not only about scientists working in research laboratories. All levels of technology and skills—ranging from sophisticated scientists to engineers and technical and vocational workers—have to be developed, in the appropriate proportions and sequence.
- STI capacity building is not just about research and development. It is also about getting knowledge out of the laboratory and into the

market. Knowledge diffusion is a critical component of the capacity-building process. This means that the private sector must have the marketing, management, and entrepreneurship capacity to utilize new and existing knowledge to produce higher-value-added, more knowledge-intensive goods and services. Supporting the development of entrepreneurship, marketing, and management skills must therefore be essential elements of Rwanda's STI capacity-building program. Rwandan workers must receive the training they need to perform increasingly sophisticated tasks.

- Public–private partnerships are an essential aspect of STI capacity building. The government has an indispensable role to play in supporting essential research, providing basic education, and creating an environment that will enable the private sector to create the jobs that will diversify the economy and generate wealth. But government investments in science and education will not bear fruit unless government capacity-building programs are consistent with the needs and requirements of the private sector. Developing these programs in partnership with the private sector is the best way to ensure the required consistency.
- Because STI capacity building is a multisectoral, cross-cutting issue, an effective capacity-building program must put a premium on developing high-quality implementation and coordination capacity within the government. Donor harmonization, along the lines of the Paris Declaration on Aid Effectiveness, will be critically important.
- Given the complexity of STI capacity-building programs, committed leadership is essential. This commitment must start at the top, but it cannot be isolated there. The commitment must flow from the top to middle and lower layers of the bureaucracy and permeate the strata of civil society.
- Technical and research institutions perform poorly because of weak or ill-conceived incentive structures. Improving incentives, boosting institutional performance, and building an institutional culture of innovation are requisite components of STI capacity-building programs.
- There are potential advantages to being a latecomer. A latecomer such as Rwanda does not have to invent everything it needs. It can achieve significant results and solve many problems by adapting and using off-the-shelf technology. However, even this seemingly simple task requires significant investments in capacity building.
- STI capacity building is not only about high tech. Producing high-quality coffee, silk, and roses, as Rwanda expects to do, requires significant scientific, engineering, and technical capacity.

- STI capacity alone cannot solve all the problems of a sector. Finance, entrepreneurship, fiscal incentives, regulatory measures, government regulations, government support programs, and public—private partnerships are critical elements that must function properly for STI capacity building to deliver concrete results.
- Innovation must be a way of life for everyone, not a sporadic activity of a few isolated scientists.

In addition to these broad general lessons of experience, the following specific recommendations emerged from the individual NAAPs:

FOOD PROCESSING

Raising agricultural yields will not improve food security if surplus food rots because it cannot be safely processed and stored. Appropriate technologies need to be developed and deployed to process and store food without utilizing large amounts of (unavailable) electricity. Developing a food-processing industry would also help generate off-farm income in rural areas. This, in turn, would help meet the government's objective of providing employment and income-generating opportunities in rural areas without pushing people off the land and into urban slums. A functioning food-processing industry would also help Rwanda transform its agricultural produce into higher-value products (such as fruit juices, chilled vegetables, dried fruit, and processed meat) for export and local markets. Indeed, according to the Rwanda Investment and Export Promotion Agency (RIEPA), Rwanda lacks the capacity to meet the potential demand for its produce.

A shortage of STI capacity in the food-processing industry is the chief constraint to growth. The capacity problem exists at all levels:

- Farmers and producer cooperatives lack the skills they need to process their output (the ability to crush fruit to produce pulp or cool milk so that it does not spoil before reaching urban consumers, for example) before selling it to processing firms. As a result, they receive only a fraction of the potential revenue they could potentially generate.
- There is a shortage of trained food technicians and food scientists.
- Because of the shortage of trained hygiene specialists, food products frequently fail to meet health and environmental quality standards.
- Farmers and food-processing firms lack adequate awareness of technological options for improving quality and productivity.

- Regulatory agencies, such as the Rwanda Bureau of Standards (RBS) and the Rwanda Environmental Management Authority (REMA), lack the technical capacity to define and enforce health and environment standards.

In addition to these human resource constraints, electricity is not available in most rural areas and is extremely expensive in areas where it does exist. Road transport facilities, especially from remote rural areas, are poor and expensive. Customs and environmental regulations have the unintended effect of hampering the development of a local food-processing industry.

The recommendations in this report address all of these issues. Specific recommendations include the following:

- Technical and vocational education and training (TVET) courses are typically taught and formulated without input from potential private sector employers. TVET schools should start piloting hands-on courses for food technicians, in close consultation with local and regional industry leaders.
- Courses at universities and engineering schools must become more practical and less theoretical. To forge closer links with industry, the Kigali Institute of Science, Technology and Management (KIST) should establish "production units" that function as microenterprises for dairy or meat processing.
- Industrial apprenticeships should be created for food science students at local and regional firms.
- Industry and local research centers should design joint research programs to build and utilize applied research and development (R&D) capacity to solve practical problems in food-processing and packaging (such as the lack of environmentally safe and low-priced food-packaging materials). Competitive grants can provide useful incentives to local research centers for conducting such industry-focused collaborative research.
- Regulatory agencies need greater technical capacity to design and enforce effective food safety and food hygiene standards that do not inadvertently deter the development of the food-processing industry. Local technical institutes can play a crucial role in building technical capacity in regulatory agencies. KIST and the National University of Rwanda (NUR), for example, can offer technical courses tailored to meet the special technical needs of regulatory agency staff.

VALUE-ADDED EXPORTS

In the past five years, Rwanda has developed high-value-added export industries in coffee, roses, and pyrethrum. Private investors have plans to move into additional value-added sectors, including tea, silk, herbs and essential oils, and specialty vegetables. Investments in each of these existing and proposed ventures share several common features:

- They have carved out a niche at the high or premium end of the market, typically the most lucrative and most difficult-to-access segment.
- The entrepreneurs who developed these businesses all work (or plan to work) in partnership with subsistence farmers.
- The entrepreneurs provided the undertaking with an invaluable package of rare (for Rwanda) skills, including an understanding of the importance of quality control; a technical understanding of how to achieve quality control; management, organizational, and entrepreneurial capacity; technology awareness and knowledge; and access to markets or a clear strategy for establishing links to buyers. Individual subsistence farmers, who have been isolated from the global marketplace for generations, and even cooperatives made up of small-scale subsistence farmers cannot be expected to possess these skills and know-how. The entrepreneur is thus the critical ingredient for the success of any subsequent capacity-building program.
- The entrepreneurs started with a basic understanding of what the market requires in terms of quantity, quality, and technical specifications. They then reverse-engineered the production process to identify the required inputs and the capacity-building programs (training, supply chain linkages, logistics, and so forth) required to meet the market demand. They also trained farmers in modern production techniques and quality control mechanisms.

In effect, these entrepreneurs become STI capacity-building agents as well as employers of the STI capacity they help create. With this in mind, STI capacity-building programs should identify market-friendly, pro-business options for supporting private innovation. Some options include the following:

- Align technical and vocational courses to industry needs by preparing technical manuals in French and Kinyarwanda that codify the in-house expertise of existing value-added enterprises. The manuals could then guide technical and vocational schools in course design and delivery.

- Establish a training grant facility to support enterprise-based training projects for delivering technical and management courses to workers and out-growers. The modules would be designed by the enterprises, with assistance from training specialists.
- Establish an organic production and research association in collaboration with NUR's soil lab. The association would train enterprises in organic practices for pest control, erosion management, soil restoration, and soil fertility. In addition to the environmental benefits, organic certification would help firms producing coffee, flowers, fruits and vegetables, and silk command premium market prices for their products. Very little knowledge exists in Rwanda on the right methods of organic soil management. Setting up an organic production and research association with public and private support could help by collecting best-practice information, organizing worker training programs, inviting foreign experts, and developing local knowledge of world-class organic practices.
- Establish a technology advisory service to help firms search, acquire, and upgrade their technology.

PRODUCTION AND DIFFUSION OF APPROPRIATE TECHNOLOGY

"Appropriate technologies" are affordable and accessible technologies that can improve living conditions in villages and cities or boost family and business incomes. The development and diffusion of these technologies has been slow and fragmented in Rwanda. The technology diffusion agencies (the Centre for Innovation and Technology Transfer [CITT] at KIST, the Institute for Scientific Research and Technology [IRST]) have limited capacity to identify appropriate technologies, modify them for use in Rwanda, and get them into the hands of entrepreneurs who can produce, market, and distribute them.

Capacity shortages and weaknesses exist at several critical points in the appropriate technology value chain:

- The agencies responsible for producing technologies (CITT, IRST) focus more on development (design, prototypes) of new technologies and less on transferring these technologies to small and medium-size enterprises.
- Design and prototyping takes place without feedback from clients or potential retailers. As a result, prototypes fail to get from workshops to end-users.

- The products produced in CITT and IRST are not always affordable or efficient.
- Low-cost technologies are frequently available outside Rwanda, but the technology agencies do not make an effort to search for and acquire them.
- The low purchasing power of most Rwandans suppresses the uptake of technologies.

To address these issues, the report recommends a variety of recommendations:

- Boost the technology transfer skills of CITT personnel by initiating specialized training courses in cost-benefit analysis, market value chains, project formulation, proposal writing, and business communication.
- Establish an international outreach program that would link CITT with global counterparts through staff exchanges, staff visits, and seminars.
- Establish a technology diffusion trust fund that would finance joint proposals by universities, private firms, research centers, and civil society organizations for technology sourcing, development, or distribution projects. Encourage the private sector and organizations other than CITT to participate in technology development and diffusion projects.
- Revise the system for evaluating research proposals so that the criteria include such factors as demonstrated demand for the research and the proposed transfer and dissemination strategy.
- Devise incentives to encourage CITT and IRST to focus on the transfer and distribution of appropriate technology as well as on prototyping and production. Create positive incentives (salary increases, bonuses, promotion, and learning opportunities) for good results and negative incentives for poor results.
- Design TVET courses in conjunction with technology development and diffusion agencies. The general shortage of skilled workers—installers, demonstrators, trainers, repairers, metal workers, spare-parts manufacturers—hampers the diffusion and adoption of appropriate technologies. Technical and vocation schools in Rwanda already offer a number of technology-related courses, but these courses are too theoretical and impart little hands-on knowledge. Designing TVET course in conjunction with technology development and diffusion agencies would help to address this problem.

DELIVERY OF CLEAN DRINKING WATER

Waterborne diseases, caused by a shortage of potable water, are a major source of illness in Rwanda. Cities and villages face shortages of clean drinking water. In rural areas, a majority of Rwandans drink and use unclean water from springs and swamps. Even in Kigali, the municipal water networks meet only about half of the demand for drinking water. Rainwater harvesting and other technologies in widespread use around the world can provide a relatively low-cost effective water supply for use in cooking and drinking water.

The techniques and technologies for delivering clean drinking water to rural villages are widely known but not widely used in Rwanda. Part of the problem is the shortage of technical and vocational skills needed to build and maintain water distribution networks. Engineering and technical capacity is also needed for exploring and drilling for underground water.

Capacity shortage exists at several levels in the water sector. Districts face a shortage of well-trained plumbers, mechanics, spring workers, engineers, and technical managers to run and maintain water networks. The central regulatory bodies (the RBS and the Rwanda Utility Regulation Authority [RURA]) need greater technical capacity to manage the quality of water and the quality of imported water equipment. The local utility company, Electrogaz, lacks the engineering capacity to assess and exploit underground water resources. It also has poor laboratory resources for water quality control.

To address these issues, the report recommends several policies and programs:

- Establish a three-year technical support program for vocational training centers that offers certificates and diplomas for water technicians. Most of these centers are nongovernmental. They lack skilled trainers, curriculum designers, evaluation resources, and the financial resources needed to maintain laboratories, expand class-size, and provide scholarships. A technical support program would help these schools deliver good-quality courses that focus on building practical skills for water technicians.
- Add courses on water management to the civil engineering course at KIST. KIST could help build hydrogeology expertise at Electrogaz that would allow the company to explore and exploit underground water. Electrogaz could partner with KIST to set up joint certificate programs that would impart practical water management skills to graduates, thus boosting the quality of the human resources available to all players in the water sector.

- Institute a hydrogeology course at KIST in collaboration with the Council for Scientific and Industrial Research (CSIR) water laboratory in South Africa to build capacity in underground water assessment.
- Add a rural water management course at NUR.

GEOSCIENCES AND GEOTHERMAL ENERGY

Most Rwandans live in villages that are not connected to the power grid. Building standard thermal power plants that use imported fuels and connecting remote villages to the central grid are neither feasible nor affordable options. Therefore, Rwanda will need to develop alternative, cost-effective energy sources, including, where appropriate, wind, solar, small-scale hydro, and geothermal.

According to the U.S. Geological Survey, Rwanda is potentially rich in untapped geothermal resources and could potentially even become an exporter of geothermal energy. Unfortunately, Rwanda currently does not have the capacity to exploit its geothermal resources, evaluate what resources it has, or participate with other countries in the joint World Bank–United Nations Environment Programme East Africa Rift Geothermal Energy Facility.

To address the problem, Rwanda needs to develop a cadre of geologists and geoscientists and build technical geosciences capacity in various government ministries and technical institutions, such as KIST and NUR. It also needs to begin evaluating and exploiting its existing geothermal resources, in a way that uses the first round of investments as training opportunities for technical, vocational, and engineering students. Doing so calls for both short- and long-term approaches to STI capacity building.

Capacity-building gaps exist at several levels. Rwanda faces a shortage of geoscientists, geothermal engineers, geologists, and drilling technicians. Government ministries need the technical and managerial capacity to plan and implement projects for resource evaluation and exploitation. NUR and KIST do not offer courses in earth sciences or geosciences. There is little or no capacity in applied geoscientific R&D. This capacity would be useful not only for exploring for geothermal energy sources but also for exploring for water and mineral resources.

To address these issues, the report recommends a variety of policies and programs:

- Send students from KIST and NUR to study geosciences at appropriate institutions in Africa, Europe, and the United States. This training is crucial to meet Rwanda's geothermal energy goals.

- Establish a three-year technical support program for the Ministry of Infrastructure. A team of geoscience experts would assist the ministry in planning and monitoring projects for geologic assessment, testing resources, and developing pilot plants. All these tasks must be completed before any electricity could be generated from geothermal resources. This expert group would also help KIST, NUR, and IRST develop their geosciences programs.
- Create on-the-job training programs for Rwandan students and engineers. Training could take place at geothermal programs in Ethiopia or Kenya or at programs expected to get under way shortly in Rwanda.
- Establish an applied geosciences research program in three crucial areas: geothermal resource testing for power generation, testing and drilling underground water resources for drinking, and assessing and mapping mineral resources.

CLIENT-FOCUSED AGRICULTURAL RESEARCH AND OUTREACH

The agricultural research and outreach system in Rwanda is fragmented and has limited capacity for meeting such priority needs as boosting productivity of food crops, creating value-addition through postharvest processing, and ensuring sustainable use of land resources for farming. As a result, the overall level of knowledge employed in the agriculture sector remains low, and agriculture is not living up to its potential as an engine of economic growth.

Capacity gaps exist at several levels. Agricultural research laboratories lack the capacity to identify research needs of individual farmers or agribusinesses. There is a lack of coordination and communication between groups involved in technology transfer and technology users (farmers, agro-entrepreneurs). State research and training institutions (ISAR, NUR, ISAE) need to improve the training and quality of their staff. The two national institutions of higher learning in agriculture—NUR and ISAE—have inadequate capacity to produce high-quality scientists and technicians. NUR and ISAE do not help farmers and agro-industry enterprises upgrade the skills of their workers.

To address these issues, the report recommends several policies and programs:

- Develop specialist postgraduate training and skills upgrading program for the staff of ISAE and the Faculty of Agriculture at NUR. In the long term, at least 80 percent of all academic staff should have Ph.D. degrees.

- Build or rehabilitate properly equipped specialist teaching and research laboratories at NUR and ISAE.
- Introduce short modular courses and in-service training for professionals and practitioners in public agencies devoted to agriculture research and training activities.
- Develop continuing education services at ISAE and NUR (short, field-based training courses to workers and managers in agro-industry enterprises).
- Institute a technical support program to help ISAR revise its research agenda to make it results oriented. The program would also help ISAR develop profit centers (such as commercial soil testing and tissue culture labs). The result would be increased cash flow for the laboratory and increased productivity for agro-industry enterprises.
- Establish a competitive grant fund to finance merit-based research proposals. Special emphasis would be placed on proposals that foster cooperation between public research institutes and the private sector and that emphasize technology diffusion of the research results.
- Establish a client-led National Agriculture Technology Advisory Board. The board would review research needs of clients, progress in technology transfer, and the granting of competitive funds to research proposals.

CHAPTER 1

Overview and Summary of Results

The World Bank and the Government of Rwanda began work on a science, technology, and innovation (STI) capacity-building technical assistance program in August 2006. The objective was to help Rwanda build the STI capacity it needs to identify, design, and implement practical solutions to everyday practical economic and social development challenges. These challenges fall into two broad categories: (a) improving the lives of the rural poor, reducing poverty, and achieving the Millennium Development Goals (MDGs) and (b) generating wealth, diversifying the economy, and supporting private sector initiatives to produce and sell value-added natural resource (mostly agricultural) exports.

This chapter provides an overview and summary of this program. The first two sections discuss Rwanda's current social and economic problems and the Government's commitment to STI capacity building. The purpose of these sections is not to rehash the well-known litany of problems and policy initiatives but rather to show how development issues and policy initiatives shaped the design and structure of the STI capacity-building program that eventually emerged from the partnership between the Government and the World Bank. Too often, government STI capacity-building programs do not closely link specific STI investments and the country's economic and social development objectives, almost as if investing in science and research and development (R&D) obviated the need to design detailed programmatic linkages and develop mission-oriented capacity-building programs. That was not the case in Rwanda, which makes this program unique and worth studying in detail.

The third section describes the design of the program and discusses some of the basic principles that influenced its design and implementation. The fourth section examines some of the general lessons that emerged from the program. The last section considers some implementation issues.

CURRENT SOCIAL AND ECONOMIC SITUATION

Rwanda has made impressive development strides, recovering remarkably well following the 1994 genocide. The economy grew at an average rate of almost 10 percent a year between 1995 and 2005. The Government has introduced market reforms and privatized many state-owned enterprises. Economic and political governance has improved dramatically. The Government has introduced measures to promote reconciliation and peace. Poverty and mortality rates are down significantly, and immunization and literacy rates have risen substantially.

These results are impressive. But growth is beginning to slow, as the natural rebound effects from the depths of the genocide begin to wear off. And Rwanda still has a long way to go before it achieves the MDGs or raises per capita incomes even to lower-middle-income levels. With per capita income of about $260 a year, the average Rwandan still lives below the $1 per day poverty line. About 90 percent of Rwandans are engaged in subsistence agriculture, and only 6 percent have access to electricity and clean water.

Wood, charcoal, and biomass are the main fuel sources, even for many middle-class urban Rwandans. Electricity shortages and overdependence on biomass led to deforestation and soil erosion, and they adversely affect productive sectors, schools, health centers, and households. Simple technologies to tap and preserve water during the two annual rainy seasons are not used. Surplus food rots because of the lack of storage and processing capacity, while many of the people who produce crops lack the security of a stable year-round food supply. Productivity of such staple crops as rice, beans, and cassava is below that of neighboring countries. Building capacity to address these challenges would provide a major boost to national welfare and quality of life and go a long way toward helping Rwanda reduce poverty and achieve the MDGs.

With per capita income of only $0.71 a day, Rwanda needs to boost per capita income by 40 percent just to lift the average Rwandan above the $1 a day poverty line. Put differently, if Rwanda hopes to become more prosperous, it must find ways to reduce the ranks of the rural poor, not merely develop technologies that make life more tolerable for them.

Reducing the ranks of the poor must entail creating more-productive, higher-paying jobs outside or alongside subsistence agriculture; developing new exports with higher value added;[1] and improving the quality of science and technical education at all levels.

Meeting these challenges entails building STI capacity. Rwanda cannot hope to achieve the MDGs if it does not have the scientific, engineering, and technical/vocational capacity to handle such mundane problems as delivering clean drinking water to rural villages or preventing food from rotting shortly after it is harvested. It cannot hope to prosper in an increasingly competitive global economy and open trading system if it does not build the appropriate science, technology, innovation-entrepreneurial, engineering, and technical/vocational capacity to produce more value-added goods and services.

Fortunately, much of the science, engineering, and technical knowledge needed to achieve these challenges is already widely used outside Rwanda. Unfortunately, it is not being used inside Rwanda. The primary challenge is therefore to train farmers, entrepreneurs, engineers, technicians, scientists, and teachers to find appropriate technologies, import them, adapt them to local conditions, and use them to solve local problems and produce and market higher-value, more knowledge-intensive goods and services.

To do so, Rwanda will have to improve the quality of its applied engineering and scientific research institutes, as well as its technical and vocational education. It will also have to focus more of its teaching, training, and research efforts on using existing knowledge to develop, produce, and deploy such simple, low-cost technologies as more efficient wood-burning stoves, manual irrigation pumps, food-processing and storage equipment, nonelectrical refrigeration or food-cooling equipment, and low-cost construction materials and methods.

Enterprises will not be able to exploit the competitive opportunities generated by appropriate technologies if they do not have the organizational and managerial skills and the technical competence to build businesses around these technologies. For businesses to be profitable, their workers must have the requisite skills to use new technology and perform more complex tasks. Rwanda suffers from a shortage of skilled technicians and craftspeople.[2] At the same time, graduates from the country's few technical and vocational schools find it difficult to find jobs, apparently because they do not receive appropriate technical training, according to a 2006 Japan International Cooperation Agency (JICA) tracer study. STI capacity building needs to encompass innovative ways of delivering and financing technical and vocational education.

IMPROVING THE LIVES OF THE RURAL POOR, REDUCING POVERTY, AND ACHIEVING THE MDGS

Rwanda's primary development challenge involves building the STI capacity needed to acquire, adapt, and utilize existing knowledge to solve Rwanda's pressing social and economic development challenges. Capacity improvement in five areas is critical:

- *Develop food-processing and food-storage capacity.* Increasing agricultural yields will not improve food security if surplus food rots because it cannot be safely processed and stored. Appropriate technologies need to be developed and deployed to process and store food without consuming large amounts of (unavailable) electricity. Developing a food-processing industry will also help generate off-farm income in rural areas. This, in turn, will help meet the Government's objective of providing employment and income-generating opportunities in rural areas without pushing people off the land and into urban slums. Moreover, developing food-processing capacity will allow Rwanda to transform its crops, vegetables, fruit, and livestock into higher-value processed products (juices, chilled vegetables, dried fruit, or packaged meat). Demand for processed food is strong inside Rwanda, in neighboring countries, and in more distant markets, but Rwanda has yet to exploit this market in a way that reduces poverty. The chief capacity problems are poor technical capability in training and regulatory institutions; poor technological capability in enterprises and farmer associations; and the shortage of trained food technicians and managers. To break into the processed food market, Rwanda will need sustained capacity-building efforts at universities, vocational schools, technical institutes, and private enterprises.
- *Improve agriculture research and outreach.* The agricultural research and outreach system in Rwanda is fragmented and has limited capacity for meeting such priority needs as boosting the productivity of food crops, creating value addition through postharvest processing, and ensuring sustainable use of land resources for farming. As a result, the level of knowledge employed in the agriculture sector remains low, and agriculture is not yet living up to its potential as an engine of economic growth. Capacity gaps exist at multiple levels: public laboratories are poorly linked with farmers and the private sector; skilled researchers and technical staff are in short supply; and the private sector does little in-house research and training. Rebuilding the capacity of the agricultural research

and training system—the NUR Faculty of Agriculture; technical schools, such as the Institut Supérieur d'Agriculture et d'Elevage (ISAE); public research laboratories, such as the Institut des Sciences Agronomiques (ISAR); and technology transfer centers—are essential elements of the national STI capacity-building program.

- *Encourage the development and diffusion of appropriate technologies to improve living conditions in villages and cities*. Simple technologies—such as biogas, rainwater harvesting, Ecosan latrines, pumps, maize millers, drip irrigation, and small tractors—can improve living conditions in Rwanda. They can also boost business incomes. The development and diffusion of these technologies has been slow and fragmented across urban and rural users. The technology diffusion agencies (the Centre for Innovation and Technology Transfer [CITT] at KIST, the Institute for Scientific Research and Technology [IRST]) have limited capacity to identify appropriate technologies, modify them for use in Rwanda, or get them into the hands of entrepreneurs who can produce, market, and distribute them. A major capacity-building task would consist of training technology and research institutes in transfer and commercialization activities.
- *Improve the delivery of clean drinking water*. Waterborne diseases, caused by a shortage of potable water, are a major source of illness in Rwanda. Rainwater harvesting and other technologies in widespread use around the world can provide a relatively low-cost supply of cooking and drinking water. One of the reasons why these technologies are not used in Rwanda is that the technical and vocational skills needed to build and maintain water distribution networks are in short supply. A vocational training program to boost the supply of trained technicians along with a program to finance the construction of drinking water systems might help address both the supply and demand side of the equation. Engineering and technical capacity is also needed for exploring and drilling for underground water. Capacity-building efforts need to focus on technical and vocational schools; the Kigali Institute of Science, Technology and Management (KIST); the National University of Rwanda (NUR); and the public utility company (Eletrogaz).
- *Increase capacity in geosciences and geothermal energy.* Most Rwandans live in villages that are not connected to the power grid. Because it is either infeasible or unaffordable to build standard thermal power plants that use imported fuels or connect remote villages to the

central grid, Rwanda will need to develop alternative sources of energy, including, where appropriate, wind, solar, small-scale hydro, and geothermal power. Rwanda is potentially rich in untapped geothermal resources and could potentially even become an exporter of geothermal energy. It lacks the capacity to exploit its geothermal resources, evaluate its resources, or participate with other countries in the joint World Bank–UNEP East Africa Rift Geothermal Energy Facility, however. It therefore needs to develop a cadre of geologists and geoscientists and build technical geosciences capacity in various government ministries and technical institutions, such as KIST and NUR. It also needs to begin evaluating and exploiting its existing geothermal resources, in a way that uses the first round of investments as training opportunities for technical, vocational, and engineering students. Doing so calls for both short- and long-term approaches to STI capacity building.

- *Strengthen technical and vocational education*. Rwanda suffers from a major shortage of skilled technicians and craftspeople needed to perform such diverse tasks as repair automobiles, repair and maintain electrical appliances and such electronic equipment as printers and copiers, and design and construct drinking water systems and geothermal energy installations. Paradoxically, at the same time, graduates of existing schools face difficulty finding jobs, because they do not receive enough hands-on training to be of immediate use to the employers. Rwanda will have difficulty moving beyond subsistence agriculture without an adequate supply of personnel trained in these mid-level skills. Developing new, more effective ways to deliver technical and vocational education and linking this education more closely to the needs of industry are critical challenges.

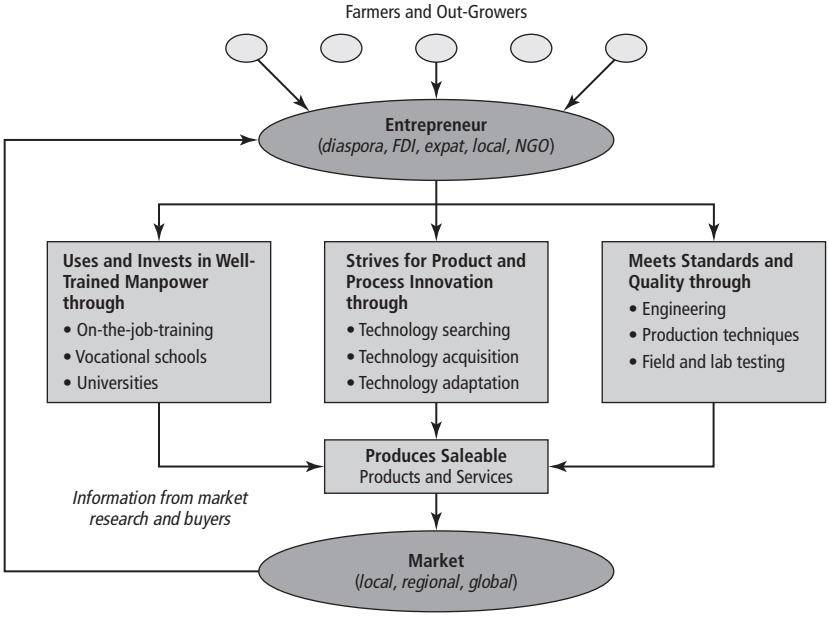
CREATING WEALTH AND DIVERSIFYING THE ECONOMY

In the past five years, Rwanda has developed high-value-added export industries in such diverse fields as coffee, roses, and pyrethrum. Private investors have plans to move into additional value-added sectors, including tea, silk, herbs, essential oils, and specialty vegetables. Investments in each of these ventures share several features:

- Entrepreneurs carved out a niche at the high or premium end of the market. This is typically the most lucrative end of the market and the one that is most difficult to access.

- Entrepreneurs work (or plan to work) in partnership with subsistence farmers. Specifically, local farmers devote a portion of their time and land to growing a cash crop. The rest of their time is devoted to subsistence agriculture. The cash crop is expected to generate annual income of $300–$500 per family. (A proposed horticulture program envisions cash income of $3,500 per family within five years.) Subsistence farming will provide most of the family's basic food supply; the cash income can be used to finance such items as school fees, health care, or even an occasional nonessential item. The additional spending power of families has a noticeable impact on the commercial vitality of the village.
- In the case of pyrethrum and roses, the primary entrepreneurs are former Rwandan expatriates who returned to start businesses in Rwanda. In the case of the coffee enterprise, the initial entrepreneur was a U.S. expatriate funded by the U.S. Agency for International Development (USAID). Numerous Rwandan entrepreneurs have entered the market for producing, processing, and exporting premium coffees. The silk industry is being developed primarily by a foreign investor.
- Entrepreneurs provided the undertaking with an invaluable package of rare (for Rwanda) skills, including an understanding of the importance of quality control; a technical understanding of how to achieve quality control; management, organizational, and entrepreneurial capacity; technology awareness and knowledge; and access to markets or a clear strategy for establishing links to buyers. Individual subsistence farmers, who have been isolated from the global marketplace for generations, or even cooperatives made up of small-scale subsistence farmers, cannot be expected to possess these skills or know-how. As a result, the entrepreneur is the critical ingredient and the key to the success of subsequent capacity-building programs.
- Entrepreneurs started with a basic understanding of what the market required in terms of quantity, quality, and technical specifications (figure 1.1) They then reverse-engineered the production process to determine the required inputs and the capacity-building programs (training, supply chain linkages, logistics, and so forth) required to meet market demand. These successful capacity-building programs were designed by market-savvy entrepreneurs in response to market demands and requirements. They were not developed and implemented in isolation from market requirements or created as the result of abstract capacity-building programs.

Figure 1.1: Enterprise-based Model of STI Capacity Building



Source: Authors.

These enterprises provide much more than markets for local farmers. They help farmers organize into local producer coops. They train farmers in modern production techniques and quality control mechanisms. They also provide training in such "ancillary" activities as public health and sanitation and modern cultivation techniques for subsistence crops. Thus, in addition to boosting Rwanda's production of high-value-added crops and increasing the cash income of participating farm families, the enterprises provide a major impetus to local economic development, education, and technology upgrading. In effect, entrepreneurs become agents of STI capacity building as well as users of the STI capacity they help create.

GOVERNMENT COMMITMENT TO STI CAPACITY BUILDING

The Government of Rwanda has a long-standing commitment to STI capacity building. This broad vision guided the design of the STI capacity-building approach adopted in Rwanda.

The commitment to STI capacity building starts at the top, with guidance from His Excellency President Paul Kagame, who declared:

> Today, Africa faces the best opportunity for growth in its past 30 years . . . . To sustain this growth, the continent needs to harness

> science and technology, integrate Africa into the global market, and transform the economies for fierce competition in a world fueled by information and driven by knowledge. The application of science and technology is fundamental, and indeed indispensable, to the social and economic transformation of our countries. . . . Historically, whether one considers the role played by indigenous technologies in Africa, or the 19th century industrial revolution that transformed Europe and North America, or contemporary Asian experiences, it has been all about using scientific and technological applications to achieve fundamental socioeconomic transformation. . . . We in Africa at times seem trapped in consuming end-products of science and technology produced by others, as opposed to deploying this knowledge to build products or adding value to the existing ones. [The challenge for Africa] is about applying science and technology holistically—in all levels of education and training . . . in commercializing ideas, in developing business and quickening the pace of wealth-creation and employment-generation, in enabling government to provide better services . . . and indeed in providing basic tools to society at large for self- and collective betterment.[3]

The Government's Vision 2020 Statement and its National Science, Technology and Innovation Policy (NSTIP) are designed to convert this broad vision into tangible policies and programs.[4] Both policy initiatives are based on the premise that Rwanda will have difficulty achieving its growth, poverty reduction, wealth creation, and export diversification objectives unless it embarks on a concerted effort to build STI capacity.

The concept of a "concerted effort to build STI capacity" raises three important questions: What are the objectives of building STI capacity? What STI capacity should Rwanda build? How should this capacity be built? Vision 2020 and NSTIP provide general answers to the first two questions. The Government of Rwanda–World Bank STI Capacity-Building Technical Assistance Program attempts to answer the third question.

The starting point for Vision 2020 is a comprehensive catalogue of high-priority social and economic development challenges facing Rwanda. These include such issues as the following:

- Meeting the food and nutrition needs of the population at large.
- Broadening and diversifying the economic base by producing a larger range of higher-value-added, more knowledge-intensive goods and services for the domestic market and for export. Rwanda has neither the location nor the topography to support the

production and transportation of low-value bulk commodities. It must therefore learn to produce low-volume, high-value, high-quality goods and services.
- Generating cash income for subsistence farmers. This income will, in turn, help revitalize the economic and social life of village economies and provide the financial resources for sustainable social programs.
- Improving access to basic infrastructure and services such as housing, water, and sanitation.
- Improving access to electricity and reducing dependence on biomass.
- Improving access to clean drinking water.
- Improving nutrition and hygiene.

Rwanda's problems can be resolved in a sustainable manner only if Rwanda builds appropriate STI capacity. According to Vision 2020, its STI capacity should be directed at solving these problems. It should be a highly targeted, mission-oriented task, much like putting a man on the moon was for the United States in the 1960s.

The NSTIP was designed to outline the different types of STI capacity Rwanda needs to build.[5] Its principal policy objective is "to integrate science, technology, scientific research and innovation in a framework that shall include capability building, technical transfer initiatives, and the promotion of innovation in the context of the issues facing Rwanda. Science, technology and scientific research shall be catalysts to underpin all public and private sector activities to enable Rwanda's Vision 2020 to be realized."

NSTIP proposes to build STI capability in four areas:

- knowledge acquisition, which will entail "interventions at all levels of science and technology education and training," starting with preprimary and ending with higher education;
- knowledge creation, which involves "the high-level equipping of all research institutions to provide high-level theoretical and practical training to produce high-caliber scientists, engineers, doctors, and so forth";
- knowledge transfer, which entails policies to improve the linkages between research and industry and programs to establish technology consultation centers, science parks, and so forth; and
- innovation culture, which involves inculcating an entrepreneurial, innovative culture at all levels of society, including business, the public sector, and universities.

Vision 2020 and NSTIP point Rwanda in the right direction, an essential first step in reaching any destination. But the Government quickly recognized that these broad policy objectives need to be supplemented with detailed implementation blueprints comprising specific capacity-building policies and programs. The joint Government of Rwanda–World Bank STI Capacity-Building Technical Assistance Program was explicitly designed to help the Government take this next step.

METHODOLOGY AND DESIGN OF THE STI CAPACITY-BUILDING PROGRAM

The STI Capacity-Building Program was designed to proceed in two phases. The first phase, completed in June 2007, involved the preparation of a series of STI capacity-building needs assessments and action plans (NAAPs) by joint teams of international and Rwandan experts. These plans are expected to be followed by an implementation phase in which the Bank and donors finance the recommendations in the NAAPs.

The preparation of each NAAP was organized as follows:

1. *Define priority areas.* Following several months of detailed consultation with Government officials in numerous ministries and agencies, university rectors, directors of national training institutions, bilateral donors, private sector support organizations, industry associations, entrepreneurs, nongovernmental organizations (NGOs), World Bank colleagues, and other stakeholders, it was agreed that the program should focus on the preparation of a series of NAAPs in the six high-priority areas specified in the NSTIP: food-processing; adding value to natural resources in such sectors as coffee, silk, pyrethrum, horticulture, specialty vegetables, herbs, and essential oils; development and diffusion of appropriate technology[6]; delivery of clean water to rural villages; geosciences and geothermal energy; and agricultural research and outreach.[7] It was also agreed that each NAAP would attempt to answer three broad questions: What is Rwanda's current capacity? What capacity does Rwanda need to meet the Government's social and economic development goals? What specific policies and programs are needed to build this capacity?
2. *Prepare draft terms of reference (TOR) for each study.* Each TOR was discussed extensively and agreed on with the full range of stakeholders identified above. An important objective was to avoid receiving reports that consisted largely of broad generalizations ("develop policies to link existing R&D capacity more closely to the needs of industry,"

"target appropriate technology to the needs of the market," and so forth). Instead, the TORs called for preparation of detailed, specific policy and programmatic recommendations; detailed descriptions of how to implement each recommendation; and estimated costs.

In preparing the TORs, it was important to set some sort of boundary between STI capacity building and other sector issues. For example, in the course of preparing the NAAP for geosciences and food-processing, the expert teams made no effort to assess the cost-effectiveness of geothermal energy relative to other forms of energy or to estimate the market demand for processed food in neighboring countries. These are important issues, but they are far beyond the realm of this STI capacity-building exercise. Consequently, they are not discussed in this report. However, each NAAP was prepared in close consultation with World Bank and donor colleagues working in particular sectors. As a result, the expert teams preparing each NAAP were able draw on the extensive existing background literature that these colleagues had prepared. Indeed, the TORs for each assignment specifically contained a list of related background documents that the consultants were expected to read and absorb.[8]

The NAAP did not ask if there would be demand for this capacity once it was created. This is not an oversight. Conducting an analysis of market demand for such items as processed food or electricity generated from geothermal energy was beyond the remit of these STI capacity-building studies. Nevertheless, demand is important, and the NAAPs did not simply assume that demand would automatically be present if the requisite capacity were developed. On the contrary, the expert teams relied on recently published reports that covered demand-side issues extensively (see appendix 1). Consultations and interviews with agencies and institutions in Rwanda helped refine the demand side aspects of a given sector. (A list of these institutions is provided in appendix 3.)[9]

3. *Identify suitable consultants following stakeholder consultation.* Although there was never an explicit decision to hire engineers to the exclusion of other professionals, most of the consultants selected are engineers. Each consultant has extensive technical work experience in the sector in question; many have extensive experience working in that sector in Rwanda or nearby countries. Technical and regional-specific work experience were mandatory; broad generalists were not engaged. This flattened the learning curve and helped ensure that each consultant could hit the ground running.
4. *Assemble teams of international and local experts.* Including Rwandan experts served two important functions. First, they contributed detailed

sectoral knowledge. Second, by teaming with international experts, they learned how to prepare NAAPs, ideally developing a detailed understanding of the specific recommendations in each NAAP. Although not a guarantee of success, this team-based approach helped ensure that foreign experts did not simply jump in and out, leaving behind a written report that was only vaguely understood and owned by local officials and stakeholders. The fact that the consultants had long-standing working relationships in Rwanda or nearby countries also helped ensure continuity.

5. *Engage each three-person team for about 30–40 days of intensive fieldwork and discussions in Rwanda.*[10] In total, the preparation of six NAAPs required 18 staff-months of consultant time over a five-month period from February to June, 2007.
6. *Convene stakeholder meetings after a preliminary draft of each NAAP is available.* Each meeting was chaired by a representative of the Ministry of Science, Technology and Scientific Research and attended by about two dozen participants, including representatives from other ministries, directors of relevant government agencies, university rectors, NGOs, bilateral donors, UN agencies, and other interested parties. The meetings provided yet another opportunity to receive comments and criticism, publicize the findings, and build a consensus around the overall work program.

A common philosophy—a series of "do's" and "don'ts"—undergirded the preparation of each NAAP. A central premise was that education and skill development were the critical ingredients for each NAAP. Without them, nothing else could succeed; with successful skill development and education programs, other related capacity-building programs had a chance of achieving their desired objectives. This principle flowed from the observation that too few people in Rwanda have the skills they need to solve their problems. The knowledge to address each of the six high-priority issues already exists and is widely applied outside Rwanda. But this knowledge is not being applied in Rwanda, largely because of the lack of trained personnel (workers, managers, and government officials). For example, developing a food-processing industry and delivering clean water to rural villages in Rwanda do not require new scientific developments. Taking the first steps toward meeting these goals does not require going into a laboratory and making a new discovery. It does require highly focused technical training and skill development programs, which, in turn, may require programs to train both university professors and vocational instructors so that they can train others.

These training initiatives therefore became essential elements of STI capacity building.

Training and education are not the only issues that must be addressed. Finance, entrepreneurship, fiscal incentives, regulatory measures, government regulations, government support programs, and public-private partnerships are also critical elements in the capacity-building equation. Unless these issues are also addressed, training and education initiatives will not translate to results on the ground.

Training does not have to be provided exclusively through the formal education system. Significant training can and should be provided by private enterprises, cooperatives, or producer associations. Such training is already taking place on a limited scale in the coffee, silk, and horticulture sectors, where the vast majority of outgrowers are semiliterate subsistence farmers. Public-private training partnerships could be critical to the success of any scaling-up effort.

Preparation of each NAAP was governed by a series of principles that influenced what this STI capacity-building program would not entail. Four of these principles deserve special mention.

First, given the focus on the mundane, day-to-day problems of economic development and poverty reduction, the program did not focus on improving university teaching or research proficiency in biology, chemistry, physics, or mathematics. Improvements in teaching and research capacity may be indirect byproducts of the NAAP recommendations, but the objective was not to develop academic science per se.

Second, the program did not focus on improving Rwanda's ability to conduct cutting-edge scientific research, publish articles in world-class scientific journals, or generate patents. These accomplishments are frequently cited as measures of national scientific proficiency. This type of proficiency was neither the objective of this program nor the metric of success.

Third, the program had nothing to do with developing high-tech industries in Rwanda or attracting foreign investment in high-tech industries. STI capacity and high tech are not synonymous. The capacity-building program was not designed to help Rwanda gain a toehold in the information technology industry or to become a major player in the global biotech, nanotech, or new materials industries. On the contrary, the program focused on developing such low-tech but critically important activities as building the capacity to can and preserve potatoes and deliver clean water to rural villages. These activities do not require the same cutting-edge research capacity as nanotechnology. They do require considerably more STI capacity and knowledge inputs than are currently available in Rwanda.

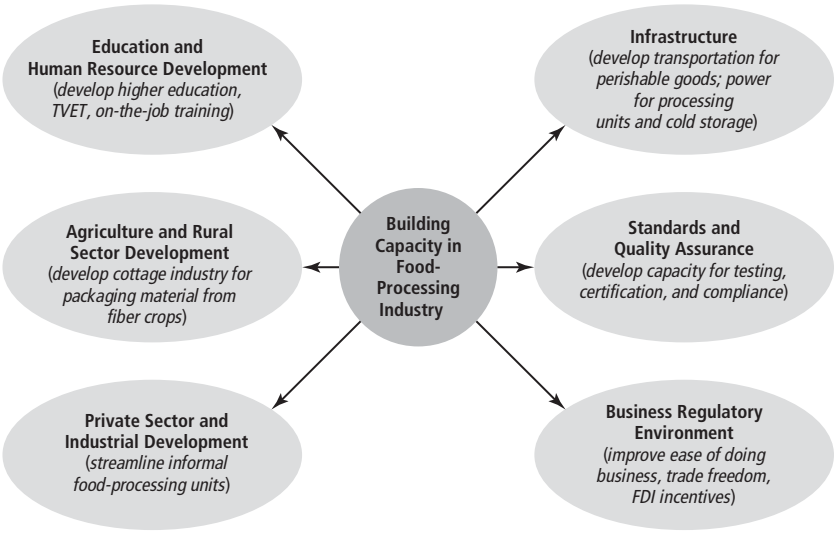
Finally, the program was not about acquiring information and communication technology or reducing the digital divide. These issues are being addressed in a comprehensive fashion by the World Bank's eRwanda project and the Government's National Information and Communications Infrastructure (NICI) Plan.[11] Instead of duplicating eRwanda's goals, the STI capacity-building program builds on the achievements of eRwanda (for example, many of the institutions targeted by eRwanda are the same institutions in which the NAAPs recommend building human and technical capacity).

LESSONS LEARNED

Several broad principles for building STI capacity emerged from the NAAPs and related work:

- STI capacity building should focus on finding practical solutions to practical problems. Especially for small countries like Rwanda that are at an early stage of the development process, broad, unfocused efforts to build science in general will probably not have the desired developmental impact.
- STI capacity building is a cross-cutting issue with a direct impact on such diverse programs as private sector development, rural and agricultural development, eRwanda, infrastructure and sustainable energy development, and education, among others. It would be difficult, for example, to raise agricultural productivity and the cash incomes of rural farmers without training them to employ modern cultivation techniques and to use more knowledge-intensive inputs. Thus, training farmers—and training extension agents to train farmers—can be classified as both STI capacity building and agricultural development.
- Because STI capacity building is a cross-cutting issue, something as seemingly simple as developing a food-processing industry or improving the competitiveness of the food-processing industry requires coordinated action across a large number of ministries and agencies (figure 1.2). Failure to coordinate and integrate actions and policies across these bureaucratic silos runs the risk that the capacity-building program will not achieve its objectives and that the money invested by other agencies and organizations will not produce the desired result. Even though the program may produce voluminous outputs, there will be a paucity of satisfactory outcomes.
- Individual sector reforms (education policy, reducing administrative barriers to the development of small and medium-size enterprises,

Figure 1.2: Cross-cutting Nature of STI Capacity Building

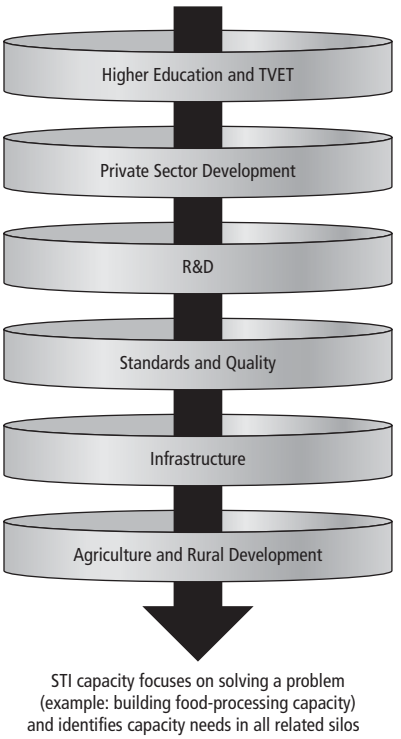


Source: Authors.

reducing the cost of doing business, and so forth) are necessary. By themselves, however, they will not be sufficient to generate the emergence of a food-processing industry or to deliver clean water to a rural village. These individual sector reforms must be complemented by a problem-solving approach that cuts across individual sectors and builds coherent, integrated capacity in all required areas (figure 1.3). Put differently, reforming the education sector will not lead to the emergence of a food-processing industry, but it will be impossible to have a successful food-processing industry without meaningful contributions from the education sector. As part of a broader capacity-building program, education reforms are indispensable; by themselves, however, education reforms are not sufficient.

- STI capacity building is not only about scientists working in research laboratories. All levels of technology and skills—ranging from sophisticated scientists to engineers and technical and vocational workers—have to be developed, in the appropriate proportions and sequence (figure 1.4.)
- STI capacity building is not just about research and development. It is also about getting knowledge out of the laboratory and into the market. Knowledge diffusion is a critical component of the capacity-

Figure 1.3: STI Capacity Building Cuts Across Traditional Silos of Development

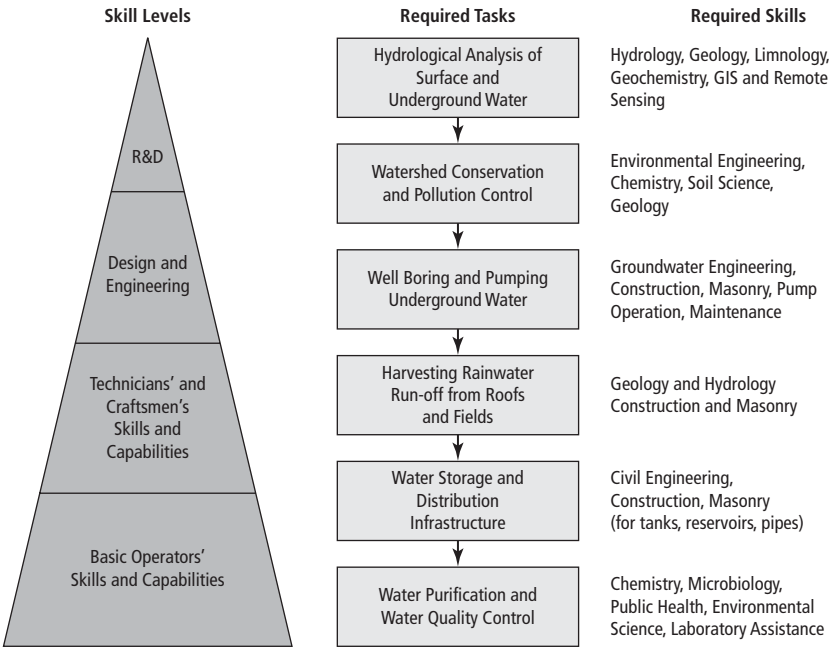


Source: Authors.

building process. This means that the private sector must have the marketing, management, and entrepreneurship capacity to utilize new and existing knowledge to produce higher-value-added, more knowledge-intensive goods and services. Supporting the development of entrepreneurship, marketing, and management skills must therefore be essential elements of Rwanda's STI capacity-building program. It also means that Rwandan workers must receive the training they need to perform increasingly sophisticated tasks.

- Public-private partnerships are an essential aspect of STI capacity building. The government has an indispensable role to play in supporting essential research, providing basic education, and creating an environment that will enable the private sector to create the jobs that will diversify the economy and generate wealth. But government investments in science and education will not bear fruit unless government capacity-building programs are consistent with the needs and requirements of the private sector. Developing these programs in partnership with the private sector is the best way to

Figure 1.4: Capacity-building Needs at Various Skill Levels



Source: Authors.

ensure the required consistency. In the field of education, for example, public-private partnerships may entail developing courses and curricula in close consultation with the private sector, but that is not the only possible option. In some instances, a public-private partnership may entail allowing the private sector to design and deliver a training course, with the public sector providing quality control, accreditation, and perhaps some financial support. Short courses, offering certificates of completion rather than formal degrees, may also be useful.

- Technical and research institutions perform poorly because of weak incentive structures. As a result, the overall innovation climate suffers. Fixing these incentives, boosting institutional performance, and building an institutional culture of innovation are critical components of STI capacity.
- There is an advantage to being a latecomer. A country does not have to invent everything it needs. It can achieve significant results and solve many problems by adapting and using off-the-shelf technology. Doing so still requires significant investments in capacity building.

- A small, landlocked country like Rwanda should make full use of regional markets and regional expertise to expand its learning opportunities. Its entry into the East African Community should help meet this goal: students can find training and jobs in regional firms; firms can export goods and services to larger, more sophisticated markets; and educational institutions can collaborate with regional counterparts to achieve economies of scale, avoid wasteful duplication, and establish a rational division of labor based on each institution's comparative advantage.
- STI capacity building is not about high tech only. Producing high-quality coffee, silk, and roses, as Rwanda hopes to do, requires significant scientific, engineering, and technical capacity.
- STI capacity alone cannot solve all the problems of a sector. Finance, entrepreneurship, fiscal incentives, regulatory measures, government regulations, government support programs, and public-private partnerships are critical elements that must function properly for STI capacity building to deliver concrete results.
- Innovation must be a way of life for everyone, not a sporadic activity of a few isolated scientists.

BOX 1.1 IMPROVING INSTITUTIONAL CAPACITY AND BUILDING AN INNOVATION CULTURE

Implementing many of the recommendations in the six NAAPs will depend critically on the ability of Rwanda's research, training, and technology development institutions to perform their existing functions more efficiently and effectively while, at the same time, taking on new and more complex functions. Will they be up to the challenge? What can be done to help them meet these challenges?

These institutions must begin to develop and nurture a culture of innovation and excellence. To help them do so, the Government will need to:

- *Strengthen the chain of accountability and incentives for meeting objectives and achieving results*. Rwanda lacks a system of positive and negative incentives: good performance is not rewarded, and poor performance is not penalized or reprimanded. As a result, mediocrity flourishes, motivation suffers,

and the linkages between technology centers, research laboratories, and universities on the one hand and students, the private sector, and end-users on the other hand are weak. Because Rwanda's institutions remain isolated from their clients, their knowledge products are poorly designed and diffused, and the incentives to innovate are weak. This aloofness partly reflects the culture and mindset of staff and management, but it also reflects the fact that the current incentive system does not reward closer contact with clients.

- *Attract and retain the best and brightest staff by ensuring that good performance leads to higher remuneration, better benefits, career growth, recognition, and ample learning opportunities*. Without these changes, the ongoing exodus of staff from public research or technology centers to more lucrative private firms or international NGOs will increase, further weakening public institutions.
- *Give institutions greater financial autonomy*. Institutions should be encouraged to generate and retain revenues from consulting contracts, fees for services performed for the government or the private sector, tuition from courses offered to the private sector, and so forth. The quest for financial autonomy will force these institutions to improve their performance in order to survive and prosper.
- *Give institutions greater autonomy in managing their staff, strategy, and daily business*. Innovation cannot take place without the ability to search for new ideas, make quick decisions, and revise tactics in a free and flexible fashion. The constraints of bureaucracy must be loosened to allow this freedom and flexibility.

Rwanda's technical and vocational education and training (TVET) institutions share many of the same incentive and autonomy problems as research and technology institutions. In addition, they must overcome several unique challenges if they are to boost the quality and relevance of their training programs:

- TVET institutions face a chronic shortage of financial resources and are almost completely dependent on government budget support. These institutions could boost revenues by charging modest tuition and fees. (Charging tuition would have to be

accompanied by a complementary loan program to help students finance their education on easy terms.) They could also develop courses in partnership with the private sector, using private sector funding.

- Although the purpose of TVET schools is to produce workers with practical skills directly useful to industry, schools have minimal contact with industry. Closer partnership is needed with industry at every stage, including designing curriculum, recruiting industry practitioners as teachers, and using industrial attachment programs for hands-on training. Partnership would result in better-quality training for students, increasing their chances of finding jobs on graduation.
- TVET institutions should keep an eye on the rapidly emerging value-added sectors, such as specialty coffee, floriculture, tourism, and information and communications technology. The emphasis should be on developing and delivering new courses in consultation with the industry.

IMPLEMENTATION ISSUES

The next steps for Rwanda will be to implement the recommendations and to monitor and evaluate these programs to ensure that they are producing the intended results. Implementing the STI capacity-building process will entail legal, organizational, and institutional capacity building in each of the entities entrusted with implementing specific programs. Discussing and agreeing on these detailed implementation arrangements should be one of the immediate next steps in Rwanda's capacity-building process.

This process step has only just begun. However, even at this preliminary stage, it is possible to draw several general conclusions about implementation issues:

- Rwanda does not yet have a satisfactory legal and regulatory framework for research, development, science, and innovation. DFID's Science, Technology and Innovation for Results (STIR) program, which is just getting under way, will provide long-term technical assistance to help the Government prepare the legislative and organizational framework for STI governance.[12] The program will help ensure that the Ministry of Science, Technology and Scientific

Research; various STI institutions[13] (R&D agencies, technology institutions, training institutions); and various STI initiatives (competitive grants, tax incentives, science and technology scholarships) will have the appropriate mandate to carry out their new STI capacity-building responsibilities. The STIR program will also provide assistance to create a set of consistent and measurable STI indicators. These will help the Government gauge implementation performance and benchmark Rwanda's progress against other countries.

- Because STI capacity building is a cross-cutting issue, an effective program will put a premium on developing high-quality implementation and coordination capacity within the Government. Donor harmonization, along the lines of the Paris Declaration on Aid Effectiveness, will also be critically important. An informal meeting with donors, ministries, and other organizations responsible for STI capacity-building tasks may be a useful way to get this process started.
- Coordination and harmonization are not easy tasks, which is why successful, sustained capacity-building programs are rare.
- Given the complexity of STI capacity-building programs, committed leadership is essential. This commitment must start at the top, but it cannot be isolated there. The commitment must flow from the top to middle and lower layers of the bureaucracy and permeate large strata of civil society.

These challenges are daunting. Fortunately, Rwanda has the political will and commitment to tackle them successfully.

NOTES

1. Higher-value-added should not be confused or equated with high-tech. Electronics is generally regarded as a high-tech and horticulture as a low-tech activity, for example. But producing high-quality coffee, pyrethrum (organic pesticides produced from flowers of chrysanthemum family), and horticulture exports may be more knowledge and skill intensive than simply assembling imported components into finished computers. The critical economic development issues are the value added generated by a particular activity and the labor skills required to produce a particular product, not whether the finished product is classified as high- or low-tech.

2. According to a 2002 survey conducted by the On the Frontier Group (http://www.researchictafrica.net/images/upload/SME_book-Web.pdf), one-third of small and medium-size enterprises think the lack of trained and qualified human resources constitutes a major challenge to their development.

3. Paul Kagame, "Science, Technology and Research for Africa's Development" (speech, Eighth African Union Summit, Addis Ababa, January 2007).
4. Vision 2020 is available at www.moh.gov.rw/docs/VISION2020.doc. Rwanda's National Science, Technology, and Innovation Policy is available at http://www.rwandagateway.org/IMG/pdf/Rwanda_Conference_Draft_ST_Policy_document.pdf.
5. NSTIP was formally approved by the Government in August 2005, following extensive public consultation with a wide range of stakeholders throughout civil society. To oversee the implementation of the NSTIP, the Ministry of Science, Technology and Scientific Research (under the leadership of Minister Romain Murenzi) was created under the President's Office in March 2006.
6. The term *appropriate technologies* refers to technologies that are of particular interest for poverty reduction. They can include technologies that create income or improve the quality of life, especially for people in rural areas, where the vast majority of the poor live in Rwanda. The terms of reference for this project specifically cite technologies for rural energy; sanitation and waste management; water supply, rainwater harvesting and storage; and agro-processing. The study team also considered low-cost building technologies, agricultural equipment, and rural transport.
7. These six topics were selected for several reasons. First, they were listed as priority areas in the NSTIP. Second, the World Bank had related projects in many of these areas. Third, all were viewed as vital for Rwanda's efforts to achieve the MDGs and improve the competitiveness and wealth-creating capacity of the economy. Noticeably absent from this list is any mention of the enabling environment for STI or the legal framework within which individual capacity-building programs operate. This is not inadvertent. Once it became clear that the Bank was prepared to move ahead with a program of NAAPs, the Department for International Development (DFID) began work on a parallel program to improve the legal, regulatory, and institutional framework for science, technology, innovation, and research. The two programs are complementary and were developed in close consultation. It will be difficult to implement many of the Bank recommendations without an improved legal, regulatory, and institutional framework. DFID began work on the enabling environment precisely because the recommendations flowing from the NAAPs will create a demand for these improvements.
8. A list of some of the more relevant background documents is available in appendix 1. A sample TOR is available in appendix 2.
9. In the food-processing sector, for example, the NAAP relied on reports from trade shows organized by the Rwanda Investment and Export Promotion Agency (RIEPA). For the geothermal study, after extensive consultation with various experts, it was agreed that the initial draft TOR would be broadened to include capacity building in geosciences more generally as well geothermal energy. This would help Rwanda develop the technical capacity it would need to exploit its geothermal resources. But if geothermal energy failed to materialize as a viable, cost-effective energy option, Rwanda would also have the geological capacity for mining and minerals, clean water supplies, and other related topics.
10. Two other process-related issues deserve mention. First, staggering the field visits so that no more than two teams were in Rwanda at any given time allowed

local officials to devote more time and attention to each team. It also gave the World Bank team an opportunity to adjust the TORs of (or informal verbal instructions relayed to) subsequent teams based on lessons of experience from earlier teams. Second, it was important to have a World Bank team member in Rwanda for at least the first and last week of each team visit. Absentee management would not have been effective because it would not have provided the opportunity for constant interaction with team members and detailed consultation over which issues were important, what to highlight, what to ignore or downplay, and so forth.

11. Information on eRwanda is available at http://www.erwanda.org/spip.php?article36. The NICI Plan is available at http://www.rita.gov.rw/docs/NICI percent202010.pdf.

12. The STIR program will be supported by a grant of £700,000. The principal components of the program include assistance to help the Government define the institutional structures needed to implement the national STI policy; draft the legal and regulatory framework required to implement the policy, including the establishment of a National Commission for Science, Technology and Innovation and a National Research Fund; assess the human capacity needs of the new implementing institutions; and develop a monitoring and evaluation framework for its STI initiatives.

13. Appendix 3 contains a list of institutions associated with the STI capacity-building action plan.

CHAPTER 2

The Food-Processing Industry

SITUATION ANALYSIS/NEEDS ASSESSMENT

Food-processing offers Rwanda a wealth of opportunity for industrialization, economic development, and poverty alleviation. The government's political commitment has already been demonstrated by the establishment of the agencies necessary to support and regulate such an industry. However, the industry remains very limited in extent, scale, and quality. The absence at every level of a pool of appropriate technical labor with practical skills constrains the pace at which the industry can grow.

The Rwandan market for agricultural produce is generally disorganized, marked by small-scale production and marketing. Losses due to spoilage associated with storage often exceed 30 percent of production. The price difference between farm and factory gates can be as much as a factor 10, with the added value accruing to intermediaries with access to transport. High transport costs and losses are exacerbated by the deficient road system. These problems create a haphazard supply of raw materials of variable and unreliable quality.

A critical requirement for formal-sector food-processing industries is reliable access to raw materials of constant quality in a volume that enables economies of scale. Purchasing partly processed rather than raw materials yields major savings, reducing volume and weight by 70 percent or more, with associated reductions in transport costs. In Rwanda, however, very little processing takes place at the farm or community level, raising transport costs and postharvest losses. The huge number of

micro-producers, the lack of organization of the industry, and poor transport significantly limit the industry's potential.

Production in the formal sector is constrained by unpredictable input volumes and quality, as well as deficiencies in technical and managerial skills. With the exception of coffee- and tea-related enterprises, which are well organized and supported (and therefore excluded from this survey and report), the number of formal-sector food-processing enterprises listed by the Ministry of Industry and Commerce and the Rwanda Investment and Export Promotion Agency is about 40. This list includes 5 large, 12 medium-size, and 23 small-scale enterprises, most of them located in Kigali City. These firms employ 10–558 employees each. They process or produce coffee, tea, meat, biscuits, beer, fruit, mineral water, sugar, cooking oil, milk, animal feed, wheat, and maize flour.

Hundreds of informal food-processing businesses provide local markets with traditional products, such as banana wine, sorghum beer, meat, fruit juices, cereal and cassava flour, and bread. The Government encourages these informal food-processors to convert to the formal sector, notably through the formation of cooperatives. Toward that end, a new cooperatives law has been drafted and submitted to Parliament for approval.

The interview-based needs survey revealed several main constraints to expanding this sector:

- the shortage of trained human resources with appropriate practical or technical expertise, at all levels;
- the lack of a reliable supply of raw material;
- inadequate access to, the high costs of, and restrictions regarding the use of packaging materials;
- inadequate capacity of regulatory and other government agencies;
- the lack of cohesion and access to information necessary for commercial development, particularly technological;
- insufficiently supportive financial and business environment;
- the high cost of power;
- the high cost of transport; and
- problems with the water supply.

Because of the lack of a sustainable supply of local raw materials, the food industry relies heavily on imported raw materials and generally operates at less than capacity. As a result, time management is difficult, and only a few companies are able to operate three shifts a day. Most entrepreneurs lack sufficient business management skills to find the solutions necessary to address the constraints.

The cost of packaging is often prohibitive, sometimes exceeding the value of the potential export. The national ban on plastic packaging, frequently interpreted without reference to the regulations or their scientific basis, represents a serious obstacle. Overall, lack of resources severely limits the ability of the regulatory authorities to be proactive and constructively effective.

Food-processors have to make the difficult choice between investing in cheap and simple equipment from Asia or expensive and highly sophisticated versions that come from the West. They often chose the first option, purchasing separate pieces of equipment without taking account of the relative capacities of each machine. Turnkey plants tend to be more expensive but are normally designed more logically and with greater expertise. Some equipment, mainly in flour-processing plants, is assembled and welded in Rwanda by technicians hired from Tanzania or Uganda. Equipment often lacks the name and address of the manufacturer, leading to repair and maintenance problems.

The fact that some operations (peeling, washing, drying) are still frequently done manually reduces product quality. Processing facilities are often installed in sites and buildings such as garages and shops that happen to be available but are not appropriate for food-processing. This often and increasingly results in conflict with the regulatory agencies, the Rwanda Bureau of Standards (RBS) and the Rwanda Environment Management Authority.

STANDARDIZATION AND QUALITY MANAGEMENT

The RBS is working toward acquiring international accreditation. A specialist in the accreditation of laboratories has been hired to advise the staff on what is required to achieve accreditation and to train them in different laboratory tests. The RBS already is a member of the International Standards Organization (ISO) and CODEX.

The bureau faces challenges, including insufficient laboratory equipment, lack of reference materials, and insufficient trained technical staff. Lack of control at border points has led to an inflow of substandard goods into the Rwandan market. RBS now certifies processors by means of a quality mark.

HUMAN RESOURCE CONSTRAINTS

No capable technicians are available to Rwanda's food industry. For their part, managers rarely have hands-on knowledge of their industry and its

operation and are thus poorly equipped to recognize the deficiencies of their operations.

Students with bachelor of science degrees in food science and technology from the Kigali Institute of Science, Technology and Management (KIST), of which there are now some 200, have no meaningful practical experience, the subject being taught almost entirely in theory. They are thus of little use or interest to industry. KIST currently has no facilities for practical work, and the two months' training done at the Jomo Kenyatta University of Agriculture and Technology during the final fourth year of undergraduate studies is clearly insufficient to give students the practical skills they need. The performance of KIST graduates thus does not live up to the expectations of the private sector, which barely appears to be aware of these graduates. Despite the campaign conducted by KIST graduates themselves, there is considerable confusion between food-processing and cooking/hotel management skills.

As a consequence of this mismatch between industries' needs and the abilities of KIST graduates, companies understandably prefer to employ technicians trained abroad (in India, Kenya, and Uganda). The majority of the first two classes of KIST food science and technology graduates remain jobless; among those who are employed, a significant number appear to be doing jobs not directly related to their training. Discussions with local industry experts suggest that even more than university graduates, the food industry needs intermediate-level (A1) graduates with hands-on skills in butchery, baking, dairy, fruit and vegetable processing, and food services.

MARKETS FOR PROCESSED FOODS

The domestic market is constrained by the fact that only a small percentage of the population is in a position to consume processed products. Nonetheless, significant opportunities exist for import substitution, in fruit pulps and juices, dairy products, and meat products for the urban market, for example. There are also opportunities in the regional market, although uncertainty exists regarding the consequences of Rwanda's upcoming membership in the East African Community.

As for export markets, demand is not a major constraint to establishing and developing food-processing industries in Rwanda. A number of promising opportunities exist for exporting products, including honey, meat, and dried fruit and vegetables, particularly to the Gulf states. Data are scarce, because such agencies as the Rwanda Investment and Export Promotion Agency (RIEPA) have little reason to conduct market research

if the potential export does not exist or is considered too small to be profitable. A senior RIEPA official indicated that the agency currently focuses on developing the supply side rather than promoting exports, after learning at overseas trade shows that the volumes of relevant products produced in Rwanda are nowhere near those required to meet the orders of potential clients.

Access to export markets is constrained by poor quality, caused by lack of appropriate skills and expertise at all levels, inadequate technology, and the high cost of appropriate packaging materials. Poor organization prevents the necessary economies of scale permitted by high production volumes.

Given the high cost of shipment, the ideal export product for Rwanda is of low volume and weight per unit of cost or value added. Dried fruit and vegetables and products such as potato chips fulfill this requirement, because only minimal water content is shipped. These products possess the additional virtue of being highly suitable for processing in rural areas, requiring only the addition of packaging and market access. However, current production is marketed only locally, in nonfood-grade plastic bags, unprinted and with no indication of the provenance. In this form, even the potential for import substitution is limited: these products are generally found in only small shops.

DEVELOPMENT POTENTIAL FOR THE FOOD-PROCESSING INDUSTRY

Internationally, there is a strong market for dried fruit and vegetables. Accessing this market would require the creation of a high-quality rural drying industry, using simple solar-based technologies, and a formal-sector dry-packaging capacity, which would add value in terms of quality control and attractive modern packaging.

Specific subsectors that could potentially be developed include fruit juices, banana fiber, dried fruit, and beehives.

- *Fruit juices*. Pulping and pasteurizing passion fruit themselves could allow cooperatives to reduce weight and volume by about 70 percent, reducing transport costs and attracting client partnerships with formal-sector companies such as Shema Fruits and Laiterie Inyange.
- *Banana fiber*. Banana fiber—a waste product in Rwanda used only for mulching—can be made into paper. One innovative small-scale process can be carried out next to the plantation; it requires little electrical power and no water and produces no effluent. The finished paper product requires transportation to the cardboard-packaging

factory to be made into corrugated cardboard. Adopting this process could allow Rwanda to stop importing paper for bags and cartons and to export cardboard products within the region. Producing this product domestically would significantly reduce industrial costs.

- *Dried fruit*. International demand for dried fruit and vegetables is strong, particularly if they are certified organic. Because it is light and compact, high-value but low-weight dried food is the ideal export for a landlocked country. Low-cost solar dryers and good training could enable cooperatives to manufacture high-quality dried fruit and vegetables, but access to the market requires volume and attractive and hygienic packaging. The establishment of a dry-packaging factory that purchases finished products such as dried tomatoes, dried onions, and dried fruit from a large number of rural cooperatives would add value by means of packaging while simultaneously giving rural producers access to high-value and high-volume markets.
- *Honey*. Modern beehives increase honey production by a factor of at least five and increase yields of neighboring crops significantly (35 percent in the case of beans, 100 percent in the case of sunflowers). Shema Fruit would buy as much honey as available for export to existing customers in the Gulf states.

RECOMMENDED STRATEGIES

Food-processing must be linked to the production of primary material and respond to market demand. For this to happen, farmers need to develop business skills, and they need better access to market information so that they can respond more effectively to market signals.

A key strategy at the national level would be to promote simple food storage and conservation systems as well as processing technologies that have performed satisfactorily in tests. At the regional and subregional levels, seminars could be organized and a program set up to promote the prevention and reduction of preharvest and postharvest food losses, in combination with a subregional training project on the processing of tubers and root crops.

Food-processing can be profitable when raw material is available in the required quantities and quality at a viable price. To achieve this, it is important to enhance the capacity of both rural producers/primary processors and their formal-sector partner-clients. In addition, inexpensive packaging material needs to be easily available, and industrial equipment

needs to be upgraded. Successful exporting companies usually have a solid market foundation at home that helps them master the norms and standards essential for export markets concerning quality control.

The proposed strategic vision for developing the Rwandan food-processing industry involves four main components:

- organizing and training rural producer cooperatives to be commercial entities producing primary-processed crops in volume, using suitable technologies;
- establishing direct contractual links between primary-processing cooperatives and formal-sector industrial partner-clients;
- building the capacity of formal-sector food-processing industries through improved final processing, quality management, packaging, and access to markets; and
- addressing specific constraints, particularly in terms of education and in-service training of staff at all levels.

Realizing the proposed vision requires action on several fronts:

- Increase the availability of graduates with adequate theoretical and practical skills.
- Increase the number of industrial managers with specialist knowledge of and experience in specialized food-processing industry subsectors.
- Upgrade technical personnel at every level within the industry and the government agencies related to the food-processing industry.
- Organize, mobilize, and train rural producer cooperatives on a significant scale.
- Improve the financial and business environment.
- Improve consultation and cohesion between government agencies and the food-processing industry.
- Increase access to information on strategies and technologies for industrial development and the development of appropriate management mechanisms.
- Adopt a consultative approach to packaging policies and regulations and the establishment of environmentally and commercially acceptable implementation protocols.
- Increase the availability of economically viable and environmentally acceptable packaging materials appropriate for a modern export-oriented food-processing industry.
- Establish an efficient, transparent, and consultative regulatory environment and apply it identically to domestic and imported products.

- Encourage regulatory agencies overseeing commercial businesses to recognize the potential significance of the commercial food-processing industry for the economy of Rwanda.

The objectives of the proposed capacity-building options are to improve and consolidate existing enterprises and to prepare the ground for the future expansion of the industry. The key areas for which capacity-building interventions for the development of a sustainable food-processing industry are proposed include human resource development (professional training, vocational training, and in-service and other training); financial and economic support; industrial development and packaging; and regulatory environment (including laboratories and quality assurance).

Many measures can be initiated and constraints addressed immediately; other measures will take time to deliver measurable benefits. Thus, it is likely to be two or three years before the establishment of vocational training courses will begin to deliver competent technicians to the industry. Knowledgeable Rwandan managers for the food-processing industries will probably not begin to become available until the first cadre of the new practice-based training students have graduated, in six or seven years.

EDUCATING AND TRAINING PEOPLE

Human resource development is needed at various levels. Vocational training colleges and *écoles techniques officielles* could set up a food-processing technician course, to include hygiene, food-handling, and small-scale production of appropriate foods. Graduates would be suitable for employment and further training in the industry. They would also be equipped to set up and run micro-scale food-processing enterprises in rural areas.

To build capacity at the mid-level technical and management level, KIST could create a four-year, practice-based food-processing course leading to a bachelor's degree that includes a major in a particular subsector. To provide the required practical training and work experience, KIST could establish properly equipped specialist food-processing teaching laboratories. Students would acquire technical, management, and business experience through participation in self-financing production units that process dairy, meat, fruit, vegetables, and cereals. This group of units would be financially autonomous and act as a technology demonstration center for the Rwanda food-processing industry. The accounts of each unit should be accessible to commercial food-processing enterprises to assess

the cost-effectiveness of technologies and practices used. KIST could also provide in-service training by establishing evening courses and part-time programs in food-processing whose curriculum and delivery is defined by the needs of industry, and by the proposed Rwanda Food-Processing Association (described below) and commerce and regulatory bodies.

For higher-level management, a one-year, government-subsidized graduate apprenticeship (with continuing tutorial involvement) could be set up, nationally or regionally. This apprenticeship could become the basis for a one-year master's degree in the management of food-processing industries. The master's program could include enterprise and finance modules, given jointly with a school of business management. In addition, specialist postgraduate studies related to the food-processing industry could be encouraged, making use of scholarships from donor countries.

KIST could also establish an environment stream, with the objective of supplying the professionals needed to monitor and manage Rwanda's environment and to administer and manage the regulatory system. The program could train 50 environmental impact assessment experts and 50 environmental auditors specialized in various industrial subsectors, including food-processing.

The government could provide scholarships for one-year formal in-service training courses for key food-processing industry staff, principally outside Rwanda (in Botswana or Europe for meat packing and processing). It could publish a handbook on designing and implementing in-house staff training within food-processing enterprises in Rwanda. Technology-oriented study tours could be provided for enterprise decision makers, focusing on the comparison of particular technologies, their performance, and effects. Investors and managers could be educated about environmental impact assessment and significance and the benefits of environmental stewardship.

DEVELOPING BUSINESS DEVELOPMENT SERVICES

For primary producers and processors, capacity building could focus on developing business development services aiming at the identification, organization, mobilization, and training of producer cooperatives. This could include establishing mobile business development services that deliver on-site support to rural cooperatives in the establishment of primary processing enterprises and contractual partnerships with formal-sector food-processing industries. Regional study tours could be organized to allow local experts to visit and examine business development services for

food-processing, to enable business development services consultants to make use of the experience of others.

To increase the capacity of staff of regulatory agencies, KIST could establish training capacity for in-service training for Rwanda Environmental Management Authority (REMA) staff (generic and specialist), provided through evening classes. All hygiene inspectors should be trained to implement Rwandan standards, and only trained and qualified specialist hygiene and health and safety inspectors should be permitted to carry out inspections.

IMPROVING TRANSPORT AND PACKAGING

A joint research project involving KIST, the RBS, and REMA in collaboration with the proposed Rwanda Food Processors' Trade Association could identify environmentally and commercially appropriate packaging and promote its introduction and use as well as the appropriate regulatory framework. Research could be conducted on improving the transport of perishable foods, particularly meat, fish, and raw milk, including development of commercially viable low-cost technology solutions and handling systems.

CONDUCTING MARKET RESEARCH AND FEASIBILITY STUDIES

Market research could be conducted to identify suitable food-processing products and manufacturing capability in relation to local market and export opportunities. A database, managed and regularly updated by RIEPA, could be constructed on specific subsectors as a resource for investors, enterprises, and business support services.

Feasibility studies could be undertaken on the following topics:

- establishment of a food-processing park adjacent to a significant renewable-energy generation installation, capable of supplying sufficient power for modern food-processing industries and associated cold storage at modest cost;
- establishment of a frozen food factory in the food-processing park for potato chips, French fries, vegetables, meat products, and other products;
- importation of livestock from Burundi and the Democratic Republic of Congo for processing in and subsequent export from Rwanda;
- establishment of a dry-packaging enterprise capable of buying appropriate finished food-processing products in bulk from rural producer cooperatives and attractively packaging and exporting them;

- application of renewable energy systems available in Rwanda;
- the potential for introducing papermaking from crop residues, particularly banana stems, including the identification and investigation of any decentralized low-input and environment-friendly processes suitable for decentralization;
- the local manufacture of corrugated cardboard and cartons from sheets of paper made locally from crop residues, with particular reference to technology and quality (specific packaging requirements studied should include meat-grade, water-resistant cardboard boxes suitable for freezing);
- the potential for establishing commercial manufacture and distribution of intermediate nonmotorized means of goods transport (such as trailers for cycles and motorcycles and extended cycles); and
- the manufacture from banana palm fiber of impermeable sacks for meat packing, as a substitute for imported jute sacks.

ADOPTING COMPLEMENTARY MEASURES

A variety of complementary measures could also be taken:

- Support the formation and consolidation of an inclusive national Food-Processing Trade Association (FPTA) able to negotiate directly with regulatory authorities and other government agencies. The FPTA should include all food-processing stakeholders, including the formal-sector industry, producer/primary processor cooperatives, and KIST. The FPTA could fund industry twinning and exchanges with other countries in the region in order to increase capacity in Rwanda.
- Reduce or remove duties on food-processing production equipment not available within Rwanda, in order to encourage investment in appropriate modern equipment.
- Establish a national food-processing information center at KIST and a national rural technology information service, primarily Web based, created to provide information for relevant technologies in Rwanda and the region, furnish design information on appropriate equipment to manufacturers within Rwanda, and establish links with other disseminators of technology information.
- Define and implement strategies and mechanisms through which the regulatory authorities can improve their empathy with, accommodation of, and assistance to the food-processing industry, in order to develop a culture of constructive engagement and increase

the transparency of regulatory policies and decisions and the science upon which they are based. This process should involve developing and legally establishing an independent appeals procedure by which regulatory decisions can be challenged.

- Have the RBS publish a list of manufacturers whose laboratory equipment is acceptable for certification for specific processes within Rwanda; facilitate the training of a cadre of laboratory equipment maintenance technicians; publish clear protocols for all procedures, conforming to internationally accepted practices; maximize, together with REMA, regulatory alignment with other regional economies; increase and reinforce the capacity to test and analyze a significantly larger proportion of processed food imports in order to ensure conformity with Rwandan standards, including the indication of contents and conformity with environmental regulations; and create the capacity to encourage and deliver organic certification as a means of adding value and increasing market appeal.
- Identify and develop appropriate mechanisms for awareness-raising and the dissemination of information on regulatory issues and the protection of health and the environment.

CHAPTER 3

Value-Added Exports

SITUATION ANALYSIS/NEEDS ASSESSMENT

A small group of expatriate entrepreneurs has demonstrated that Rwanda can export and compete in high-value product markets. They have paved the way for future investors and entrepreneurs to build on this momentum. To leverage the initial momentum, public–private support mechanisms should help current and future entrepreneurs train their workers, acquire technology, produce innovative products, meet quality standards, understand market trends, and target premium market niches—all in the context of highly competitive, fast-moving global markets and with limited financial and technical resources.

It is almost impossible to increase agricultural production in Rwanda by expanding the amount of land being farmed because no additional land is available. Some productivity gains can be made in primary production, but these gains are unlikely either to enhance Rwanda's global competitiveness or to create jobs for youth who will begin entering the labor market in the next 5–10 years.

With agricultural production constituting 40 percent of GDP, employing 80 percent of the population, and accounting for 80 percent of exports, it is clear that the main raw materials available for Rwanda's industrial sector are agricultural. It follows that what is required to create income and employment—and thus reduce poverty—is adding as much value as possible value to as many agricultural products as possible. Any

new cash crops being introduced should not only maximize production value per hectare but also have major potential for value addition.

The ideal export product for Rwanda has three major characteristics. First, it should be a high-value agricultural product with high-value-adding potential. Second, a significant percentage of the value addition should take place in rural areas. Third, the final product should be as light and low volume as possible because of the very high transport costs from this landlocked country.

A fundamental problem for Rwanda is limited human capacity in both the public and private sectors. Enterprises repeatedly cite access to qualified labor, particularly technical labor, as their primary constraint. Although state-sponsored technical and vocational schools have been established, at considerable expense to the government and donors, these institutions do not seem to be turning out graduates with the skills required by potential employers. Capacity-building partnerships between the private and public sectors are essential if the economy is to move into a self-sustaining productive phase.

Certain socially beneficial activities may be undertaken by enterprises on the basis of enlightened self-interest. For example, if poor health is reducing worker productivity, some investment in their health is good management. However, it would be bad policy to encourage any enterprise to make commitments that could lead to an excessive financial burden for the business, jeopardizing its longer-term competitiveness and commercial success. Even in the case of a cooperative, in which social benefits are likely to be seen as an important outcome, mixing income generation and social benefits should be minimized. Ideally, if an enterprise development project is also being used as a conduit for noncommercial tasks, the two should be visibly separated, by the use of parallel project teams.

The ideas for the public–private partnerships discussed in this chapter are based on interviews with managers of the following enterprises and projects devoted to producing and exporting value-added agricultural products from Rwanda:

- *The Technoserve Coffee Project:* This project—still in its early stages in Rwanda, following seven years of highly successful work in the Kilimanjaro region of Tanzania[1]—focuses on the production of high-quality specialty coffees by cooperatives using small-scale washing stations.
- *The SPREAD Coffee Project:* This project involves production and value addition of high-quality specialty coffees. It has had

considerable success with the Maraba and other coffee brands, sold with fair trade certification in the United States. SPREAD is also involved in chili and cassava production and value addition, and it delivers a wide range of social and health benefits through ancillary funding from the U.S. Agency for International Development (USAID).

- *The Rwanda Pyrethrum Co., Ltd. (SOPYRWA):* This company operates a processing factory in Ruhengeri, established with the help of the United Nations Industrial Development Organization (UNIDO) in 1986. Some 26,000 out-growers supply the factory with about 3,000 metric tons of dried flowers a year. These farmers have been cultivating these crops for several generations high on the volcano foothills. SOPYRWA is just completing the recommissioning of its refining plant. The principal constraints on the industry are in primary production: the increasing impoverishment of both the soil and the 20-year-old pyrethrum plant stock. Primary producers are supervised and supported by company extension agents.
- *The UTEXRWA textile factory:* This factory has been a major commercial producer of cotton and synthetic fabrics. Production is based on imported raw materials. The company is now spearheading a major initiative to introduce sericulture in Rwanda. Private commercial and cooperative out-growers will grow mulberry, rearing the caterpillars and harvesting the cocoons. UTEXRWA has 55 hectares under mulberry cultivation. About 200 hectares are grown by private and cooperative farmers, who also manage small-scale reeling stations, adding about $1 to the value of every kilogram of cocoons. UTEXRWA runs 15-day training courses for would-be out-growers and employs several extension workers. It plans further value addition, including exports of finished silk garments to other Africa countries.
- *Organic horticulture enterprise:* An organic horticulture enterprise employing about 200 people is currently working its own farm of about 20 hectares and training another 40 youths, more than 80 percent of whom are women, as horticulturists. The most qualified of the trainees will be selected and trained as extension agents, who will become responsible for training a network of out-growers producing high-quality organic vegetables intended for export and for the Kigali hotel and restaurant market. Training for out-growers will also include life skills, to be delivered by specially trained staff members.

RECOMMENDED PUBLIC–PRIVATE PARTNERSHIPS FOR CAPACITY BUILDING IN VALUE-ADDED ENTERPRISES

Public–private partnerships can take several forms. The goal of each public–private partnership proposal sketched below is to expand the information, knowledge, expertise, technology, and research capability of local firms.

PUBLIC–PRIVATE PARTNERSHIP FOR TECHNICAL AND VOCATIONAL TRAINING

Increasing the relevance and reach of vocational training in Rwanda can significantly increase employment and productivity. More than 91 percent of Rwanda's population depends on agriculture, and women do most of the work in the fields. But most vocational and technical training centers cater to urban areas, and the classes are overwhelmingly male. For rural producers and workers, training opportunities are negligible.

Formal-sector enterprises based in urban areas work in close partnership with rural producers. Rural producers grow their crops and sell them to urban enterprises for value addition through processing and packaging. Rural producers could undertake some processing of primary products (washing coffee, pulping fruit) before passing them on to enterprises for further value addition. To do so, however, rural producers and out-growers require well-structured training in order to deliver in a timely manner the quality and quantities of produce that urban enterprises require from rural producers.

As a result of the market-driven interaction between enterprises and rural producers, firms are in the best position to guide the training of producers and out-growers. Firms know what is required from primary producers and how it can be achieved, and they keep a close watch on what sells best. Hence, the knowledge and expertise residing within firms is an appropriate guide to what technical and vocational skills producers and out-growers must possess.

How can this knowledge be codified and transferred to out-growers through vocational and technical training? Most formal-sector enterprises are owned and managed by expatriates, mainly from Kenya and Uganda. Codifying their knowledge would be the first step toward developing relevant training and instruction content for vocational and technical courses. Preparation of manuals and books that support vocational and technical courses could help codify this expert knowledge. Likely subjects for these books and manuals include organic farming techniques, coffee

husbandry and washing, sericulture and reeling, leather tanning, organic horticulture, aquaculture, pyrethrum cultivation, marketing, and entrepreneurship.

A partnership involving formal-sector enterprises, commercial publishers, the government, and international organizations would help prepare and publish these training manuals. Each text would be prepared under the guidance and support of a subject-matter expert. The text would be illustrated, edited, and translated into Kinyarwanda. A portion of the copies could be presented to enterprises for use in their internal training; the rest could be distributed to libraries and vocational training institutes. Enterprises could also purchase additional copies from the publisher.

These texts and manuals could support the syllabi of technical and entrepreneurship courses at *écoles techniques officielles* (ETOs) and *écoles agro-veterinaires* (EAVs). The specialists who helped prepare the training texts could be hired to train the ETO/EAV teachers. After receiving the training, the ETO/EAV instructors could continue to update the texts with knowledge gathered from private and public sector enterprises. This interaction would help ensure that the training materials remain relevant. This approach could prove useful in various subsectors of horticulture, aquaculture, coffee, tea, leather, food-processing, and sericulture.

PUBLIC–PRIVATE GRANT FACILITY FOR ENTERPRISE-BASED TRAINING

Enterprises need to train their workers to survive and compete in regional and global markets. The exacting nature of export markets means that workers must be trained in the latest production and marketing techniques. Enterprises in Rwanda employ a wide range of specialists, technicians, and farm workers, only a small percentage of whom have received good-quality technical or business training.

Training programs for workers must be efficient in structure and content. The program must ultimately help workers with different initial skills attain a minimum threshold level of competence. This competence would allow workers to meet design specifications and fulfill quality standards, be it for specialty coffee, silk garments, or fresh flowers.

A grant facility—funded through a partnership between the government and private enterprises—could help enterprises meet these training challenges. The facility could help enterprises identify training needs of workers with different initial skills, design the training modules, deliver training to workers, and evaluate results. The facility could also support training programs for the rural self-employed. The expected outputs of a training facility would be an increased level of skills in the workforce, job

opportunities for prospective workers, mobility for workers with certified skills, productivity of both rural and urban enterprises, and capacity for the rural self-employed.

ESTABLISHING A PUBLIC–PRIVATE TECHNOLOGY INFORMATION SERVICE

Many enterprises have limited information about technological options. As a result, they make inappropriate investments in technologies. A service or a portal that provided information on options to enterprises would help avoid such pitfalls. The technological options would consist of cost-effective and pragmatic solutions to such questions as what technologies best meet the productive needs of the enterprises, how to acquire a technology from local or foreign suppliers, how to adapt the acquired technology to local needs, how to use and maintain the technology, and how to build a technology locally.

The information service would help enterprises acquire and adapt ready-made technologies. It would also help them build technologies and equipment, using blueprints and designs acquired from abroad. Making such information easily available would provide a boost to the local machinery industry.

Starting a technology information service would involve a partnership between industry and public technology institutions (including the Centre for Innovation and Technology Transfer). The tasks of the service would include cataloguing every technology hardware product (domestic and imported) for sale in Rwanda and providing contact details for the source, technical information on the product, and, if possible, prices. It would also provide information on availability, performance, and comparative advantages. To begin with, the information service could build an inventory of all productive agricultural and industrial equipment in use in Rwanda. This would help enterprises planning to invest in a technology to locate a working example through the database, see it in operation, and discuss performance with the operator. Such information would allow end-users at every level to make informed judgments when choosing and purchasing equipment.

In addition to cataloguing information about locally available technologies, the service could collect information from chosen technology providers outside of Rwanda, especially those based in neighboring countries and other developing countries. The information service could also establish links with similar technology information services outside of Rwanda, such as the AESD/MOFA Rural Technology Unit in Ghana, the International Network for Technical Information, and Practical Action, to

name a few.[2] Such links would allow Rwandans to stay abreast of up-to-date developments.

A technology information service could also provide training on how to use this information service and how to think about technology acquisition and management in a systematic way. Such courses could prove useful for enterprise staff interested in purchasing equipment and for consultants and advisers working on technical and financial aspects of technology.

ESTABLISHING A MATCHING GRANT PROGRAM FOR INVESTMENT IN PRODUCTIVE TECHNOLOGIES

A matching grant facility would complement the previous proposal. In addition to poor access to timely information about prospective technologies, many enterprises lack the finance needed to acquire and upgrade their technology. A public–private mechanism could encourage an enterprise to build savings and use it to acquire technology. Later, when the enterprise chooses to invest its savings in productive hardware, the fund could provide proportional matching grants.

A technology acquisition fund could operate as a savings bank, paying interest on money invested by individuals, cooperatives, or enterprises, with money deposited and withdrawn for any purpose at any time, without restriction. The interest rates could be competitive, in order to encourage savings. The proportion of the matching grant could vary according to the status of the investor (a small-scale investor or cooperative might qualify for matching funding of 50 percent, for example; a larger enterprise might qualify for a smaller percentage of matching funding). The proposed fund would work in close partnership with the technology information service. It would encourage enterprises to make full use of the information service in choosing the most appropriate technology and the most suitable vendor.

CREATING A PUBLIC–PRIVATE ORGANIC PRODUCTION AND RESEARCH ASSOCIATION

Despite the strong interest of horticulture and agriculture enterprises in using organic methods of farming, enterprises have limited knowledge of soil management and organic production. Yet organic farming techniques are ideally suited for Rwanda for three principal reasons. First, Rwanda has a rapidly deteriorating soil structure due to soil erosion. The result is an overall deterioration in the quality and fertility of soils. Second, the

cost of inorganic farm inputs is high. Third, an organic certification of export products (coffee, tea, cotton, silk) can fetch a high premium in the export markets. Prices for organic coffee, for example, can be more than one and a half times those for nonorganic coffee.

The Swedish nongovernmental organization Vi-Life and the Gako Organic Farming Training Centre on the outskirts of Kigali are developing on organic farm in Rwanda. Vi-Life combines the introduction of antierosion agroforestry techniques with organic practices. It intends to establish a series of working model organic farms. The Gako Organic Farming Training Centre is a successful example of intensive organic agricultural practice, complete with a separate smallholding plot to illustrate what can be done on the typical Rwandan land plot. The National University of Rwanda (NUR) intends to establish organic agriculture as a subject within the Faculty of Agronomy. The university also wants to start a program for certifying farms as organic.

Several steps could help promote organic farming in Rwanda:

- acquiring knowledge of existing organic techniques, practices, and systems used elsewhere;
- conducting research on the applicability and comparative virtues of these methods in Rwanda and, over time, adopting the practices as necessary;
- disseminating knowledge and information about organic farming methods and their sustainable economic virtues, so that their adoption becomes the agricultural norm; and
- building capacity to certify farms and their products as organic—a valuable certification for export products.

The NUR proposal (described below) addresses the second and fourth points on this list. To address the first and third points, the study recommends establishing a membership association tentatively called the Rwanda Organic Production and Research Association (ROPRA). ROPRA could act as a channel of internal and external expertise, helping farmers learn from one another. The organization would also develop relationships with other relevant institutions, such as NUR's organic initiative and its soil laboratory. ROPRA would maximize access to technical information, training, support, and research directly focused on the needs of Rwandan agricultural and horticultural producers.

ROPRA could undertake such capacity-building activities as preparing and publishing technical instruction material, disseminating and transferring technical knowledge on organic practices, establishing links with international expert organizations, and exchanging information with

counterpart organizations. A crucial role of ROPRA would be to boost the exchange of information among Rwandan farmers about organic faming practices.

BUILDING CAPACITY FOR ORGANIC PRODUCTION AND CERTIFICATION

In addition to popularizing organic practices among enterprises, it is important to develop research capacity for optimizing organic practices suitable for Rwanda. It is also important to develop the capacity for issuing internationally recognized "organic" certification for export items. NUR intends to establish organic agriculture as a subject within the agronomy department, with the intention of training specialists for production support and granting organic certification to farmers. Certification immediately adds considerable value to exported crops and products.

Support to the university could focus on three areas: setting up a graduate program in organic agriculture; developing a soil and certification laboratory meeting international standards, available to farmers and commercial agribusinesses; and establishing internationally recognized organic certification capacity within NUR to certify Rwandan agricultural producers.

"Organic" certification can take up to seven years from the time inorganic inputs were last applied in the farm. Considerable expert guidance is thus required during the process of detoxification. Qualified graduates from NUR could be trained to provide such guidance.

PUBLIC–PRIVATE INSTRUMENTS FOR CAPACITY BUILDING IN DESIGN AND PRODUCT DEVELOPMENT

Enterprises in Rwanda need greater proficiency in design, which can add value to processed and manufactured products. This is especially true for the nascent textiles and garments sector. Creating a distinctive identity for Rwandan products through good design and packaging would help differentiate these products from similar products on the market. Appealing design and packaging can boost marketability, price, and sales volume.

To build capacity in design and product development, professionals from relevant sectors (textile, packaged food) could take design courses outside Rwanda, supported by a public–private partnership. Short- and medium-term programs would be best suited for midcareer professionals. Selected students could also receive merit-based scholarships for master's-level training abroad. Establishing an institutional twinning arrangement

with a design school outside Rwanda could facilitate visits by international experts and trainers to Rwandan universities and colleges.

NOTES

1. Information on the Technoserve Coffee Project is available at http://www.technoserve.org/africa/tanzan-1.html.

2. For information on AESD/MOFA Rural Technology Unit in Ghana, see www.aesdmofa.org/rtiu. For information on the International Network for Technical Information, see www.inti-online.org. For information on Practical Action, see http://practicalaction.org.

CHAPTER 4

Development and Diffusion of Appropriate Technologies

SITUATION ANALYSIS/NEEDS ASSESSMENT

This chapter summarizes the World Bank study on capacity building for the development, dissemination, and application of appropriate technology for poverty reduction in Rwanda. It gives special attention to two public institutions, the Centre for Innovation and Technology Transfer (CITT) and the Institute for Scientific Research and Technology (IRST), both of which play central roles in the development and transfer of appropriate technologies in Rwanda.

The term a*ppropriate technologies* refers to technologies that are of particular interest for poverty reduction. They can include technologies that create income or improve the quality of life, especially for people in rural areas, where the vast majority of the poor live in Rwanda. The terms of reference for this project specifically cite technologies for rural energy; sanitation and waste management; water supply, rainwater harvesting, and storage; and agro-processing. The study team also considered low-cost building technologies, agricultural equipment, and rural transport.

Appropriate technologies—some of which are already in place in Rwanda (table 4.1)—should be affordable and financially attractive to rural clients, through individual ownership or some form of cooperative management. Such technologies are best manufactured locally; if this is not feasible because of lack of production facilities, skills, or raw material, local people should at least be able to carry out essential maintenance and repair services. For a technology to be appropriate, it should not only

Table 4.1: Status of Appropriate Technologies in Rwanda

Type of technology	Status
Rural energy	
Biogas for institutions	Ongoing and spreading
Biogas for households	Pilot program of 163 units, started in 2007
Micro-hydropower	Six installations in preparation, more possible in future
Biofuel	No national program or policy
Wind	No national program or policy
Peat	Large stocks but limited exploitation
Efficient stoves for urban areas	National program ongoing
Efficient stoves for rural areas	Some programs ongoing
Rice/coffee husks for briquette production	Limited programs
Photovoltaic systems	Technology available but market slow
Solar water heating	Technology available but market slow
Water and sanitation	
Roof water harvesting	Scale limited
Boreholes	Few and expensive
Hand pumps	Imported from region or India
VIP and Ecosan latrines	Technology available but uptake limited
Agricultural technologies and transport	
Irrigation through treadle and motorized pumps	Uptake limited
Drip irrigation	Starting
Animal traction for tillage and transport	Promoted in certain areas
Small tractors for rice puddling and transport	Few units imported
Rice threshing/winnowing	Few machines available or locally produced
Rice hulling	Opportunities for small-scale processing
Maize milling	Machines imported and locally made
Oil presses for sunflower, soya, essential oils	Starting
Livestock spraying	Locally made machines available
Low-cost building	
Rice/coffee husks and peat for briquette burning	Some use
Hand-operated brick press machines	Locally made and imported machines available
Engine-operated brick press machines	Imported machines available

Source: Hendriksen et al. 2007.

be affordable and financially attractive for end users; its production and marketing should also be financially attractive for local manufactures and distributors.

Various organizations, including CITT, have carried out general needs assessments for rural technologies. The conclusions of these assessments

have been of limited value, however, because they reflect the specific expertise and interests of the organizations conducting the studies. Moreover, there are limitations to needs assessments, especially when the target group is unaware of the existence of solutions to specific problems and expected benefits and costs are not yet known. Only when people are fully aware of technologies and their economic or social advantages will they be able to rank them relative to other needs and wishes.

The most effective way to test a market for a technology is to offer a range of options based on agreed priorities and to monitor the response of producers, distributors, and users. (The assessment needs to recognize that uptake of some products is facilitated by government subsidies.)

For public programs to promote the development, production, and marketing of new technologies, priority has to be given to those that are expected to be the most relevant for economic and social development. Attention should be given to technologies that can make a significant contribution to poverty reduction, gender equality, and alleviation of environmental distress.

The private sector has a crucial role to play in developing sustainable technological solutions. Enterprises are most familiar with the potential market and the needs and purchasing capacity of potential customers.

Unfortunately, the private sector in Rwanda is still weak, particularly in rural areas, where it consists mostly of microenterprises lacking technical skills, business skills, and access to inputs and capital. In Kigali there are some medium-size enterprises that are capable of manufacturing a range of goods. Some larger workshops have adapted and manufactured coffee-processing equipment, cassava-grating machinery, and milling equipment. Some smaller workshops are producing and marketing treadle pumps for irrigation and hand shellers for maize. However, many products imported from neighboring countries and from India or China are less expensive than those produced locally because of the high prices of raw materials, the low level of productivity, and the small scale of production. Local workshops compete with imported products only for products that have to be adapted to local requirements. Many workshops therefore concentrate on niche markets for specialized products or repair services, for which demand is immediate and profit margins much higher.

The private sector in urban areas, notably Kigali, is supported through various programs that provide assistance to companies that want to acquire new technologies. Little support is provided for the development and diffusion of appropriate technologies in rural areas. A major obstacle to such dissemination is the lack of a government extension service.

Several organizations have a presence in the districts. They include the following:

- Business Development Centers, established by the Rwandan Private Sector Federation (RPSF), are operating in four districts, to be expanded to eight by the end of 2007. These centers help local businesses prepare business plans and offer other business development services. They do not focus on technology issues.
- The Belgium Survival Fund is planning to establish six Community Innovation Centers by 2008, which will be owned by local communities, to display agricultural and rural technologies. Once this pilot phase is completed, it plans to develop these centers in each of Rwanda's 416 sectors.
- The Ministry of Science, Technology and Scientific Research plans to establish District Innovation Centers to make optimal use of local resources. No indication is given of when this program is going to start; the issue will be addressed by the National Commission on Science Technology and Innovation that is to be established within the coming years.
- CITT has established two satellite centers in rural areas to facilitate the diffusion of appropriate technologies.

In addition, most national, provincial, and district agencies have programs in rural areas, some of them related to promoting technology. For instance, the Ministry of Agriculture has introduced rice threshers and winnowers through various cooperatives, using imported models. CITT and private workshops have contributed to the program; some of the machines are now manufactured locally. Biogas systems for households are tested and will be promoted under a pilot Ministry of Infrastructure program. Low-cost building technologies and fuel-efficient stoves for rural areas have been promoted by the Rwandan Defense Forces. The École Technique Officielle Gitarama has built a few biogas systems for schools. CITT has constructed many large digesters for waste management at prisons and schools. These efforts are rather piecemeal, however, with none yet having achieved the stage at which large-scale dissemination takes place through commercially successful, and therefore sustainable, production and marketing.

In general, the private sector lacks capacity for new product development. It has limited access to information (although small and medium-size enterprises [SMEs] are now accessing the Internet); it uses relatively simple equipment and a very limited range of raw materials (including scrap metal). SMEs lack the financial resources to accept the risk of

developing new technologies or adapt existing products. There is therefore a role for the public sector to support technology innovation and transfer processes.

Capacity in manufacturing simple food-processing equipment hardly exists in Rwanda because it requires the use of stainless steel to maintain hygienic standards. The necessary raw materials are very difficult to find even in Kigali, and the prices for stainless steel sheets are many times those for comparable mild steel sheets. Special welding equipment and skills are also required. Only two workshops, one run by the Catholic Mission (Don Bosco) and one run by CITT, have access to the materials and skills to manufacture stainless steel products. This is a serious constraint for the promotion of local food-processing.

AGENCIES AND INSTITUTIONS RESPONSIBLE FOR PROMOTING APPROPRIATE TECHNOLOGY

CITT was created by the Kigali Institute of Science, Technology and Management (KIST) in 2002, with a mandate to research, develop, and transfer appropriate technologies to rural and periurban areas. It has been supported by multiyear projects funded by Department for International Development (DFID) (from 2003 to mid-2006) and the Dutch Nuffic–NPT program (from 2005 to the end of 2008). CITT has a well-equipped metal workshop that can produce prototypes of new equipment. It also produces prototypes and simple machinery on demand. It has been very successful in installing biogas in prisons and implementing public programs to popularize fuel-efficient cook stoves. In other areas, efforts have failed to go beyond copying of prototypes of existing technologies. Dissemination to end-users and engagement of the private sector to produce and market these technologies has barely been attempted.

CITT has to seek funds from the Government of Rwanda, international donors, or other organizations for its technology development efforts. Over the past few years, its work has focused largely on implementing contracts for proven technologies, notably biogas, funded by the Government of Rwanda. Partly as a result of the success of its biogas contracts, CITT has shifted its focus from creating new technologies toward implementing proven technologies, with most of its skilled engineers involved in project implementation. This has reduced staff time for the development of new technologies and dissemination to the private sector. The lack of attention to technology development and transfer was exacerbated in 2006, when, as a result of across-the-board salary cuts at KIST (to bring salaries in line with other institutions of higher learning), many employees

left CITT for better-paying jobs elsewhere, resulting in nearly 20 vacancies at the time of this study.

In technology transfer, CITT's role has been limited to training groups of artisans in the products CITT has developed, notably wood-saving cook stoves. No examples were found of SMEs having successfully taken up production and marketing of CITT–promoted technologies. A key problem appears to lie in the reluctance of CITT management and staff to contact and cooperate with the private sector in developing and transferring technology. A different approach and attitudes will be required within CITT and other relevant government organizations to engage and cooperate with the formal and informal workshops that provide products and services to Rwandan customers.

The DFID Rural Travel and Transport Program (RTTP) project included a competitive research fund of £500,000, intended to support NGOs, community-based organizations, and research and private organizations in developing and transferring rural technologies. CITT was charged with managing the fund.

The fund did not live up to expectations, for a number of reasons. First, CITT was both manager of the fund and provider of research and development (R&D) services, leading to confusion and conflict of interests. Second, the expected national contribution of 50 percent to the fund could not be realized during the project period. Third, the need for specific technical assistance and dedicated staff resources was underestimated, and no clear implementation strategy was developed in RTTP's inception stage. The fund supported only three proposals before RTTP ended in June 2006.

The Nuffic-NPT technical assistance team prepared a number of strategic documents promoting ideas for improving the effectiveness of CITT in technology development. Themes addressed included priority-setting for technologies for CITT to work on; a more participatory approach to technology development and strategies for technology transfer; and ideas for improving management, by using a project approach and adopting an appropriate management information system. The Nuffic–NPT team also suggested restructuring CITT by separating the metal workshop and commercial contracting for technology implementation from the core business of technology development and transfer and put forth ideas for facilitating income generation, staff retention, and greater financial transparency and accountability, in combination with increased autonomy for CITT so that it can increase its responsiveness to paying clients. None of these suggestions and proposals has yet been implemented to any significant extent, partly because of the preoccupation of CITT management

and staff with contracted projects for technology implementation. There appears to be a need for further discussion and decision making on the part of KIST, CITT, and other relevant stakeholders.

In 2005 CITT, set up, with support from the Nuffic–NPT project, two satellite centers. The goal of these centers is to disseminate CITT technology in rural areas and to develop projects promoting the use of appropriate technologies—CITT or other—for local development. By 2010, the satellite centers will have to generate most of their own income; KIST-CITT will retain a controlling interest by continuing to finance 30 percent of satellite center salaries and operational costs. Expansion of the satellite center concept to other provinces is planned if the experience is evaluated as positive and funding becomes available.

The Institute for Scientific Research and Technology (IRST) is an autonomous institute directly under the Ministry of Science, Technology, and Scientific Research. Its Centre for Applied Science Research (ARSC) has 15 professionals, who work on appropriate technologies such as biogas, solar energy, peat pyrolysis, and use of rice husks as fuel. The research budget for ARSC for 2007 is Rwandan francs (RF) 59 million, fully financed by the Government of Rwanda. Most of ARSC's research work is done under controlled conditions on campus, with little or no attention paid to transfer and dissemination. As a consequence, there is little evidence that the results of the research are taken up by other organizations or companies.

ARSC has plans to work on locally made fertilizers, low-cost building materials, solar drying, micro hydropower, software applications, wastewater management, utilization of rice husks, and the use of seeds of the moringa tree for oil extraction, water purification, and human consumption and animal feed. Most of the research work seems to be driven by ideas from researchers, to be implemented in isolation, and to lack clear linkage to existing problems. IRST needs a system to evaluate proposals and ongoing research work against a clear set of priorities that should be linked to national policy guidelines.

Other institutions crucial for developing and transferring technologies are vocational training schools. Vocational training is Rwanda is not delivering the right quality and quantity of graduates with the hands-on experience needed to support industry and services. As a result, many companies have to import the required skills from neighboring countries. This is not an option for small enterprises in rural areas, which therefore lack personnel with the technical and managerial skills required to uptake new technologies.

Vocational schools can be an important source of the skilled labor needed to develop and diffuse appropriate technologies. Rwanda has a

serious shortage of practical skills required to develop, manufacture, and maintain technologies, including the relatively simple products that are the focus of this report. The small number of vocational schools includes nine *écoles techniques officielles* (ETOs), which provide training up to A1 level. Almost all of Rwanda's technical schools are poorly staffed and equipped, because of lack of funding and the shortage of qualified teachers. Technical training is four times more expensive than general secondary school training, because of higher student-teacher ratios (officially 60 for general secondary school and 30 for ETOs) and the cost of providing practical training. The Government of Rwanda seems unable to fully fund the ETOs, which have to raise some funding from other sources to pay for materials and other operating costs. The practical training aspects suffer most from a lack of funding.

ETOs and other vocational schools could play a greater role in assisting local communities and individuals identify appropriate technology needs and possible solutions, especially when cooperating with the private sector and relevant government and nongovernment organizations (NGOs). In principle, they could provide technical expertise, use their facilities for testing and demonstrating technologies, and help local businesses start manufacturing relevant products. However, because of serious shortages of qualified instructors and financial resources, these schools have not yet provided much support in appropriate technology development and transfer.

FACTORS HAMPERING THE DEVELOPMENT AND TRANSFER OF APPROPRIATE TECHNOLOGY

Several factors hamper the development and transfer of appropriate technologies, particularly in government organizations such as CITT and IRST:

- Too much attention is paid to the technical/engineering aspects of technology development and to development at the institution. Insufficient or no attention is given to testing and adapting technologies in the field with end-users, in close cooperation with the private sector actors expected to be the ultimate producers and distributors.
- Most technologists and engineers lack market knowledge and have little idea of the costs and benefits of technologies for users, manufacturers, or distributors.
- Engineers and managers involved in technology projects have the unrealistic expectation that once a prototype has been developed,

extension services and the private sector will adopt the technology almost automatically.
- Engineers focus on the construction of prototypes; in many cases it is better and quicker to adapt imported products to local conditions, working with local manufacturers.

A consequence of these perceptions, especially the perception that the institute's work is done when a prototype has been produced, is that the time and resources required for developing and especially transferring new technologies are seriously underestimated. Planners should be aware that identifying, adapting, and testing new technologies are time-consuming and that there is no guarantee of success; many ideas will ultimately fail, or there will be long delays caused by trial and error. They should also recognize that clients in rural areas and local producers have limited purchasing power, are risk averse, and have limited access to credit. Successful transfer to the private sector requires major efforts in awareness-raising for the product as well as technical and business support services for the SMEs involved.

RECOMMENDED STRATEGIES

The recommended strategy brings together the knowledge and capacity of key stakeholders in the early stages of the process, in order to increase chances of success in development and diffusion of new technologies. Crucial elements of the approach include the following:

- Change the attitude of technologists from knowing what is good for beneficiaries toward listening to clients—end-users and private enterprise—in order to work out different options with them.
- Engage key stakeholders as early as possible in the development and adaptation of new technologies. Technology developers should involve the private sector, which is ultimately responsible for large-scale production and marketing, from the early stages of the process, in order to obtain their perceptions of the problems and to draw on their technical expertise, experience, and knowledge of the market.
- "Mine" available knowledge and adapt existing products in the region or beyond, taking account of lessons learned in comparable situations in order to avoid the costly tendency of reinventing the wheel and repeating mistakes.

Market forces alone are often not sufficient for the successful introduction of appropriate technologies because private actors lack resources

and are unable or unwilling to take risks. Therefore the Government has a role to play in promoting and supporting technology innovation processes, especially those considered crucial for economic or social development. Overall, the Government should provide an enabling environment that encourages innovation and provides financial support where necessary. The mission suggests that the Government of Rwanda consider establishing a technology diffusion fund to provide assistance to individuals and institutions engaged in client-oriented technology development and diffusion; building capacity in public institutions such as CITT and IRST/ARSC that have a mandate in appropriate technology; and supporting training institutions in their efforts to increase capacity in teaching appropriate technologies.

The following strategic options could increase capacity for the development and transfer of appropriate technologies:

- Adopt and promote an innovation process to identify, develop, and diffuse technologies.
- Strengthen the supply of appropriate technology by providing financial support to initiatives for development of new technologies in priority areas.
- Strengthen demand for appropriate technology by raising awareness and improving access to credit for clients and intermediaries.
- Increase the capacity of key public institutions that have a mandate for appropriate technology innovation and diffusion, notably CITT and IRST.
- Improve the capacity of learning institutions providing vocational training, which is crucial for appropriate technology development, manufacture, and maintenance.
- Build innovation capacity at institutions of higher learning and vocational training institutions. This is a long-term task. Strategies for building this innovation culture are suggested below.
- Build a system of incentives that induces different actors involved in different stages of technology development and distribution to work together. This system would bring together public technology agencies, private sector technology providers, and the nongovernmental sector. A proposal for a technology diffusion fund aimed at this goal is sketched below.

BUILDING CAPACITY AT CITT

The capacity-building program at CITT should commence with the recruitment and training of seven to nine new staff from a mix of disciplines,

including engineering, agriculture, marketing, and social sciences. Staff and management should be trained in acquiring and implementing financing for technology development and transfer from sources other than the core KIST budget. Such capacity building is needed both for selected CITT staff and for the staff of the satellite centers.

All staff should partake in short-term training courses that will expose them to value-chain development, participatory needs assessments, gender issues, cost-benefit analysis, "mining" of technologies through the use of the Internet and networking with appropriate technology organizations, communication and awareness-raising, technology transfer, public-private partnerships, and marketing. Not all staff have to go through all courses; the selection of participating staff should be made based on position, capacities, and interests. CITT should also invite other interested parties, notably people from NGOs and the private sector, to take part in these courses, to ensure that CITT staff do not develop their capacity in isolation but are continuously challenged by other professionals with different backgrounds and motivations. Bringing in people from outside the institution would also help build partnerships for technology innovation projects. It therefore represents a good investment in networking and cooperation as well as capacity building.

Funds could be reserved for field activities aimed at producing an overview/database of existing technologies and actors in Rwanda, as well as for updating the inventory of technology needs, in line with both end-users' priorities and national development needs. Two new satellite centers could be established in the southern and western provinces. Funds would be required to attract and train staff, provide office and transport facilities, and allocate a small operating budget for the start-up period. Financial support would be gradually reduced over a three-to-five-year period, as the satellite centers become largely self-financing.

Jointly with staff from IRST and other relevant institutions, CITT staff could also participate in study tours to appropriate technology centers in Kenya, Tanzania, and Uganda, as well as, if justified, Ghana, Nigeria, and South Africa. These trips would focus on lessons learned from specific technologies, including not only their development but especially their transfer and larger-scale dissemination to the private sector. Staff participating in the study tours would assess the possibility for replication in Rwanda. These exchange visits should lead to professional contacts and collaborative work in the future.

Capacity building is also required to produce a database of lessons learned with specific technologies in Rwanda and technology options and lessons learned elsewhere, in settings comparable to Rwanda. Skills

would be developed in defining priority areas for technology development and transfer, in line with the needs of the population and local, regional, and national policies.

Special attention in capacity building would be given to renewable energy, notably for promoting micro- and pico-hydropower. A number of small (100–400 kW capacity) hydropower plants are currently being developed; more may follow. At numerous sites in Rwanda with lower hydrogenerating potential, pico-hydropower (5–10 kW) could be installed, for use by individual households and small enterprises. It is therefore suggested that CITT determine the requirements for graduates specializing in micro- and pico-hydropower, including both technical requirements (civil engineering for dams and head works, mechanical and electrical engineering for turbines and generators) and management, economic, and marketing requirements.

The Nuffic–NPT project has ample budget for training CITT staff for the remainder of 2007 and 2008, with a possible extension into 2009. The bottleneck in capacity building so far has been lack of time of staff, because of the priority given to carrying out commercial contracts for implementing already developed technologies, such as biogas.

BUILDING CAPACITY AT IRST

Though technology transfer is part of IRST's mandate, the institute has focused almost exclusively on research.[1] IRST should revise its strategic plan to arrive at a consensus on what its research priorities are and how it can integrate the transfer of knowledge and technologies into its core business. IRST research managers then need to work out new targets with IRST research centers. Some of these activities will still be carried out with core funding from the Government; others could be supported by organizations that have a direct interest in the application of science and technology for wealth creation or the improvement of social conditions.

The focus of the Applied Sciences Research Centre (ASRC) is to promote the practical application of knowledge produced by IRST. To do so, ASRC works closely with potential users of the results of IRST and other research and engages in collaborative projects with other stakeholders. ASRC has some interesting proposals on peat processing and rice-husk bracketing, for example; it should look for private sector partners to develop these ideas into viable options for commercial exploitation. It also has expert knowledge on the use of moringa for oil production, food security, and drinking water applications.

IRST staff, especially ASRC staff, need capacity building in technology transfer, communication, and partnering with the private sector, NGOs, community-based organizations, and other end-users. Selected staff require capacity building in project acquisition and management, to enable them to attract new sources of funding. They need guidance in proposal preparation and writing, identification of funding options, and monitoring of activities and outputs to keep clients adequately informed of results. Mastering these skills is very important, because future funding for IRST activities is expected to come directly from projects commissioned by specific ministries rather than from core funding by the Ministry of Science, Technology, and Scientific Research as it does today.

BUILDING CAPACITY AT VOCATIONAL TRAINING CENTERS

Production and dissemination of appropriate technologies requires adequately trained craftspeople and artisans, such as metal-workers and manufacturers of spare parts. Rwanda's vocational schools are falling short in turning out graduates with the required practical skills.[2]

The new technical training institute École Technique Oficielle (ETO) Tumba is developing a special course on alternative energy. This course deals with solar, micro-hydropower, wind power, and biogas for rural households. It does not cover appropriate technologies in other fields, such as water harvesting, agricultural mechanization, postharvest technology, and food-processing. It is therefore suggested that Tumba and other ETOs cooperate with the main Rwandan provider of tertiary education in agriculture, the Institut Supérieure d'Agriculture et d'Elevation (ISAE), in designing and setting up courses in appropriate agricultural technologies. Courses could be developed in agricultural equipment and food-processing, including milk processing, as well as in irrigation/water harvesting, rural transport, and possibly low-cost building methods. The cost of developing new courses is estimated at $25,000 per course, which includes the cost of hiring national and international experts to pull the required materials together. The curriculum outline could be used by various institutes for courses on appropriate technology. Significant teacher training, including practical training, would be required for ETO staff to implement the courses successfully.

Most learning institutions in Rwanda lack proper practical training facilities. Investments are needed in this crucial area to ensure that students acquire the necessary practical skills. Laboratory services could be made available to clients willing to pay for them. However, before the Government makes large investments in specialized laboratory equipment, an

inventory should be made of the specialized equipment already available at the country's different institutions. This information could be made available in an up-to-date database and placed on the Internet, to be combined with instructions for clients interested in using specific services. In this way, a task division among relevant organizations and laboratories could be achieved. For vocational training in more advanced areas, possibilities for cooperation within the East African region could also be explored.

ESTABLISHING A TECHNOLOGY DEVELOPMENT FUND

A technology development fund (TDF) based on a competitive selection process could finance joint initiatives of public and private sector organizations and individuals for the development and diffusion of appropriate technologies. Resources would also be available to public institutions, such as CITT and IRST. The idea is to induce public agencies to focus on diffusion, not just development, and to work with SMEs and civil society, not just in isolated labs and workshops.

The project has six outputs:

- an institutional framework;
- operational procedures and a manual for management, including guidelines for proposals, financing, reporting, monitoring, and impact assessments;
- a professional and adequately trained and equipped management team;
- disbursement of funds to approved projects working on innovation and diffusion of appropriate technologies;
- a credit guarantee mechanism supporting banks and multilateral financial institutions to develop credit lines for new technologies; and
- independent project evaluation and impact assessments to support decision making on the future of the TDF.

The institutional embedding of the TDF has to be determined before further steps can be taken to set it up and commence implementation. This debate needs to be held at the required ministerial and political levels. Ideally, funding and implementation functions should be structurally separated to avoid conflicts of interest.

One option would be to locate the TDF within the Ministry of Science, Technology and Scientific Research. The ministry currently has very limited direct implementation capacity because of its lack of staff. However,

within its policy framework are provisions for the creation of a National Research Council and the establishment of a National Research Fund. It is expected to take two to three years to secure the necessary cabinet and parliamentary approval before the council and fund will be operational. The TDF could be started much earlier and used to build up useful experience with competitive funding mechanisms. Subsequently, the TFD could merge into the planned National Research Fund. Even if the TDF is located within the ministry, however, actual management of the fund should be subcontracted to an independent institution with the required capacity and interest, such as a professional consultancy bureau or the RPSF.

Another option is to allow the RPSF to operate the TDF directly. RPSF represents all areas of the Rwandan private sector through its specialized chambers. On behalf of the World Bank and other development partners, the RPSF is already managing the business plan competition, which supports young entrepreneurs developing business plans by providing start-up grants and technical assistance. RPSF therefore has experience in managing competitive funding mechanisms. It is also being considered by DFID's Research into Use program as a possible implementing agency for a competitive fund to support the transfer of technologies for natural resources management.

The TDF is expected to fund small innovative projects to develop and diffuse technologies for rural and periurban areas in areas such as rural energy, water and sanitation, agricultural equipment, rural transport, small equipment for food-processing, and low-cost housing. Projects will closely involve partners in the field, such as local authorities, SMEs, distributors, and NGOs. They should contribute to poverty reduction through wealth creation, job creation, or both. A significant percentage of projects should focus on the needs of women. It is expected that the average costs of a project would be $25,000 (excluding contributions made by partners) and that 50 projects would be implemented over a three-year period, bringing the total sum to be disbursed to $1.25 million. Large projects could be implemented in phases over several years.

The TDF should be client oriented, with a professional and lean management structure that is responsive to the needs of all stakeholders and the power and ability to make implementation decisions without drawn-out decision-making processes. With the assistance of external experts, management would prepare implementation guidelines, contract formats, and disbursement and replenishment procedures and create awareness and interest among potential partners. It would also provide coaching on problem identification and preparation of project proposals and be responsible for progress monitoring and reporting on field

activities carried out under contracts. The costs for managing the TDF, including technical assistance to build the necessary management capacity, are estimated at $900,000 for three years. With a credit fund of $350,000 and 5 percent contingencies, the total budget for the proposed TDF is about $2.2 million.

NOTES

1. In 2006, IRST started a program for building substations in different areas of the country, starting with six locations in 2007.

2. The forthcoming World Bank–supported mission on technical and vocational education and training (TVET) is expected to produce insights on existing capacity and possible courses of action. Capacity building for TVET—of teaching staff as well as students—is therefore not addressed in this report.

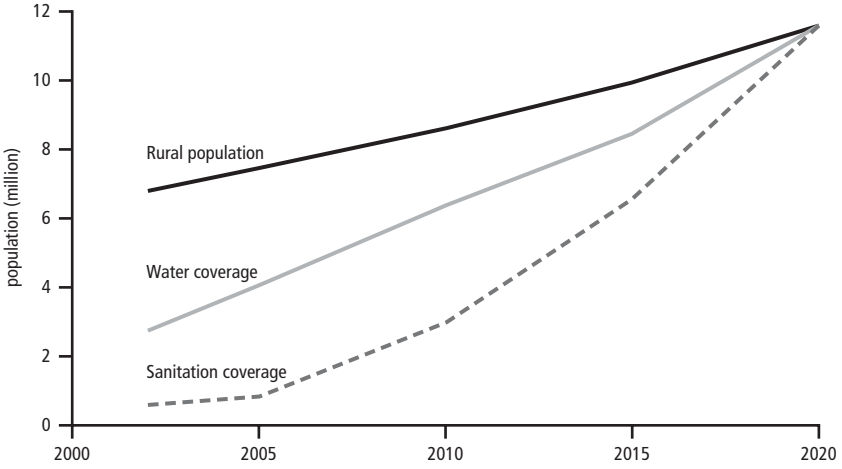
CHAPTER 5

Delivery of Clean Drinking Water

SITUATION ANALYSIS/NEEDS ASSESSMENT

Less than 40 percent of people in Rwanda have access to safe drinking water (figure 5.1). Poor access to drinking water is a problem not only in rural areas but also in urban towns and cities. The total capacity production of water supply in Kigali, for instance, is about 30,000 cubic meters a day—half of what is needed.

Figure 5.1: Access to Clean Drinking Water and Sanitation, 2000–20



Source: Lothe et al. 2007.

Drinking water in rural areas is delivered via natural springs, water supply networks, and boreholes. According to data from 2004, of 23,000 natural springs, about 19,000 were equipped with simple infrastructures maintained by low-skilled workers. These springs served 1.9 million people. Water supply networks, mostly gravity fed and simple to maintain, with very low running costs, served another 2 million people through public taps and 17,000 through private connections. Boreholes and shallow wells made subterranean water available to 18,500 people. These figures overstate the actual number of people served, however, because about 30 percent of the water supply infrastructure is dysfunctional, requiring major repairs or rehabilitation. The population actually connected to water networks is about 2.7 million.

The water supply in Rwanda is based mainly on surface water exploitation; underground water reservoirs remain largely untapped. Lack of engineering and technical capacity is the chief reason why drilling and exploitation of underground water have not happened so far.

The aim for 2020 is to serve 11.6 million people, including 9 million through public taps fed by networks. Achieving this goal would require rehabilitating existing networks, springs, and boreholes and expanding networks. This rehabilitation and expansion work would require a major boost in the technical and managerial capacity of the water supply agencies and workers.

The sanitation goals to be achieved by 2020 are even more ambitious. The PHAST (Participatory Hygiene and Sanitation Transfer) program is led by Compagnons Fontainiers du Rwanda (COFORWA), a local nongovernmental organization (NGO) involved in water management and training. The program has two components: a "soft" one, focusing on education on good hygiene, and a "hard" one, aimed at building three ecologic sanitation (ECOSAN) latrines per sector, for a total of 1,248 units. Hygiene education will focus on making the population aware of hygiene issues through a participatory approach that emphasizes, for example, appropriate methods of hand washing and water and sanitation hygiene. The program requires that clean water be available. The sanitation program is thus closely linked to the water coverage program.

This chapter assesses the needs of and proposes an action plan for capacity building for delivery of clean drinking water. Its recommendations must be viewed in the context of the ongoing decentralization of the water and sanitation sector. The new law transfers management of the rural water supply to the districts. The law aims to have users pay for water, with districts outsourcing infrastructure management to the

private sector. A water agency is to be created to support and supervise the 30 districts in their new task of general coordination of the management of the water and sanitation infrastructures of Rwanda's 416 sectors and 2,650 cells.

RECOMMENDED STRATEGIES

Capacity building is required at the following levels:

- workers and technicians charged with equipping springs and plumbers for maintaining pipes, valves, and taps;
- low-level managers working as fee collectors, bookkeepers, and network managers (most of these networks are small and simple; some are managed by private sector entrepreneurs, others by user associations under district supervision);
- higher-level managers working in district-level water agencies;
- national-level officers in charge of coordination and support to the districts on such issues as quality control surveys and supply of equipment.
- engineers and specialists working in central and district water agencies; and
- staff of central agencies responsible for managing water supply and regulating water quality (the national water agency, the Rwanda Bureau of Standards).

Technicians, plumbers, spring workers, and tap keepers are trained at vocational training schools. Lower-level managers attend secondary schools. District- and national-level managers, engineers, and technicians attend colleges and universities.

Meeting the Millennium Development Goals and the national objectives for 2020 requires major improvements in human resources, not only for surveying and building the new networks but most of all for managing and maintaining the installations. In the framework of the proposed program, needs will be identified for the coming five years, including training of trainers and educators required to cover the growing staff needs through 2020. Capacity building will also require significant institutional strengthening (table 5.1).

TRAINING LOCAL WATER TECHNICIANS

The new decentralization law entrusts the maintenance and management of the networks to the private sector, using legal tender procedures.

Table 5.1: Recommended Capacity-Building Activities in the Water and Sanitation Sector

Activity	Type of support/institution providing assistance
Human resources	
Train basic workers (spring workers, tap keepers, plumbers, and so forth)	Compagnons Fontainiers du Rwanda, vocational training centers
Train managers of the water supply networks and sectors	Vocational training centers
Train district officers in charge of water and sanitation	Technical assistance, trainers, high school teachers
Train and upgrade officers in charge of water and sanitation	Technical assistance, trainers, high school teachers
Train water management experts and hydrogeology experts	KIST, NUR
Provide training in sanitation (train trainers for PHAST program, train contractors for latrines, and so forth)	COFORWA
Institutional strengthening	
Improve efficiency of vocational training centers (Compagnons Fontainiers du Rwanda and other groups)	Financial and technical support for curriculum development, staff training, and qualification standardization
Create new department for water resource management in the faculty of agronomy at NUR	Financial and technical support, international and regional partnerships
Establish a diploma in rural engineering (soil conservation and water engineering) at ISAE	Financial and technical support, regional partnerships
Reinforce civil engineering curriculum in KIST with water and sanitation modules; develop hydrogeology curriculum in KIST	Financial and technical support, international and regional partnerships
Provide technical assistance to the Ministry of Science, Technology and Scientific Research for supervision	Financial and technical support

Source: Lothe et al. 2007.

However, private contractors are likely to be interested only in larger schemes with treatment and pumping stations, which can generate an appreciable cash flow. Smaller and simpler networks, especially in more remote areas, will probably have to be managed by users associations on a cost-recovery basis. The average size of a network is estimated at 10 kilometers, with 10 taps and about 5,000 consumers. Association or water network managers will require training in association management to avoid the failures experienced in the past with the associative approach.

For water supply via springs, workers are needed to install, operate, and maintain the required equipment. Plumbers are needed to maintain

Table 5.2: Projected Number of Workers Needed to Handle Basic Water Supply and Management Tasks

Type	Existing (estimated)	2008–11	2012–20	After 2020
Spring workers	400	1,000	1,000	120
Plumbers	200	1,200	1,200	260
Tap keepers	500	10,000	7,500	1,000
Pump keepers	100	170	230	50
Managers	50	800	800	100
Mechanics	20	40	40	10

Source: Lothe et al. 2007.

networks, and tap keepers are needed to take care of the public taps and collect fees. Local managers are needed to supervise these workers and take charge of overall management of the infrastructure. A significant number of mechanics, treatment specialists, and other kinds of specialists will be needed (table 5.2).

Training of workers who operate spring infrastructures currently takes place at COFORWA. Established in the 1980s, this organization is based in Gitarama and technically and financially supported by a Belgian NGO under Belgian cooperation funding. Training, given to 20–30 people at a time, lasts 10 days and is given in Kinyarwanda and French; trainees receive textbooks and instruction materials. The cost of this training, which is both theoretical and practical, is about $200 per person. There is no follow-up of trainees, because of lack of means (vehicles, trainers, money) and because the clients did not request follow-up (COFORWA works on a contractual basis).

An important problem for COFORWA is that most of the trainers, particularly those for spring equipment, are senior; recruitment of young people is needed. With current facilities, COFORWA can train 70–80 trainees a month; if training could be organized at different sites, capacity could be raised to 100 trainees, which would roughly cover Rwanda's needs for the next 20 years. COFARWA would greatly benefit from new training tools, lab material, and an update of its curriculum.

Several other NGOs are potentially able to train plumbers, spring workers, accountants, managers, tap keepers, and similar workers. All of them need additional financial support and training facilities to carry out more training in rural communities, however. They also need support for preparing improved curricula, to be provided through technical assistance (see below).

TRAINING DISTRICT- AND NATIONAL-LEVEL MANAGERS

The decentralization law plans for supervision of water and sanitation at the district level by the person in charge of infrastructure. Field visits revealed that these managers often have expertise in roads or power; they are often not qualified in water supply and have even less expertise in sanitation. Managers are not aware of the number of networks or equipped springs in their districts; relevant maps or survey data are not available. Managers also lack knowledge of water quality and ways to assess it.

Management of water and sanitation in a district of about 300,000 people is a full-time job. The training needs for water and sanitation officers are thus huge. It will be necessary to upgrade knowledge of water and sanitation at the 30 district offices in charge of infrastructure, in close collaboration with the newly formed water agency. Capacity-building needs for sanitation, notably the large-scale diffusion of PHAST, include training of one trainer and three supervisors for each of the 416 sectors.

The needs for capacity building for supervision at the national level are also great. As the water agency does not yet exist, capacity will have to be built from scratch. The Rwanda Utility Regulation Agency lacks expertise in water and sanitation expertise.

No institution has the capacity to train the officers that will be in charge of the water and sanitation sector at the district and national levels. Technical assistance is proposed to specify the training needs for each district, taking account of the background of the available staff and the specific conditions of the water supply (geographic constrains, existing infrastructure and projects, scale of the networks, and so forth). Full technical assistance should be provided for the first two years before being gradually reduced. Providers of this assistance should supervise the basic training carried out by NGOs and the setting up of various activities at the national supervision level.

None of Rwanda's institutions of higher learning has a coherent curriculum in water and sanitation. Training capacity must be strengthened at three institutions of higher learning: the Kigali Institute of Science and Technology (KIST), Rwanda's only engineering school; the National University of Rwanda (NUR); and the Institut des Sciences Agronomiques et Environnementales (ISAE).

Building Capacity at KIST

KIST should be able to cover part of the training needs identified at the district level. It has a training program for civil engineers, but the program

does not cover water management and water supply. The existing curriculum in civil engineering should therefore be reinforced with lessons on water management for rural water supply. KIST could also organize special training sessions for district officers in charge of water and sanitation. KIST could train 20–30 people in a six-month course provided outside the civil engineering curriculum.

In addition to adding water management courses to the civil engineering curriculum, KIST could also help fill expertise gaps in hydrogeology. A hydrogeology curriculum should be developed in close consultation with the needs of the water supply agencies, such as Electrogaz. Regional universities in Kenya and South Africa with programs in hydrogeology could act as partners in developing this module at KIST. The need to exploit underground water resources is too great for KIST to ignore.

KIST should also develop stronger links with the vocational training schools in charge of training in plumbing and water management, especially through in-service training arrangements for its staff and trainers. To strengthen the hands-on skills of staff and students, KIST could design a joint training program with Electrogaz leading to a certificate. Electrogaz has expressed interest in partnering with KIST to develop this joint training program.

Building Capacity at NUR

Rwanda urgently needs to build national capacity in water management for agriculture and natural resources management, in order both to develop agricultural land to improve food security and reduce poverty and to safeguard wetlands. Rwanda currently has very few trained people in the relevant fields, handicapping achievement of the targets of Vision 2020. This capacity should be achieved through both undergraduate and graduate training.

NUR should be responsible for capacity building in agricultural water resources development and management as well as irrigation and drainage, including measures to control erosion, flooding in the rainy season, and the drying up of springs and rivers in the dry season. NUR intends to set up a master's degree program in water management, irrigation, and drainage. It already has staff and facilities, but both need to be upgraded or expanded. New curricula have to be prepared and new teaching staff recruited. After a set-up phase of three years, the course could produce 20 graduates a year.

Building Capacity at ISAE

ISAE has an undergraduate training program in agriculture. Currently, the rector's office is elaborating a proposal for a two-year rural engineering course with tracks in soil engineering and water engineering. Once the program is running, it should produce 20 graduates per year.

Rural engineers work at the farm level to support farmers in improving production and natural resource management. They require skills in such fields as agronomy, livestock, land use, soil protection, water supply, and water management. To provide students with the training they need, ISAE needs to upgrade its training facilities, including its engineering workshop and laboratory for hydraulic and soil mechanics; improve its campus infrastructure, including student housing; and recruit new teaching staff for courses in water management.

CHAPTER 6

Geosciences and Geothermal Energy

According to a preliminary report by the U.S. Geological Energy Association, Rwanda's geothermal resources may be sufficient to provide 100 percent electrification in Rwanda.[1] This chapter proposes a two-track, sequential action plan for tapping these resources.

Rwanda does not have a long history of geothermal resource exploration. For this reason, geological and geophysical data from the geothermal prospects under investigation are sparse and inconclusive. Mapping of hot springs, fumaroles, and other geothermal surface manifestations has not been carried out in a systematic, comprehensive manner.[2] Building capacity for a systematic analysis of country's resource would be a primary goal of this program.

Systematic assessment and exploitation of geothermal resources for energy production would not only help meet the ongoing energy crisis; it would also help meet long-term needs of energy security. To be sure, a narrow focus on geothermal capacity is not advisable, because commercial viability of geothermal resources is yet unproven. But this study considers broader applications of geoscientific capacity: geothermal, minerals, oil, and underground water. Once a threshold capacity in geosciences is developed, Rwanda can use it in a variety of sectors relevant to national needs.

The first track is a fast-track "urgent" program to identify one or more viable geothermal resources and generate power on a pilot basis within three years. The pilot plant would pave the way for larger-scale geothermal power generation as quickly as possible. The Fast-Track "Urgent" program

could be a short-term initiative managed by an expert team housed within the Ministry of Infrastructure's unit of Energy and Communications. Once the pilot geothermal plant is installed and is operating, Rwandans can plan, tender, monitor, and operate the system. In the future, larger-scale geothermal plants could be transferred to a permanent geothermal department (Electrogaz or elsewhere in the government).

The second track will focus on long-term capacity building for improved oversight and management of mining operations, hydrogeological operations, and geothermal operations. This initiative, steered by a proposed Rwanda Geoscientific Center (RGC), can provide support for human and institutional capacity building to a wide range of government and private sector agencies on a long-term basis.

Capacity building under the long-term track would be both supply and demand driven. The program would focus on building human resources by strengthening existing educational institutions. It would also build linkages with regional and international educational institutions. The primary goals of the long-term capacity-building track would be to (a) help develop a cadre of well-trained professionals in the geosciences sector who can conduct applied research, investigate geological resources, plan and implement projects, and design policies and (b) develop greater technical and managerial capacity in the Ministry of Infrastructure and the Ministry of Energy.

The two tracks would accelerate the resource assessments, tests, and drilling needed to enable Rwanda to quickly begin to generate electricity on a pilot basis using geothermal energy and, subsequently, to develop human and institutional capacity to expand geothermal-based power generation to a much larger scale. They would also improve national capabilities to manage mining and hydrogeological activities for increased export-based revenue earning, expand access to potable water at affordable costs, and increase large and small hydropower generation.

The two tracks should ideally operate in parallel. However, in view of limited resources, the first track could implement the action items for building human resources, even if the second track is not formally operational.

STRATEGY A: FAST-TRACK "URGENT" PLAN FOR GEOTHERMAL RESOURCE ASSESSMENT AND PILOT POWER GENERATION

The fast-track component seeks to support the Government's goal of conducting resource assessment and resource testing studies to establish the viability of geothermal resources in Rwanda. If resources prove viable for

commercial development, the fast-track program will support the tasks needed to have a 2–5 MW (megawatt) pilot plant installed and operating in Rwanda within three years. If pilot phase proves satisfactory, Rwanda can expand production of geothermal energy to 30–50 MW.

Implementing this strategy would require establishment of a geothermal task force (or expert group) within the Ministry of Infrastructure. This group would carry out the following tasks:

- Begin work immediately with the Federal Institute for Geosciences and Natural Resources (BGR) to initiate and complete required geothermal resource assessment work as quickly as possible and identify the most promising geothermal sites in Rwanda.
- Identify and invite other suitable public and private agencies for resource assessment and testing.
- Prepare a database of the results of geothermal investigations and rank the studied sites according to their potential for commercial use.
- Arrange for "slim-hole" exploration drilling and resource testing at two or three of the most promising sites for the pilot plant.
- Oversee the installation, commissioning, and operation of the pilot plant, if resources are tested commercially viable.
- Prepare an application for gaining entry to the East African Rift Valley Geothermal Program (ARGeo), citing results of resource analysis and viability testing.
- Select and ensure that Rwandan geoscientists and engineers participate in all stages of geothermal resource assessment; exploration drilling; technical analyses; tendering for, installation, and operation of the pilot plant; and monitoring of the geothermal resource.
- Enter into discussions with multilateral and bilateral development agencies and private companies that may be interested in assisting Rwanda with its geothermal program, and explore their possible involvement/support/qualifications for exploration drilling, purchase, and installation of the pilot plant and larger-scale geothermal power generation projects.
- Build close ties for sharing knowledge with East African countries in advanced stages of resource assessment and exploitation. Ethiopia, Kenya, and Uganda have greater geothermal expertise than Rwanda. Particularly useful would be potential collaboration for on-the-job training in geothermal investigation and plant operation.

Achieving the pilot plant objectives within the three-year time frame would require a high level of commitment and initiative on the part of

the task force staff. Participation of bilateral and multilateral agencies should be encouraged to accelerate and finance geothermal resource assessment, exploratory drilling, resource testing, and pilot plant installation.

INSTITUTIONAL SET-UP

Responsibility for power generation is currently housed within the Ministry of Infrastructure, Office of the Minister of State in charge of Energy and Communications. Within this office, the Department of Geothermal Coordination consists of one part-time person. It is recommended that two consultant professionals and one administrative support person be hired to work in the department for three years and that the consultant professionals have Rwandan counterparts work with them and learn on the job. The Geothermal Department director can be an expatriate from the East Africa region, Europe, or the United States. He or she should have a geoscientific or engineering background and expertise in geothermal resource assessment, institutional management, and fundraising in East Africa. The director would have overall responsibility for the implementation of the geothermal resource assessment, evaluation of the results, tendering for exploration drilling, resource testing, and analysis. He or she would also be responsible for preparing monthly progress reports that would be distributed to interested Government stakeholders to keep them informed of project progress.

The Geothermal Department technical adviser should have an engineering or other technical degree and experience in planning and overseeing the tendering, installation, and commissioning of geothermal power plants. The job would include overseeing the tendering, contracting, and installation of the planned 2–5 MW pilot plant. The technical adviser should be an expatriate from the region, Europe, or the United States.

CAPACITY BUILDING THROUGH HANDS-ON TRAINING

In order to familiarize Rwandan counterparts with geothermal plants and projects in the region and overseas, provision should be made for study tours and training visits to Ethiopia, Kenya, Iceland, and the United States. The visits should include both short- and long-term training opportunities, including travel to geothermal training seminars in the United States and month-long, hands-on training sessions at geothermal plants in the United States and elsewhere. Longer-term training sessions should be planned if funding is available and training opportunities can

be arranged. Rwanda should also establish membership in the East African Rift Valley Geothermal Program (ARGeo) once work has been initiated on the planned geothermal resource assessment.

Suggested topics for hands-on training during the resource investigation phase include the following:

- geological investigations and mapping (surface surveys, mapping, and well site geological work);
- geochemical analyses (major element geochemical sampling and analyses, gas chemistry, and isotopic surveys, including interpretations);
- geophysical surveys;
- exploration drilling and drilling engineering;
- well testing;
- reservoir engineering;
- field development and management;
- well-logging and downhole measurements;
- well output testing;
- site selection and development;
- well design;
- rig sizing, operation, maintenance, and repair;
- drilling costing and economics;
- resource management;
- reinjection and waste disposal planning, monitoring, and management;
- reservoir analysis, modeling, and computer simulation;
- geothermal resource and steamfield data management;
- interference testing; and
- scaling and corrosion analysis and mitigation technologies.

STRATEGY B: LONG-TERM INSTITUTION/CAPACITY BUILDING FOR GEOTHERMAL ENERGY AND GEOSCIENCE DEVELOPMENT: THE RWANDA GEOSCIENTIFIC CENTER

The proposed Rwanda Geoscientific Center (RGC) would focus primarily on building human resources. It would assist government agencies and the private sector in building capacity to carry out applied research, gender-balanced training, technology demonstration, monitoring, evaluation, and information dissemination activities to upgrade and promote the use of improved techniques for resource identification and use of geothermal energy, underground water assessment and exploitation, and

mineral/mining assessment and exploration. Priority would be given to accelerating the use of improved techniques for mining, hydrogeological research, and use of geothermal energy for power generation. The use of geothermal energy for direct use applications (such as greenhouse heating and fruit and vegetable drying) would also be considered.

The proposed RGC would work both independently and in collaboration with the other ministerial services involved in geoscientific work (namely, the Rwanda Geology and Mining Authority of the Ministry of Lands, Environment, Forestry, Water and Mines). It is recommended that the RGC receive support from international organizations to carry out the following tasks:

- Establish a geoscientific information system, including a Geographic Information System (GIS) database that will provide information on geothermal, mining, and hydrogeological resources for dissemination to public and private sector stakeholders.
- Provide support and technical assistance to the Kigali Institute of Science, Technology and Management (KIST) to strengthen its capacity to train geothermal scientists and engineers.
- Assist with the planning and implementation of in-country and overseas training in geothermal energy, mining, and hydrogeology. This training should include training programs at KIST, NUR, and the Geology and Mining Authority, as well as long-term overseas training programs for graduate-level geoscientists.
- Lobby the Government of Rwanda to address policy, regulatory, and procedural constraints to private sector–based geothermal and mining development (for example, time requirements for concession agreements, permits) and enactment of necessary incentives (import duty exoneration, tax holidays, sovereign guarantee), in order to foster continuing and active private sector participation in geothermal power and mineral extraction projects.
- Provide support for public awareness and extension services in rural communities to promote private sector–based mining activities and use of geothermal energy.
- Monitor and evaluate ongoing geothermal, mining, and hydrogeological projects in Rwanda and elsewhere in the region and world.
- Provide information and technical assistance to private sector entities seeking to establish geothermal and mining initiatives.
- Plan and implement applied research and development (R&D) activities on geothermal, mining, and hydrogeological investigations on a commercial basis (or with donor funding), to enable the RGC to become self-sustaining;

- Liaise with other Rwandan institutions (including the Electrogaz Water Analysis Department and the Rwanda Geology and Mines Authority) to carry out necessary mining and hydrogeological tests and analyses.
- Organize mass educational and promotional efforts on issues related to geothermal energy, mining, and hydrogeology.
- Undertake economic and financial analyses of geothermal, mining, and water resource-related projects, including the impact of the sale of carbon credits as a result of the use of environmentally clean geothermal energy.
- Carry out an inventory of existing geothermal and mineral workshop and testing equipment in Rwandan national educational institutions and laboratories;
- Collaborate with (and strengthen) other facilities for geothermal, mining, and water resource–related work in Rwanda (including the Water Quality Monitoring Division of Electrogaz, the Rwanda Geological and Mining Authority, and the Geographic Information System (GIS) Center of the National University of Rwanda [NUR])
- Provide short training courses in water analysis procedures in Rwanda, and allow six Rwandans to spend three months training in Tunisia.
- Establish linkages with other East African geoscientific agencies, national power companies, geothermal equipment manufacturers, and geothermal plant operation/service providers through staff exchanges.
- Establish a relationship with ARGeo for information, training, equipment, and potential risk-mitigation financing for exploratory drilling.
- Establish linkages with multilateral and bilateral technical assistance and financing agencies in industrial countries that are assisting Rwanda in the development of sustainable energy resources, in order to enlist their support to address the urgent need for geothermal power generation.
- Link with the Ministry of Infrastructure and the Electrogaz Electricity Department to ensure that geothermal activities are carried out in conformity with Government policies and electricity sector planning.
- Establish learning relationship with the Geothermal Education Office in California, which could help Rwandan institutions obtain instructional materials on geothermal energy and the geosciences.

- Establish a geothermal laboratory and testing facility to carry out geological mapping, geochemical testing, and certain aspects of geophysical surveys.
- Establish linkages with local and regional companies that have rigs capable of carrying out geothermal drilling.
- Provide practical training at geothermal plants in East Africa, Europe, and the United States.
- Provide on-the-job training in Rwanda in geothermal resource assessment.

The proposed RGC would support the following stakeholders:

- Rwandan Government agencies involved in promoting and regulating private power developers, mining interests, and water resource exploration (that is, the Rwanda Geology and Mines Authority);
- students and faculty at Rwandan schools and institutions of higher learning;
- private sector companies in Rwanda with mining and geothermal-related capabilities (well-drilling, water analysis, and so forth);
- private investors and mining and geothermal companies interested in financing or developing power generation, mining, or water resource projects;
- local and overseas financial institutions involved in purchasing carbon credits generated by the use of geothermal plants;
- bilateral and multilateral aid and lending agencies that may be able to assist with various components of future large-scale geothermal and mining projects;
- Rwandan and international environmental standards organizations;
- foreign companies that provide geothermal, mining, and water resource–related goods and services; and
- the Rwanda Central Water Quality Laboratory (part of Electrogaz).

The RGC would be expected to carry out the following activities in order to promote and assist private sector–based geothermal, mining, and water resource development:

- Assess policy and regulatory constraints the private sector faces in geothermal, mining, and water sectors (taxes, delays in concessions and permits, negotiation delays, lack of skilled local human resources, environmental requirements).
- Organize workshops, seminars, and conferences for private sector geothermal and mining stakeholders to describe upcoming

commercial opportunities and understand and address barriers to private sector participation.
- Help establish a Geothermal Association of Rwanda (GAR) to act as a focal point for public and private sector involvement in geothermal development issues. The GAR would organize monthly stakeholder meetings on various geothermal issues and issue a quarterly electronic newsletter.
- Support RGC and GAR membership in the Geothermal Resources Council, the International Geothermal Association (IGA) and the Geothermal Energy Association in order to receive membership rosters, newsletters, and other publications, including lists and descriptions of private sector suppliers of geothermal-related goods and services.
- Bring technical advances in geothermal and mineral resource identification, testing, power-plant, and mineral extraction technologies to Rwanda, and strengthen local private sector geothermal and mining companies.

The RGC would deliver the following outputs:

- development of the human resources needed for systematic assessment and exploitation of Rwanda's geological resources (geothermal energy, minerals, oil, and groundwater);
- establishment and operation of a national center to promote and accelerate the use of geothermal energy technologies in ways that are appropriate to Rwanda, including grid connection, power supplies to minigrid-based rural electrification projects, and direct uses via the public and private sectors;
- an enhanced intellectual capital base to provide baseline data to potential geothermal independent power producers and overcome barriers to increased development of private sector–based geothermal energy;
- ongoing applied R&D programs, including distance learning using links to research-related institutions in Africa, Asia, Europe, and North and South America;
- continuing program of monitoring and evaluation of ongoing geothermal projects in Rwanda;
- testing and evaluation of equipment used to provide geothermal services in accord with international standards;
- ongoing information dissemination, using a range of media mechanisms to increase public awareness about geothermal issues and options;

- ongoing geothermal-related educational programs in primary, secondary, and tertiary institutions;
- strengthened geothermal capacity in the private sector and with other national stakeholders; and
- a sustainable level of applied R&D activity in Rwanda to pave the way for expanded development of geothermal power generation and direct uses, with support from private contracts and donor agencies.

The RGC could be part of the Ministry of Infrastructure but housed elsewhere. Alternatively, it could be part of the soon-to-be-created National Agency for Energy in Rwanda (ANER); a Kigali-based annex to the Institute for Scientific Research and Technology (IRST) of the Ministry of Science, Technology and Scientific Research; or an agency of the Ministry of Lands, Environment, Forestry, Water and Mines.

REQUIRED CAPACITY-BUILDING EFFORTS

Implementation of the strategies proposed in this study requires capacity building at several levels. Options for building capacity in government agencies and educational institutions are presented below.

The five-person Task Force for the Rwanda Geology and Mining Authority is part of the Ministry of Lands, Environment, Forestry, Water and Mines. The authority plans to employ about 25 people, including 15 geologists and mining engineers. Its main objectives will be to:

- produce raw geological data to promote investment in the mining sector (large-scale geological maps, geochemical and mineral data);
- regulate the mining industry, by elaborating mining laws, supervising private mining activities, and monitoring compliance with environmental rules;
- upgrade mineral quality, by adding value through basic mineral processing such as smelters; and
- train and advise people working in small-scale mining activities grouped in cooperatives (19 such cooperatives are functional in Rwanda).

Capacity building for the Rwanda Geology and Mining Authority (RGMA) is needed to overcome the following constraints:

- gaps in exploration work (exploration has not been conducted since the 1980s);
- low level of investment in industrial minerals and rocks;
- small-scale, artisanal nature of mining in Rwanda;

- low level of financing available to local mining companies; and
- export of low-quality mineral ores.

Capacity building includes the training of NUR and KIST chemistry, physics, and engineering graduates as geoscientists (geologists, geochemists, and mining engineers), to be employed by the RGMA.[3] Training is to be carried out in Tanzania, South Africa, and possibly Ethiopia and Uganda, at an estimated annual cost of about $6,000 per person. Training in Europe could take place in Belgium or France, at an estimated annual cost of $12,000–$15,000 per person. Training at the bachelor's level would focus on the practical aspects of mining; master's-level training would produce a cadre of specialists in geological mining, geochemistry, geophysics, and mining engineering.

Capacity building would also target the 19 mining cooperatives, in the form of training seminars and access to credit for mining operations. Training would cover modern mining techniques, economies of scale, administration and bookkeeping, and other relevant topics.

Efforts to strengthen the geosciences-related capabilities of NUR and KIST would include the following:

- Establishment of links with institutions of higher education in Africa, Europe, Asia, and North America to facilitate Rwandan student participation in bachelor's, master's, and Ph.D. programs in the geosciences and engineering as they apply to geothermal resource utilization and power plant operation. Programs would include both basic and applied R&D programs, to facilitate public and private sector–based geothermal development, build national geothermal capacity, and promote the establishment of public and private sector–based geothermal services appropriate for the Rwandan and East African marketplace.
- Establishment and use of a distance-learning facility at RGC, with satellite links to universities, national laboratories, and other institutions carrying out applied research in various aspects of geothermal energy development.
- Curriculum development, preparation of instructional materials, and training of teaching staff at primary and secondary schools, technical colleges, and institutes in geothermal educational programs.

In order to strengthen Rwandan geoscientific capacity, it is necessary to train students at the university level for both bachelor's and master's degrees. It is recommended that NUR and KIST build learning partnerships with universities in Tanzania, South Africa, Kenya, Uganda, or Europe,

where selected Rwandan students would study geology, geophysics, and geological engineering.

NOTES

1. See background documents in appendix 1, especially Gawell, Reed, and Wright (1999).

2. Some limited observations and surface geochemical work was conducted at hydrothermal springs in the western and central part of the country.

3. To put the human resource requirements of operating geothermal plants in perspective, the Kenya Electricity Generating Co., Ltd. (KenGen) employs about 60 full-time professionals to maintain two geothermal plants of 45 MW and 70 MW. They include geologists, geophysicists, geochemists, reservoir engineers, drilling engineers, and power station operation, maintenance, and electrical engineers, some of who have master's degrees or Ph.D.s in geothermal technology. Fifty-nine Kenyan professionals have graduated from specialized institutions, including the Geothermal Institute at the University of Auckland (New Zealand) and the United Nations University Geothermal Training Program in Iceland.

CHAPTER 7

Client-Focused Agricultural Research and Outreach

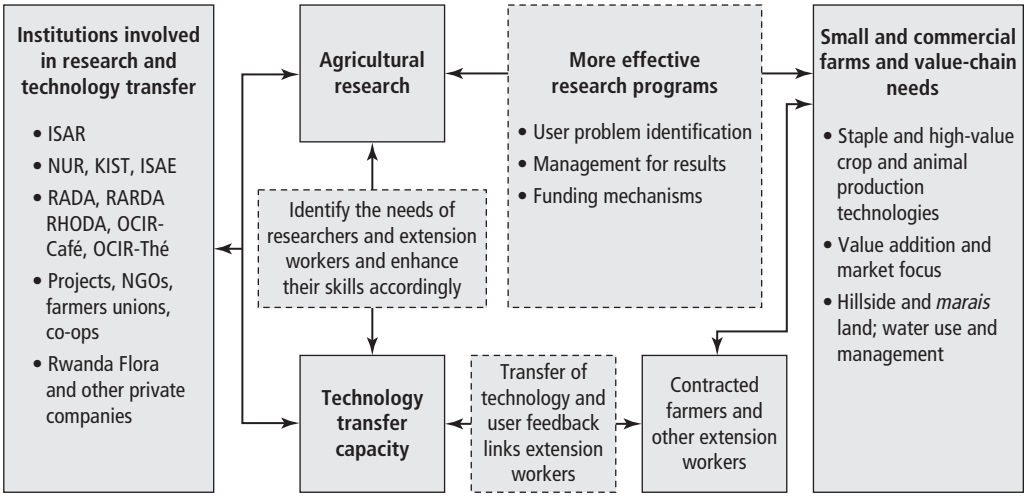
This chapter summarizes the assessment of agricultural research and technology transfer in Rwanda, with a focus on the Agricultural Sciences Institute of Rwanda (ISAR) and its downstream technology transfer partners. It develops principles for a national strategy to address revealed weaknesses and proposes an action plan for addressing specific capacity constraints in the system. The emphasis is on (a) creating a research and technology transfer system that can help mitigate food insecurity for the bulk of Rwanda's population (very small-scale farmers); (b) promoting commercially viable export agriculture across both traditional export cash crops and high-value horticulture; and (c) improving the performance of animal and animal product industries, postharvest and storage research, and other related topics.

SITUATION ANALYSIS/NEEDS ASSESSMENT

An efficient agriculture research and technology transfer system can fulfill three desirable yet unmet needs in Rwanda:

- Boost food security by increasing the productivity of basic food crop and animal production systems so that more food is available in rural areas and cheaper food is available in urban areas. Productivity will increase primarily through commodity-specific improvements. But closer integration of animal and crop production systems and the spread of field-level agroforestry practices that have dual roles in erosion control and livestock feeding can also help.

Figure 7.1: STI System for Agricultural Research and Technology Transfer (ARTT) in Rwanda



Source: Tizikara et al. 2007.

- Stabilize and improve the sustainable utilization of Rwanda's natural resource base, namely, its land, soil, and water resources, especially hillside and *marais* production areas. The tighter integration of animal and crop production systems and the expansion of multiple-use agroforestry systems will be important components in improving the sustainability of hillside production through better soil fertility and improved erosion control. These efforts can have strong impacts on the sustainability of production systems lower in the watershed (*marais* lands) as well as on yields at all hillside levels.
- Increase the volume and profitability of commercial value-chain production for local and export markets. This will require strengthening existing or emerging chains in products such as Arabica coffee, potatoes, rice, milk and milk products, and high-value horticulture for regional or international export.

The three areas constitute the "user needs" that the evolving agricultural research and technology transfer system must satisfy (figure 7.1).

The first two activity areas are partially "public goods" areas because end-users cannot fully pay for these research and technology transfer services. For example, the public research system must always be ready to solve urgent production problems such as disease or pest attacks, while continually working to increase per unit productivity on important food crops. The third area, market-oriented value chains, has the potential to

be more self-sustaining or to produce a larger portion of the funding needed for its own research and outreach.

WEAKNESSES IN THE PERFORMANCE OF THE AGRICULTURAL RESEARCH AND TECHNOLOGY TRANSFER SYSTEM

Rwanda's agricultural research and technology transfer system is performing poorly. Structural and functional problems weaken both the research and the technology transfer subcomponents. The following problem areas form the basis for recommended actions:

- End-users of research and technology are isolated from different stages of problem identification, system planning, and execution and evaluation of technology development and transfer.
- Private sector and civil society are removed from the development and dissemination of agricultural technology in a value-chain framework, and the profit-loss aspects of farming systems and value-chain systems are often ignored.
- Government and donor funding of research and technology transfer is insufficient, disorganized, and poorly prioritized. Cost-recovery mechanisms and financial autonomy are needed for ISAR and downstream partners to be at least partially financially self-sustaining.
- ISAR is underperforming in terms of the execution of contracted research activities, the transmission and packaging of timely results to users, and monitoring and evaluation of system results.
- Technology transfer to farmers—through nongovernmental organizations (NGOs), farmers' unions, cooperatives, independent projects and projects based at the Ministry of Agriculture, private sector companies, and the Ministry of Agriculture's own priority programs conducted with district and sector agronomists—is poorly coordinated and fails to meet performance standards. Lessons learned are not communicated effectively.
- Key state research and training institutions lack trained staff to produce the personnel that national plans and policies are demanding and nongovernmental partners need for their work. Incentives to retain and motivate staff at key institutions are lacking.
- The two national institutions of higher education in agriculture, the National University of Rwanda (NUR) and the Institut Supérieure d'Agriculture et d'Elevation (ISAE), have inadequate capacity to train the scientists and technicians needed by Rwanda's future agricultural industries.

- The decentralization of the research and outreach system (both within ISAR and at the district and sector levels) is not yet producing desired results and needs modification.

WEAKNESSES IN THE PUBLIC RESEARCH AND TECHNOLOGY TRANSFER SYSTEM

Weak links between research and extension and internal weaknesses in ISAR's funding and management have so far been the greatest hindrances to effective transmission of improved technology to producers. Research is often conducted without considering the real needs of farmers or value-chain participants. No mechanism exists for the consolidated gathering and dissemination of information on all innovations and technological solutions to potential users, although the Center for Agricultural Information and Communication (CICA) to be created in the Ministry of Agriculture by the new Decentralized Extension Project (PVD) promises to create such a mechanism.

Research results fail to reach end-users because the capacity for dissemination is weak, whether in pilot tests in farmers' fields or in mass dissemination campaigns such as the recent campaign to replace existing varieties of cassava with mosaic-resistant varieties. This failure occurs because the system is fragmented, with information flowing in bits and pieces.

The research being conducted in public (ISAR) laboratories is adaptive in nature. This is appropriate given the state of agricultural transformation in Rwanda and the backlog of more general knowledge of plant and animal systems appropriate for Rwanda, which largely needs to be fine-tuned in order to have substantial impact in farmers' fields. ISAR has severe problems in human resources, funding, internal management, and delivering on contracted research, but these problems are more concentrated and easily solved than the more complex real-world challenges of making proper use of available technology in the promotion of specific commodity subsectors and the development of models of sustainable production in hillside and *marais*-land farms.

Over the next 10 years, ISAR staff will need substantial strengthening to carry out its mandate and respond to the activity areas identified above. Its greatest relative strength is in areas where its basic research programs are well geared to what is needed to improve basic food crop production and can support improvement in widespread local cash crops (bananas and sorghum for local beer making, for example).

ISAR's ability to handle integrated small farm management, watershed management, and related areas, such as crop-livestock joint products and agroforestry, is weak. The established programs are not designed for ease of outreach and impact at the farm level. However, the integrated watershed management program has made a good start at showing the way forward in this important area.

ISAR is perhaps weakest in its ability to support the development of commercially important value chains. In some areas (such as in the tissue culture production of seed potato in Ruhengeri), its technical competency seems to be responding reasonably well; in other important areas, however, such as coffee and tea research, almost nothing has been accomplished in recent years, despite funding to ISAR by these industries. Little is being done with ISAR's model coffee plantation and washing station at Rubona. The overall technology transfer system for crops (between ISAR and its downstream extension partners) remains fragile and very dependent on donor intervention to function.

Animal research appears to be even more limited. Most of what is being done in Rwanda seems to involve observational trials of the productivity of improved mixed-race animal species, feeding trials, and the introduction of exotic breeds (such as Holstein and Jersey dairy cows, Boer goats from South Africa, and wool sheep breeds) for genetic improvement of farm-level herds and repopulation of domestic herds. Animal health research is not covered by ISAR, and only a few observational trials are undertaken at the central laboratory of the Rwanda Animal Resources Development Authority (RARDA) at Rubirizi. Most technology transfer involves RARDA and NGO programs in artificial insemination, animal health campaigns, and cooperation with groups promoting the provision of improved livestock to farmers in support of campaigns such as "one farm, one cow" for milk production.

For horticultural crops, no research or technology transfer systems are operating (except for passion fruit and temperate fruit tree trials). The Rwanda Horticulture Development Authority (RHODA) was created at the Department of Agriculture in 2007. ISAE is planning to create a horticultural department, which will begin training operations and industry collaboration within two years or so. ISAR has a small horticultural unit. But rather than developing products that have high export potential—such as ethnic varieties of vegetables (cabbage, carrots, lettuce) or ornamental flowers (orchids, roses)—the unit is devoting most of its effort to donor-funded projects for preventing indigenous vegetable species from disappearing.

WEAKNESSES IN PRIVATE SECTOR PARTICIPATION

Compared with its competitors in East Africa (Ethiopia, Kenya, and Uganda), Rwanda has little private sector participation in the larger-scale, formal-sector portions of agribusiness. With a few notable exceptions, most commodity chains have seen only limited growth of modern private sector companies that take an active role in the more technically complex and potentially lucrative segments of these chains. Much of the growth in recent years has been by cooperative structures fostered by donor and NGO development projects. These cooperatives have become the training ground for potential independent Rwandan entrepreneurs of tomorrow. They also introduce modern production and postharvest processing technologies.

Given the embryonic development of formal private sector agriculture enterprises, it should not be surprising that private sector participation in technology generation and transfer has been limited. Three private or semi-private enterprises (Rwanda Flora, OCIR-Thé, and OCIR-Café) all report having recently provided funds to ISAR for contracted research but not having received the contracted research output.

The parastatal and private firms operating in agriculture have provided some technology transfer to producers, but this technology has generally come from sources other than ISAR. For example, much of the technical expertise required to set up and operate 150 washing stations for Arabica coffee has come from private sector actors in East Africa and, to a lesser degree, South America. Coffee-marketing expertise has come from Europe and the United States, the main markets for specialty coffees. The technology used in the rapidly growing milk industry has generally come off the shelf from the vast storehouse of accumulated knowledge of dairy production and processing systems in Organisation for Economic Co-operation and Development (OECD) countries. Rwanda Flora's production technology for roses comes largely from the huge Kenyan export floral industry, with other key pieces of technology coming from Israel, the Netherlands, and other countries.

WEAKNESSES IN THE AGRICULTURAL EDUCATION AND TRAINING SYSTEM

ISAE and the Faculty of Agriculture of NUR are the leading institutions of higher education in agriculture in Rwanda. Student populations have been increasing rapidly in recent years. ISAE currently has more than 1,500 students in its three-year advanced diploma programs, some of whom enroll in an additional two-year training to qualify for a first

degree. Laboratory facilities at ISAE have been well equipped with support from the African Development Bank. NUR has a Faculty of Agriculture with 359 undergraduates and 27 graduate students in agroforestry and soil management.[1]

Both NUR and ISAE have weak linkages with the farming and agro-business sector. They have limited capacity to deliver advice and information to farmers and agro-entrepreneurs. Farmers and investors require expert business and technical guidance for technology selection and purchase, marketing, financing, project analysis and business plan preparation, and credit and training for specific value chains. Building institutional capacity at NUR and ISAE to meet these needs will allow the agricultural research and learning system to support the national goal of creating a dynamic agriculture sector that drives economic growth.

Another problem is that research output at both institutions is low and not linked to the needs of economic and social growth. ISAE (a much smaller and newer institution than NUR) is much closer to performing its role of providing technical agricultural training and commodity industry support than NUR is to performing its more demanding role of training research scientists who will be able to contribute in the results-driven world of 21st century agriculture. NUR needs a well-structured strategy on how to meet complex user needs requiring a blend of good science training and the development of business-oriented entrepreneurial skills useful in private sector development.

RECOMMENDED STRATEGIES FOR CAPACITY BUILDING

A set of actions is proposed to address the weaknesses in Rwanda's agriculture research system.

STRENGTHEN THE KEY COMPONENTS OF THE AGRICULTURAL RESEARCH AND TECHNOLOGY TRANSFER SYSTEM

Three central problems need addressing. First, and most important, greater capacity is needed in both community-level programs (such as integrated farm and integrated watershed management) and commercial-level programs for developing attractive commodity value chains for national and export markets. Second, there is an almost total lack of systematic data on the cost of producing commodities and consumer products in value chains. This information—and related comparative and competitive advantage analyses—is needed for informed policy decision making in support of government and private sector investment in the

sector. Third, the legal and regulatory frameworks required to develop modern agriculture subsectors and enhance the capacity for exports are only very partially in place.

To address these issues, the Government could consider the following recommendations:

- ISAR needs to reengineer its research program to focus more on applied research than on basic research. This research should provide improved models for integrated small farm systems, with greater emphasis on animal-livestock integration, agroforestry, and enterprise selection for higher farm income; community-level integrated watershed management programs, in cooperation with district and sector governments and local community organizations; and improved technology generation and delivery to help solve bottlenecks in the development of traditional cash crops and newer nontraditional exports in high-value horticulture.
- A specialized applied research unit should be created and funded as a core program to coordinate the collection of cost-of-production data (to be implemented by the new agricultural data collection unit in the National Institute of Statistics and comparative and competitive advantage analyses of Rwandan agricultural value chains. The location of this unit needs to be carefully chosen, so that it can play its policy-advisory role in an impartial manner.
- In association with the new World Trade Organization–funded Rwanda Horticultural Exports Standards Initiative (to be located in RHODA) a comprehensive study and action plan should be developed to establish the needed legal and regulatory framework for domestic fresh and processed food products and those quality, origin, and phytosanitary standards required to be competitive in various regional and international export markets.

EMPOWER THE BENEFICIARIES OF AGRICULTURAL RESEARCH AND OUTREACH

A functional environment for business development in Rwanda requires greater participatory preseason joint planning and in-season operational coordination among three groups: (a) local scientific and learning institutions, such as ISAR, NUR, ISAE, and KIST, as well as independent consultants and trained personnel scattered across other institutions; (b) technology transfer groups, such as NGOs, farmers unions, and donor projects, as well as RADA, RARDA, and RHODA[2]; and (c) private sector

partners from specific commercial value chains.[3] Participation by farmers, farm groups, and value-chain stakeholders is required in the research and technology transfer system in priority setting and planning, funding (including financial accountability), performance contracting, and the monitoring and evaluation of results achieved.

To address these issues, the Government could consider the following recommendations:

- Increase participation by farmers and other value-chain stakeholder in annual research planning and feedback meetings of ISAR and key institutions (RADA, RARDA, RHODA) by involving them in a planning meeting to agree on the main research program to be supported with core funds and competitive funding and a review meeting to consider achievement of results and progress toward meeting set goals. Create a client-led National Agricultural Research Board (NARB) as a substructure in the Ministry of Science, Technology and Scientific Research (MINISTR). The board can review performance of the agriculture research and technology transfer system, set the annual research and outreach agenda in priority areas, and guide the allocation of competitive research funding (from the National Research Fund and the Innovation Support Funds) based on demonstrated competence by ISAR and other research units.[4]
- Direct the proposed NARB to identify and compile a list of the research and training needs of farmers and farmer groups, scientists at ISAR and research and training units, and downstream technology dissemination units coordinated by RADA, RARDA, and RHODA.
- Pilot a participatory system for monitoring and evaluating the efficiency and impact of research and training services. The pilot should involve farmers, inputs suppliers, processors, marketing agents, government representatives, and private entrepreneurs.

PROMOTE THE PROFITABILITY OF AGRICULTURE AND PRIVATE SECTOR PARTICIPATION

Transforming Rwandan agriculture to a more modern, market-oriented sector will take decades. Several issues need to be addressed over the next five years. First, collection, analysis, and dissemination of cost and profitability data are needed for use in policy-making debates and decision making. This analysis needs to be combined with presentations made by

commodity groups seeking public sector or donor assistance. Second, the Government needs to conduct analysis and take measures to improve the climate for foreign and domestic private sector investment in modernizing value chains. Measures need to be taken to encourage the growth of private firms in most crop, animal, and horticultural value chains. Third, the Rwandan Private Sector Federation (RPSF) and its 12 commodity-oriented chambers need to be more involved in priority setting in the NARB and component units such as ISAR, RADA, RARDA, and RHODA.

To address these issues, the Government could consider the following recommendations:

- Have the proposed NARB base at least part of its deliberations on a periodic (every three to four years) cost of production, comparative advantage, and profitability report, with annual updates on factors (such as prices and market disruptions) that change more frequently.
- The research board, together with the RPSF and the Rwanda Investment and Export Promotion Agency (RIEPA), should continually monitor problems in the investment climate for agribusiness. They should also propose solutions for eliminating investment barriers and improving the business climate in agriculture sector. Doing so would help increase investment in improved technologies, improve Rwanda's business climate indicators, induce financial and credit institutions to provide seasonal and longer-term investment credit, and protect intellectual property rights in agricultural technology.
- Create an Innovation Support Fund to provide matching-grant funding for specific proposals by partnerships of private companies and local production groups. The fund would help demonstrate proof of concept on a pilot basis, linked at later stages by commercial loan guarantee funds and business incubator approaches to strengthen new firms producing for national, regional, and international markets.[5]
- Develop approaches and mechanisms for organizing and linking poor producers to markets for high-value products. Through the Innovation Support Fund, the private sector should be supported in its efforts to develop supply-chain management and out-grower production systems for particular groups of commodities and technologies.[6]
- Support the development of private seed multiplication and distribution companies where there is sufficient farmer demand: seed

potatoes through tissue culture, for example. As an alternative, the Ministry of Agriculture and other partners might consider creating one or more for-profit private sector share companies, in which shares would be owned by individual farmers, businesspeople, farmers unions, seed multipliers, commodity-specific cooperatives, and private sector companies in the input business. This distribution company would be adequately capitalized, professionally managed, and expected to turn a profit for its shareholders by selling commercial inputs through a network of stores convenient to farmers. There is also a need to develop sustainable input supply systems (especially for seeds and fertilizer) for areas not well covered by private companies. Producer groups should be facilitated to organize themselves and establish links with research institutes, private companies, and financial institutions to make this happen.

IMPROVE ISAR'S INSTITUTIONAL PERFORMANCE

ISAR's performance needs a boost to help it fully satisfy its research clientele. To meet clients' needs, ISAR needs to become more of a learning organization, one that critically evaluates its own performance and modifies its operating procedures in the face of assessment results. It must also become a more nimble, flexible, and entrepreneurial organization if it is to remain the privileged partner in agricultural knowledge creation, adaptation, and transfer.

To meet these goals, the Government could consider the following recommendations:

- Provide ISAR with technical assistance to develop policies and staff training modules for client satisfaction in its contractual arrangements with international partners and Rwandan parastatal and private sector companies. Improving client satisfaction will be especially important if ISAR expects to play an important role in emerging high-value export value chains.
- Once ISAR develops an adequate core budget with which to pay its staff appropriately, maintain its physical plant, and ensure basic functioning of priority research functions, require it to engage in full cost-recovery problem-solving research with a variety of partners and more aggressively market its capabilities. Requiring ISAR to engage in full cost-recovery research would (a) force it to clearly categorize and prioritize research as strategic, basic, applied, or adaptive research and to define the aspects of research that are of a

"public good" nature and those that the private sector is best suited to fund; (b) promote the use of innovative research approaches by organizing multiinstitutional and multidisciplinary research partnerships in the form of teams to be responsible for specific research themes at the national and local levels; and (c) promote greater cooperation and collaboration with international research institutions and donor-funded projects (such as the Integrated Watershed Management Program, funded by the Rural Sector Support Program) in order to enhance utilization of existing techniques, technologies, skills, and information.

- Encourage ISAR to become a leader in advocating for competitive funding mechanisms to be used for more targeted problem-solving research project funding. To do so, IRAR must become competitive in terms of meeting client needs and delivering results on a timely basis, in a nonacademic format that lends itself to technology transfer to users. Experienced outside consultants could conduct a critical audit of the noncore contractual research conducted by ISAR over the past two years, draw lessons from that experience, and prepare in-house training program to improve performance.
- Undertake a diagnostic study to explore how ISAR can be given flexibility to access funds allocated for salaries and allowances for vacant full-time staff positions. These funds could then be used to contract private sector research partners and temporary/contract staff and interns to fill skill gaps and take advantage of complementarities and synergies arising out of appropriate private-public collaboration.

IMPROVE COORDINATION, METHODS, AND PERFORMANCE STANDARDS FOR AGRICULTURAL RESEARCH AND TECHNOLOGY TRANSFER

Improving performance in technology transfer will require three major reforms. First, coordination needs to be approved between the Ministry of Agriculture and its agencies and the civil society institutions involved in transmitting improved technology to farmers. Second, the success or failure of different approaches in transmitting technology to end-users on different types of farms and different value chains needs to be assessed. Third, performance standards need to be developed for delivering improved technologies to small-scale farms with limited resources and larger-scale, more commercial farms and business units in different value chains.

To address these issues, the Government could consider the following recommendations:

- In collaboration with Belgium Technical Cooperation's decentralization project and other research and technology transfer efforts, provide support as needed to strategic one-off efforts to promote better system coordination, evaluation of comparative results, and the drawing of lessons learned.
- Encourage all research and training agencies to contribute to the new Ministry of Agriculture information databases and the creation and maintenance of its dissemination Web site. Cooperation could be facilitated by periodic questionnaires and workshop training.
- Have the Ministry of Agriculture develop and disseminate standards for "public service" technology transfer services and those for which partial and total cost recovery is justified.
- Develop and disseminate models for civil society organizations and private sector agricultural delivery to groups targeted by location, commodity, size of enterprise, ability to pay, category of assistance needed, and other characteristics.

DEVELOP AND MANAGE HUMAN RESOURCES

Rwanda's major institutions of agricultural research and higher learning are experiencing desperate personnel shortages. Among Rwanda's greatest (and most expensive) one-time challenges are the need to provide advanced degree training for tomorrow's scientists and agricultural educators, recruit temporary staff, and upgrade the training of existing staff. To retain personnel and reduce turnover, especially in public institutes, staff need to be motivated and adequately remunerated.

To address this issue, the Government could consider the following recommendations:

- Carry out a training needs assessment of the staff of key public and private institutes with important research and training roles in order to formulate comprehensive training plans and programs for the advancement of scientific knowledge, instructional methodologies, socioeconomic research, and participatory methods for problem identification.
- Increase liaison between training institutions and research/advisory service providers by establishing "demand committees," through which training institutions can get a sense of future human

resource requirements based on the demands for research and extension.
- Encourage and support training institutions to provide more cost-effective "sandwich courses," in which students spend some time conducting practical research for a research service provider or commodity-specific organization.
- Raise the remuneration (salaries, wages, and allowances) of academic, scientific, and technical staff so that it is comparable to that offered by similar public institutions.
- Explore other avenues of motivation and remuneration of staff, such as retention of a defined percentage of revenue from research contracts and consultancies in which a staff member is involved in implementation; performance/achievement awards; and paid sabbaticals.
- Develop and establish scholarship, cost-sharing, and educational loan schemes and programs to enable current and prospective research scientists, including those in the private sector, to improve their knowledge and skills.

BUILD CAPACITY AT ISAE AND NUR

At a minimum, capacity building at the two key institutions of higher education in agriculture must address three priority needs. First, it should enhance the competence of ISAE and NUR graduates to better meet the needs of producers, entrepreneurs, and agriculture policy makers. Second, it should allow lower-level (A2) agricultural professionals, farmers, and agribusinesses personnel to participate and benefit selectively (in a continuing education mode) from higher education and applied research. Third, it should establish or strengthen linkages and partnerships within Rwandan institutions and other institutions at the national, regional, and international levels in order to promote cooperation in training, research, and outreach.

To address these issues, the Government could consider the following recommendations:

- Provide financial support for specialist postgraduate training and skills upgrading through sabbaticals, seminars, study visits for ISAE and NUR Faculty of Agriculture staff. At least 80 percent of all academic staff should have Ph.Ds.
- Establish or rehabilitate properly equipped specialist teaching and research laboratories and field facilities at the NUR Faculty of

Agriculture and ISAE, in order to introduce or increase more practical training into each institution's curricula. About 1,500 square meters of space is the estimated need at each institution.

- Rework advanced diploma and first-degree courses so that they are more practice based. ISAE has developed a competence-based curriculum for its training. The curriculum and the degree program need to be reviewed against the requirements of the newly established National Qualifications Framework and specialized (in the final year) by attaching students to production units established at their institution or operated by the private sector. The participating private sector units would be financially supported to serve as demonstration centers for the industry. The institutional units would be developed as self-financing centers in the long run.
- Encourage ISAE and NUR to continue to expand continuing education services to the private sector agribusiness community, through short competency-based courses, distance education, and field extension activities.

Introduce short modular courses and in-service training for professionals and practitioners. Introduction of the courses would require the design of an integrated curriculum and the resources and training necessary to implement it.

NOTES

1. The master's degree program is being conducted in collaboration with Wageningen Agricultural University and supported by the Government of the Netherlands.

2. The Rwanda Agriculture Development Authority (RADA), the Rwanda Animal Resources Development Authority (RARDA), and the Rwanda Horticulture Development Authority (RHODA) are Ministry of Agriculture agencies created to provide agricultural and animal production advisory, outreach, and extension services to new regions, districts, sectors, farmers and farmer organizations, nongovernmental organizations, and private entrepreneurs. These agencies operate through satellite centers in various agroecological zones.

3. The need for improved coordination and timely joint actions by partners is particularly critical in higher-value production and marketing chains. For example, the coffee industry, Rwanda's number one export industry, has been plagued with an inability to provide key inputs on time and to mobilize adequate seasonal credit for coffee purchasing. Ripe coffee "cherries" must be picked, purchased, and processed (depulped, fermented and washed, repeatedly sorted for quality, dried, and removed of parchment) within a fairly narrow window in order to produce good-quality "green coffee" that will command high prices on world markets.

4. An alternative name might be the National Agricultural Technology Advisory board (NATAB). The Government should choose a name that correctly reflects the board's objectives.

5. A consortium of donors used a similar approach in developing Kenya's horticultural export industries. See P. Labaste, "The European Horticulture Market: Opportunities for Sub-Saharan African Exporters" (Working Paper 63, World Bank, Washington, DC, 2005).

6. The Rwanda Flora pilot proposal, currently being circulated, is a good example of such thinking.

APPENDIX 1

Background Documents

The following background documents were used to design the terms of reference and prepare the individual needs assessment and action plan studies:

General Documents

Ministry of Finance and Economic Planning. 2002. "Vision 2020 Document." Kigali.

_____. 2007. "Economic Development and Poverty Reduction Strategy." Draft. Kigali.

Ministry of Science, Technology and Scientific Research. 2005. "National Science, Technology and Innovation Policy." Kigali.

Agriculture Sector

Agriculture Sector Working Group. 2006. "Joint Sector Review Report: Self-Evaluation of Poverty Reduction Support Grant." Kigali.

Ministry of Agriculture and Animal Resources. 2002. "Agriculture Policy Note-Draft." Kigali.

_____. 2004. "Strategic Plan for Agriculture Transformation (SPAT) in Rwanda." Kigali.

_____. "Support Project for the Agricultural Transformation Strategic Plan PAPSTA." Kigali

Appropriate Technology

CITT (Centre for Innovation and Technology Transfer). 2004a. "Impact Assessment Report." Kigali.

_____. 2004b. "Inventory of Relevant Technologies Existing in Rwandan Communities." Kigali.

Food Processing

CITT (Centre for Innovation and Technology Transfer). 2003. "Dissemination of Food Processing Technology." Kigali.

Geosciences and Geothermal Energy

Nowells, D., D. Rohrs, and J. Lifa. 2006. "Preliminary Geothermal Potential in Rwanda." Chevron Corporation, San Ramon, CA.

Gawell, K., M. Reed, and P. M. Wright. 1999. "Geothermal Energy: The Potential for Clean Power from the Earth." Geothermal Energy Association, Washington, DC.

World Bank. 2006. "Project Information Document: African Rift Geothermal Development Facility." Africa Energy Unit (AFTEG), Washington, DC.

Technical and Vocational Education and Training (TVET)

Ministry of Education. 2007. "Rwanda National Policy on Technical and Vocational Education." Kigali.

JICA (Japanese International Cooperation Agency). 2006. "Tracer Study Report on the Employability of Graduates from Technical and Vocational Schools." Kigali.

Water

COFORWA (Compagnons Fontainiers du Rwanda). n.d. "Concept Paper." Gitarama.

APPENDIX 2

Sample Terms of Reference for the Needs Assessment and Action Plan Studies

This sample terms of reference (TOR) was used to conduct the needs assessment and action plan studies. For future studies, the TOR should be tailored to the unique needs of the country and to the unique demands of local context. The general principles could remain the same.

1. OBJECTIVE

The objective of the study is to

- assess supply and demand constraints and capacity influencing the production and diffusion of appropriate technologies in Rwanda;
- develop an action plan for boosting the capacity of actors involved in technology development and distribution, and build targeted incentives for those actors; and
- increase the adoption of appropriate technologies by households, farms, businesses, youth, and women—for income generation and poverty reduction.

The needs assessment and action plan study will focus on:

- energy technologies;
- sanitation and waste management technologies;
- low-cost housing technologies;
- water supply, rainwater harvesting, and storage technologies;
- agriculture technologies and food-processing tools; and
- entrepreneurial tools and technologies

2. SCOPE AND METHODOLOGY

1. A team of one international and two national consultants will conduct a 30-day study in Rwanda.

2. The study should use the body of knowledge existing on appropriate technologies in Rwanda.
3. The study should harmonize and liaise with related initiatives and projects.
4. The study should evaluate the performance and mutual interaction of actors involved in the development and transfer of technology:

   ➢ *Demand-side actors*
   - Technology users (households, firms, farms, youth, women, schools, and so forth)

   ➢ *Intermediary actors*
   - Education and training institutions (technical and vocational education and training [TVET], universities, engineering colleges, and so forth)
   - Technology suppliers and distributors (small and medium-size enterprises, nongovernmental organizations, and so forth)
   - Microlending institutions offering credits to technology buyers

   ➢ *Supply-side actors*
   - Public institutions for technology development and transfer (the Centre for Innovation and Technology Transfer [CITT], the Institute for Scientific Research and Technology [IRST], and so forth)
   - Private firms importing/producing and selling technology

3. EXPECTED TASKS

Task 1: Conduct a baseline study of existing capacity and constraints. The baseline assessment should help answer the following questions about the development and diffusion of appropriate technologies:

- What is the demand and need for appropriate technologies in the country?
- How do demand-side factors (purchasing power, access to information, perceived benefits of technology, and so forth) and supply-side factors (capacity in technology agencies and so forth) influence technology adoption?
- How effective is the interaction between technology actors?
- What are the strengths and weaknesses of public and private technology/research agencies?
- What incentives exist for developing and diffusing appropriate technologies?

- How well are the training and education institutions meeting the needs of technology actors?

Task 2: Develop a vision and an achievable set of short- and long-term goals and objectives.
Using the baseline assessment results, what feasible goals and objectives can the country aim for in the next one to five years?

Task 3: Prepare a detailed action plan.
The action plan should list detailed and practical action steps for

- boosting the capacity of technology actors,
- improving interaction between technology actors,
- removing constraints in technology adoption,
- building targeted incentives for technology development and diffusion, and
- using education and training for capacity building at all stages of technology flow.

It should provide a timeline and costs associated with the action items.

4. REQUIRED OUTPUT

The final output is a detailed report fulfilling the expected outcomes (baseline study and needs assessment, strategic program, action plan). The intermediate outputs include the following:

- a proposed methodology and milestones for the study;
- a draft report, with consolidated results of fieldwork and tentative action proposals;
- the presentation of draft report at a stakeholders' meeting in Rwanda; and
- a final report incorporating comments.

5. EXPECTED QUALIFICATIONS

The candidate should have demonstrated success in designing and implementing technology diffusion strategies in developing countries, especially in Africa. An advanced degree in engineering, technology management, rural development, public policy, or a related field is desired; relevant experience is mandatory. Experience in handling multilateral, multicultural projects is an advantage. Knowledge of English and French is desired.

APPENDIX 3

Public Institutions Involved in STI Capacity-Building Action Plans

Table 3A.1: Public Institutions Involved in STI Capacity-Building Action Plans

Institution	Reporting to	Responsibilities
Agricultural Sciences Institute of Rwanda (ISAR)	Ministry of Agriculture	Agricultural research
Centre for Innovation and Technology Transfer (CITT)	Kigali Institute of Science, Technology and Management	Innovation and technology transfer
Human Resources and Institutional Capacity Development Agency (HIDA)	MIFOTRA	Development of human resources and institutional capacity
Institute of Agriculture and Animal Husbandry (ISAE)	Ministry of Agriculture	Scientific training in agriculture and animal husbandry
Kigali Health Institute (KHI)	MINISANTE	Health research
Kigali Institute for Science and Technology (KIST)	Ministry of Education	Education and research on science and technology
Kigali Institute of Education (KIE)	Ministry of Education	Teacher training, including in science
Ministry of Education		STI learning at all levels of education system
National Forests Authority (NFA)	MINITERE	Sustainable forestry
National University of Rwanda (NUR)	Ministry of Education	Higher education
National Water Authority (NWA)	MINITERE	Water quality management and water regulations
Rwanda Environmental Management Agency (REMA)	MINITERE	Management of environment laws and regulations
Rwanda Geology and Mining Authority (OGMR)	MINITERE	Creation of sustainable and higher-value-added mining industry
Rwanda Information Technology Authority (RITA)	Ministry of Infrastructure	Information technology
Rwanda Investment and Export Promotion Agency (RIEPA)	MINICOM	One-stop shop for investors and exporters
Institute for Science and Technology Research (IRST)	MINISTR	Science and technology research

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Hendriksen, G., R. Ruzibuka, and T. Rutagambwa. 2007. "Building Science, Technology and Innovation Capacity for Development and Diffusion of Appropriate Technologies in Rwanda." Science, Technology, and Innovation (STI) Group, World Bank, Washington, DC.

Hirsch, S., A. Abdallah, and J. P. Ngizimana. 2007. "Building Science, Technology and Innovation Capacity for Geosciences and Geothermal Energy Development in Rwanda." Science, Technology, and Innovation (STI) Group, World Bank, Washington, DC.

Lothe, P., and J. C. Nkuri. 2007. "Building Science, Technology and Innovation Capacity for Delivery of Drinking Water in Rwanda." Science, Technology, and Innovation (STI) Group, World Bank, Washington, DC.

Poston, D., and I. Habimana. 2007. "Building Science, Technology and Innovation Capacity for Value-Added Exports in Rwanda." Science, Technology, and Innovation (STI) Group, World Bank, Washington, DC.

Poston, D., J. C. Nkuri, and D. S. Nkunda. 2007. "Building Science, Technology and Innovation Capacity in the Food Processing Industry in Rwanda." Science, Technology, and Innovation (STI) Group, World Bank, Washington, DC.

Tizikara, C., D. Wilcock, and P. Celestin. 2007. "Building Science, Technology and Innovation Capacity for Agricultural Research and its Outreach in Rwanda." Science, Technology, and Innovation (STI) Group, World Bank, Washington, DC.

[1] This book is based on these six needs assessment and action plan reports that resulted from the STI analytical studies conducted in Rwanda.

Index

Boxes, figures, notes, and tables are indicated by *b, f, n,* and *t,* respectively.

A
absentee management, 23–24*n*10
academic science, 14
accountability, 19–20*b*1.1
action plans. *See* needs assessments and action plans (NAAPs)
AESD/MOFA Rural Technology Unit, Ghana, 42–43, 46*n*2
African Development Bank, 89
agribusiness, 88
agricultural research and outreach
  empowerment of beneficiaries of, 90–91, 97–98*nn*2–4
  and human resources for, 95–96
  improvement in, 4–5
  needs assessment of, 83–89
  recommended strategies for capacity building, 89–97, 97–98*nn*3–6
  situation analysis of, 83–89
agricultural research and technology transfer (ARTT)
  coordination, methods, and performance standards for, 94–95
  improvement of, 4–5
  science, technology, and innovation (STI) system for, 84*f*7.1
  strengthening key components of, 89–90
  weaknesses in performance of, 85–86
Agricultural Sciences Institute of Rwanda (ISAR), 5, 83, 85, 90, 92
  improving institutional performance of, 93–94
agricultural technologies, 59
agriculture
  background documents for NAAP studies, 99
  increasing production in, 37–38
  promotion in private sector, 88, 91–93, 97*nn*5–6
  status of appropriate technologies for, 47–48
  water resources development and management, 69
  weaknesses in education and training in, 88–89, 97*n*1
agrobusiness sector, 89
agroforestry, 89
agro-processing, 47–48
alternative energy, 59
ANER. *See* National Agency for Energy in Rwanda (ANER)
animals
  animal and animal product industries, 83
  animal and crop production industries, 84
  animal research, 87
applied research, 3, 90, 96

Applied Sciences Research Centre (ASRC), 58–59
applied technologies, 3
apprenticeships, food-processing industry, 33
appropriate technologies, 11, 23*n*6
  agencies and institutions responsible for promotion of, 51–54
  background documents for NAAP studies, 99
  development and transfer of, 5, 54–55, 55–62
  diffusion of, 5, 55–62
  needs assessment, 47–55
  recommended strategies for, 55–62
  situation analysis, 47–55
  status of, 47–48
  See also technologies; technology transfer
ARGeo. *See* East African Rift Valley Geothermal Program (ARGeo)
ARSC. *See* Centre for Applied Science Research (ARSC)
ARTT. *See* agricultural research and technology transfer (ARTT)
ASRC. *See* Applied Sciences Research Centre (ASRC)
autonomy, of institutions, 20*b*1.1

B

banana fiber, 29–30
Belgium Survival Fund, 50
Belgium Technical Cooperation, 95
beneficiaries, empowerment of, 90–91, 97–98*nn*2–4
BGR. *See* Federal Institute for Geosciences and Natural Resources (BGR)
biogas systems, 48*t*4.1, 50, 51
business development
  coordination of, 90–91
  developing services for food-processing industry, 33–34
business development centers, 50

C

capacity building
  at CITT, 56–58
  in design and product development, 45–46
  for geothermal energy and geoscience development, 72, 74–80
  at IRST, 58–59, 62*n*1
  at ISAE and NUR, 96–97
  recommended strategies
    in agriculture research system, 89–97, 97–98*nn*3–6
    in appropriate technologies, 55–62
    in clean drinking water, 65–70
    in food-processing industry, 30–36
    in geosciences and geothermal energy, 80–82, 82*n*3
    in value-added enterprises, 40–46
  through hands-on training in geothermal energy, 74–75
  at vocational training centers, 59–60, 62*n*2
  in water and sanitation management, 68–69
cardboard products, 29–30
cash crops, 7
Catholic Mission, 51
Center for Agricultural Information and Communication (CICA), 86
Centre for Applied Science Research (ARSC), 53
Centre for Innovation and Technology Transfer (CITT), 5, 47, 50
  building capacity at, 56–58
  and manufacture of stainless steel products, 51
  promotion of appropriate technologies, 51–54
CICA. *See* Center for Agricultural Information and Communication (CICA)

CITT. *See* Centre for Innovation and Technology Transfer (CITT)
civil society organizations, 95
clean drinking water, 3
  improving delivery of, 5
  needs assessment, 63–65
  recommended strategies for, 65–70
  situation analysis of, 63–65
CODEX, 27
coffee industries, 7, 38–39, 88, 97*n*3
COFORWA. *See* Compagnons Fontainiers du Rwanda (COFORWA)
commercial value-chain production, 84
Community Innovation Center, 50
Compagnons Fontainiers du Rwanda (COFORWA), 64, 67
consultants
  identification of, 12
  time required for, 13
cook stoves, 51, 52
cooperatives, 7, 8, 88
  food-processing industry, 33
  in mining activities, 80, 81
  social benefits of, 38
cost-recovery research, 93–94
cotton fabrics, 39
craftspeople, 6

D

databases
  contributions to, 95
  cost and profitability data, 91–92
  cost of production data, 89–90
  geothermal power, 79
  of GIS, 76
  inventory of specialized laboratory equipment, 60
  linked to specific technologies, 57–58
  of results of geothermal investigations, 73
Decentralized Extension Project (PVD), 86
demand-side issues, 12
Department for International Development (DFID), 23*n*7, 51, 52, 61
design, of STI capacity-building programs, 11–15, 23*nn*6–7, 23–24*nn*9–11, 105
DFID. *See* Department for International Development (DFID)
dissemination
  of appropriate technologies, 5, 51–54, 55–62
  of information on geothermal energy, 79
distance-learning facilities, 81
District Innovation Centers, 50
district managers, training of, 68–70
donor harmonization, 22
dried fruit and vegetables, 29, 30
drinking water
  in rural areas, 64
  See also clean drinking water

E

earnings, of academic, scientific, and technical staff, 96
East African Community, 19
East African Rift Valley Geothermal Program (ARGeo), 6, 73, 75, 77
EAVs. *See* écoles agro-veterinaires (EAVs)
écoles agro-veterinaires (EAVs), 41
écoles techniques officielles (ETOs), 32, 41, 54
Ecole Technique Officielle Gitarama, 50
Ecole Technique Officielle Tumba, 59
economic development
  challenges of, 9–10
  and lack of skilled human resources, 3, 22*n*2
economics, current situation in Rwanda, 2–8, 22*nn*1–2
economies of scale, 25

education, 18
  for food-processing industry, 32–33
  in geothermal energy, 81
  on hygiene, 64
  as part of NAAPs, 13–14
  weaknesses in agriculture sector, 88–89, 97*n*1
  See also technical and vocational education and training (TVET); training
educational institutions, for applied research, 3
Electrogaz, 5, 77
energy
  alternative sources of, 6
  renewable energy systems, 34, 35, 58
  rural, 47–48
enterprises
  enterprise-based STI capacity-building model, 8*f*1.1
  enterprise-based training, 41–42
  formal-sector, 40
  SMEs, 15–16, 22*n*2, 50–52, 55, 60, 61
entrepreneurs in high-value-added export industries, 6–8
environmental auditors, 33
environmental impact assessment experts, 33
equipment for food processing industry, 27, 35
eRwanda project, 15, 24*n*11
ETOs. *See* écoles techniques officielles (ETOs)
experts
  gathering teams of, 12–13
  geothermal task force, 73–74
export industries, features of, 6–8
exports
  agricultural products, 83
  characteristics of ideal export product, 38
  horticultural industries, 98*n*5
  promotion of markets for processed foods, 28–29
  See also value-added exports

F

Federal Institute for Geosciences and Natural Resources (BGR), 73
fieldwork, 13, 123–24*n*10
flower industries, 6, 7, 39, 88
food-processing industries, 23*n*9
  background documents for NAAP studies, 99
  development of, 4
  development potential for, 29–30
  needs assessment, 25–30
  recommended strategies for, 30–36
  situation analysis, 25–30
  teaching laboratories for, 32–33
  technicians for, 21–33
food-processing information centers, 35
Food-Processing Trade Association, (FPTA), 35
food security, 83
food storage and conservation systems, 4, 29
formal sector
  enterprises in, 40
  food-processing industries, 31
for-profit private sector share companies, 93
FPTA. *See* Food-Processing Trade Association (FPTA)
fruit juices, 29
fuel sources, 2
funding
  mechanisms for, 94
  weaknesses in ISAR's funding and management, 86–87

G

Gako Organic Farming Training Centre, 44
GAR. *See* Geothermal Association of Rwanda (GAR)
genocide, 2
Geographic Information System (GIS), 76, 77

geosciences, 23*n*9
  background documents for NAAP studies, 100
  increasing capacity in, 5–6
  long-term institution/capacity building for, 72, 75–80
  situational analysis of, 71–72, 82*n*2
geoscientific information system, 76
Geothermal Association of Rwanda (GAR), 7
Geothermal Coordination Department, 74
Geothermal Education Office, California, 77
geothermal energy, 23*n*9
  background documents for NAAP studies, 100
  fast-track urgent plan for resource assessment and pilot power generation, 71, 72–75
  hands-on training in, 74–75
  increasing capacity in, 5–6
  long-term institution/capacity building for, 72, 75–80
  promotion of, 78
  resource exploration, 71, 82*n*2
  situational analysis of, 71–72, 82*n*2
Geothermal Energy Association, 79
Geothermal Resources Council, 79
geothermal task force, 73–74
GIS. *See* Geographic Information System (GIS)
Government of Rwanda, 1
  commitment to STI capacity building, 8–11
  lobbying of, 76
  role in promoting and supporting technology innovation, 56
  Vision 2020 Statement, 9–10, 11
  and World Bank STI Capacity-Building Technical Assistance Program, 9
  See also Rwanda
grant facilities, for enterprise-based training, 41–42
grants, matching grant programs, 43, 92

H

hands-on training, capacity building through, 74–75
higher education institutions, 96–97
high-tech industries, 14, 22*n*1
high-value-added industries, 3, 6–8, 22*n*1, 97*n*2
high-value export value chains, 93
hillside farms, 86
honey, 30
horticulture and horticulturists, 39, 87, 98*n*5
human resources
  development and management of, 95–96
  earnings of academic, scientific, and technical staff, 96
  food-processing industry, 27–28, 32
  for geological resources, 79
  Geothermal Department, 74
  in geothermal energy, 75–80
  lack of, 85
  limited capacity of, 38
  for water and sanitation sector, 65–66
hydrogeology, 72
hydropower plants, 58
hygiene education, 64
hygiene inspectors, 34
hygienic standards, 51

I

IGA. *See* International Geothermal Association (IGA)
implementation
  capacity-building issues, 21–22, 24*n*12, 105
  capacity for, 60–61
incentives for meeting objectives and achieving results, 19–20*b*1.1
informal food-processing businesses, 26
information
  dissemination of, 79
  See also knowledge

innovation, 19
  building culture of, 18, 19–21*b*1.1
  role of government in, 56
Innovation Support Fund, 92
in-service training, 33, 34, 97
Institut des Sciences Agronomiques (ISAR). *See* Agricultural Sciences Institute of Rwanda
Institute for Scientific Research and Technology (IRST), 5, 47, 53, 57, 80
  building capacity at, 58–59, 62*n*1
institutional capacity
  for geothermal energy and geoscience development, 72, 75–80
  improvement of, 19–21*b*1.1, 105
  strengthening of in water and sanitation sector, 65–66
  and training of water and sanitation managers, 68–70
institutions
  autonomy and challenges of, 20–21*b*1.1
  improving ISAR's institutional performance, 93–94
  institutional set-up for power generation, 74
  international research institutions, 94
  public institutions involved in STI capacity-building action plans, 105
Institut Supérieur d'Agriculture et d'Elevage (ISAE), 5, 59, 68, 85
  building capacity in agricultural research, 96–97
  building capacity in water and sanitation management, 70
  weaknesses in, 88–89
International Geothermal Association (IGA), 79
International Network for Technical Information, 42–43, 46*n*2
international research institutions, 94
International Standards Organization (ISO), 27
investments in modernization value chains, 92
IRST. *See* Institute for Scientific Research and Technology (IRST)
ISAE. *See* Institut Supérieur d'Agriculture et d'Elevage (ISAE)
ISAR. *See* Agricultural Sciences Institute of Rwanda (ISAR); Institut des Sciences Agronomiques (ISAR)
ISO. *See* International Standards Organization (ISO)

J

Japan International Cooperation Agency (JICA), 3

K

Kagame, Paul, 8–9
Kenya Electricity Generating Co., Ltd., 82*n*3
Kigali Institute of Science, Technology and Management (KIST), 5, 51, 81–82
  building capacity in water and sanitation sector, 68–69
  practical experience of students, 28
  and RGC, 76
  See also Centre for Innovation and Technology Transfer (CITT)
KIST. *See* Kigali Institute of Science, Technology and Management (KIST)
knowledge
  codifying of, 40–41
  diffusion of, 16–17
  mining of, 55
  sharing of, 73
  transfer of, 58

L

laboratory equipment, 59–60
Laiterie Inyange, 29
latecomers, 18
leadership, 22
legal frameworks, 23*n*7, 89–90
living conditions, 5
low-cost building, status of appropriate technologies for, 47–48

M
maintenance of water networks, 65–67
management
  absentee, 23–24*n*10
  food-processing industries, 33
  training in water and sanitation sector, 68–70
  of water networks, 65–67
  weaknesses in ISAR's funding and management, 86–87
manuals, for vocational and technical training, 40–41
marais lands, 84, 86
markets
  agricultural produce, 25
  development for food-processing industry, 29–30
  entrepreneurs understanding of, 7
  for high-value products, 92
  for processed foods, 28–29
  regional, 19
  for technologies, 49
matching grants, 43, 92
MDGs. *See* Millennium Development Goals (MDGs)
methodology, of STI capacity building programs, 11–15, 23*nn*6–7, 23–24*nn*9–11, 105
milk industry, 88
Millennium Development Goals (MDGs), 1
  achievement of, 2, 4–6, 23*n*7
  improvements in human resources, 65
MINAGRI. *See* Ministry of Agriculture (MINAGRI)
MINICOM. *See* Ministry of Industry and Commerce (MINICOM)
MININFRA. *See* Ministry of Infrastructure (MININFRA)
mining industry, 72, 78–79, 80, 81
MINISTR. *See* Ministry of Science, Technology and Scientific Research (MINISTR)
Ministry of Agriculture (MINAGRI), 50, 85, 93, 94–95
Ministry of Industry and Commerce (MINICOM), 26
Ministry of Infrastructure (MININFRA), 72, 74, 77, 80
Ministry of Lands, Environment, Forestry, Water, and Mines, 76, 80
Ministry of Science, Technology and Scientific Research (MINISTR), 21–22, 23*n*5, 50, 60–61, 80, 91
mulberry cultivation, 39

N
NAAPs. *See* needs assessments and action plans (NAAPs)
NARB. *See* National Agricultural Research Board (NARB)
NATAB. *See* National Agricultural Technology Advisory Board (NATAB)
National Agency for Energy in Rwanda (ANER), 80
National Agricultural Research Board (NARB), 91, 92, 98*n*4
National Agricultural Technology Advisory Board (NATAB), 98*n*4
National Commission on Science Technology and Innovation, 50
National Information and Communications Infrastructure (NICI) Plan, 15, 24*n*11
National Institute of Statistics (NIS), 90
national managers, training of, 68–70
National Qualifications Framework, 97
National Research Council, 61
National Research Fund, 61
National Science, Technology and Innovation Policy (NSTIP), 9, 10, 23*n*5
National University of Rwanda (NUR), 5, 77, 85
  building capacity
    in agricultural research, 96–97
    in water and sanitation management, 68m, 69
  Faculty of Agriculture, 5, 88–89, 97*n*1
  Faculty of Agronomy, 44
  strengthening geosciences capabilities, 81–82

natural springs, 64, 66–67
needs assessments
  agricultural research and outreach, 83–89
  appropriate technologies, 47–55
  background documents for, 99–100
  delivery of clean drinking water, 63–65
  food-processing industry, 25–30
  geosciences and geothermal energy, 71–75, 82*n*2
  training needs assessment, 95
  value-added exports, 37–39
needs assessments and action plans (NAAPs)
  background documents for, 99–100
  preparation for, 11–15, 23*nn*6–7, 23–24*nn*9–11
  principles of, 14–15
  priority areas for, 11, 23*nn*6–7
  public institutions involved in STI capacity building action plans, 105
  terms of reference for, 101–03
NGOs. *See* nongovernmental organizations (NGOs)
NICI. *See* National Information and Communications Infrastructure (NICI) Plan
NIS. *See* National Institute of Statistics (NIS)
nongovernmental organizations (NGOs), 11
  and animal research, 87
  and cooperatives, 88
  as participants in training courses, 57
  technology transfer through, 85
  and training of workers in water and sanitation sector, 67
NSTIP. *See* National Science, Technology and Innovation Policy (NSTIP)
Nuffic-NPT program, 51, 52–53, 58
NUR. *See* National University of Rwanda (NUR)

O

OECD. *See* Organisation for Economic Co-operation and Development (OECD) countries
On the Frontier Group, 22*n*2
on-the-job training, in geothermal energy, 73, 78
organic certification, 30, 44, 45
organic farming, 39, 43–45
organic production and research associations, 43–45
Organisation for Economic Co-operation and Development (OECD) countries, 88
out-growers, 40–41
outputs, delivered by RGC, 79–80
outreach in agriculture sector, 4–5, 83–97, 97–98*nn*2–4

P

packaging, 45
  cardboard, 29–30
  cost of, 27
  improvement in food-processing industry, 34
Paris Declaration on Aid Effectiveness, 22
Participatory Hygiene and Sanitation Transfer (PHAST) program, 64, 68
per capita income, 2
PHAST. *See* Participatory Hygiene and Sanitation Transfer (PHAST) program
pilot systems
  in agriculture sector, 91, 92
  power generation using geothermal energy, 72–75
  Rwanda Flora, 98*n*6
policies on investment in agriculture sector, 89–90
poverty, 2–3, 4–6, 23*n*6
Practical Action, 42–43, 46*n*2
practical training, facilities for, 59–60
practice-based food-processing courses, 32–33

private sector
for-profit private sector share companies, 93
promotion of profitability of agriculture in, 91–93, 97*nn*5–6
role in developing sustainable technologies, 49–50
weaknesses in participation in agribusiness, 88
problem-solving approaches, 16, 17*f*1.3
processed foods, markets for, 28–29
processing facilities, 27, 39
product development, 45–46
production
in agriculture, 37
in food-processing industry, 26
productivity, 2, 83
public goods, 84–85
public–private partnerships, 17–18
and capacity building
in design and product development, 45–46
for organic production and certification, 45
in value-added enterprises, 40–46
and creation of organic production and research association, 43–45
grants for enterprise-based training, 41–42
and matching grant programs, 43
and public–private technology information service, 42–43, 46*n*2
for technical and vocational training, 14, 40–41
and value-added exports, 38–39
public utility companies, 5
PVD. *See* Decentralized Extension Project (PVD)
pyrethrum, 6, 7, 39

Q

quality management, food-processing industry, 27

R

RADA. *See* Rwanda Agriculture Development Authority (RADA)
rainwater harvesting, 5, 47–48
RARDA. *See* Rwanda Animal Resources Development Authority (RARDA)
raw materials
access to, 25–26
in agriculture, 37
availability of, 30–31
imported, 39
prices of, 49
RBS. *See* Rwanda Bureau of Standards (RBS)
R&D. *See* research and development (R&D)
reforms, in individual sectors, 15–16
regulatory framework, 89–90
food-processing industry, 35–36
REMA. *See* Rwanda Environment Management Authority (REMA)
renewable energy systems, 34, 35, 58
research
in agriculture, 4–5
applied, 3, 90, 96
cost-recovery, 93–94
international research institutions, 94
weaknesses in public research and technology transfer systems, 86–87
research and development (R&D), 1
in geosciences and geothermal energy, 76, 79, 81
problems with, 52
weaknesses in public research and technology transfer system, 86–87
See also agricultural research and technology transfer (ARTT); applied research
Research into Use program, 61
resource testing studies of geothermal energy, 72–75
reverse-engineering, 7

RGC. *See* Rwanda Geoscientific Center (RGC)
RGMA. *See* Rwanda Geology and Mining Authority (RGMA)
RHODA. *See* Rwanda Horticulture Development Authority (RHODA)
RIEPA. *See* Rwanda Investment and Export Promotion Agency (RIEPA)
ROPRA. *See* Rwanda Organic Production and Research Association (ROPRA)
roses, 6, 7, 88
RPSF. *See* Rwandan Private Sector Federation (RPSF)
RTTP. *See* Rural Travel and Transport Program (RTTP)
rural areas, availability of drinking water in, 64
rural energy, 47–48
rural engineering, 70
rural poor, 2–3, 4–6
rural producers, 40
Rural Travel and Transport Program (RTTP), 52
Rwanda
  economic and social conditions in, 2–8, 22*nn*1–2
  See also Government of Rwanda
Rwanda Agriculture Development Authority (RADA), 84*f*7.1, 90–92, 97*n*2
Rwanda Animal Resources Development Authority (RARDA), 84*f*7.1, 87, 90–92, 92, 97*n*2
Rwanda Bureau of Standards (RBS), 27, 36
Rwanda Central Water Quality Laboratory, 78
Rwanda Environment Management Authority (REMA), 27, 34, 36
Rwanda flora, 98*n*6
Rwanda Food Processors' Trade Association, 34
Rwanda Geology and Mining Authority (RGMA), 76, 77, 78, 80–81
Rwanda Geoscientific Center (RGC), 72, 75–80, 81
Rwanda Horticultural Exports Standards Initiative, 90
Rwanda Horticulture Development Authority (RHODA), 84*f*7.1, 87, 90–92, 97*n*2
Rwanda Investment and Export Promotion Agency (RIEPA), 23*n*9, 26, 28–29, 34, 92
Rwandan Defense Forces, 50
Rwandan Private Sector Federation (RPSF), 50, 61, 92
Rwanda Organic Production and Research Association (ROPRA), 44–45
Rwanda Pyrethrum Co., Ltd. (SOPYRWA), 39
Rwanda Utility Regulation Agency, 68

S

sandwich courses, 96
sanitation
  goals for, 64
  recommended capacity-building activities in, 66*t*5.1
  status of appropriate technologies for, 47–48
satellite centers, 50, 57
Science, Technology and Innovation for Results (STIR) program, 21–22
scientific proficiency, 14
Shema Fruits, 29, 30
silk industry, 7, 39
situation analysis
  of agricultural research and outreach, 83–89
  of appropriate technologies, 47–55
  of delivery of clean drinking water, 63–65
  of food-processing industry, 25–30
  of geosciences and geothermal energy, 71–72, 82*n*2
  of value-added exports, 37–39
skill development, 6, 13–14, 16, 18*f*1.4
skilled labor, 6, 53–54
slim-hole exploration drilling, 73

small and medium-size enterprises (SMEs), 50–52, 55, 60, 61
  development of, 15–16, 22*n*2
social conditions, 2–8, 22*nn*1–2
social development, challenges of, 9–10
soil management, 89
soil structure, 43–45
SOPYRWA. *See* The Rwanda Pyrethrum Co., Ltd. (SOPYRWA)
SPREAD Coffee Project, 38–39
staff
  attraction and retention of, 20*b*1.1
  training in food-processing enterprises, 33
  See also human resources
stainless steel, 51
standardization, food-processing industry, 27
standards for technology transfer, 94–95
STIR. *See* Science, Technology and Innovation for Results (STIR) program
study tours, 57
subsistence farmers and farming, 2, 7
synthetic fabrics, 39

T

TDF. *See* technology development fund (TDF)
team-based approach, 12–13
technical and vocational education and training (TVET), 3, 38
  background documents for NAAP studies, 100
  capacity building for, 59, 62*n*2
  challenges of, 20–21*b*1.1
  and public–private partnerships for capacity building in value-added enterprises, 40–41
  strengthening of, 6
  and water systems, 5
technical assistance
  to ISAR, 93
  linkages to, 77
  Nuffic-NPT program, 51, 52–53
technologies, 3
  development of, 16, 18*f*1.4, 55
  of geothermal energy, 79
  investment in productive, 43
  mining of, 57
  technology information service, 42–43, 46*n*2
  See also applied technologies
technology acquisition fund, 43
technology development fund (TDF), 60–61
technology diffusion agencies, 5
technology information service, 42–43, 46*n*2
technology transfer, 52, 90–91
  in agricultural research, 83–89
  coordination, methods, and performance standards for, 94–95
  factors hampering, 54–55
  IRST mandate for, 58–59
  from private sector, 88
  strengthening components of, 89–90
  weaknesses in systems of, 86–87
Technoserve Coffee Project, 28, 46*n*1
terms of reference (TOR)
  adjustments to, 23–24*n*10
  for NAAP studies, 101–03
  preparation of, 11–12, 105
textile industries, 39
TOR. *See* terms of reference (TOR)
trade associations
  food-processing industry, 34, 35
  organic production and research association, 43–45
  ROPRA, 44–45
training, 14, 95–96
  in agriculture sector, 91
  courses for CITT staff, 57
  in design and product development, 45–46
  in distance-learning facilities, 81
  of district- and national-level managers, 68–70
  enterprise-based, 41–42
  for food-processing industry, 32–33

training—*Contd.*
in geothermal energy, 73, 74–75, 76, 78, 81
hands-on, 74–75
in-service, 97
manuals for, 40–41
on-the-job, 73, 78
practical, 59–60
skill development, 6, 13–14, 16, 18*f*1.4
in technology information service, 43
under NUFFIC-NPT project, 58
in water and sanitation sector, 65–67, 77
weaknesses in agriculture sector, 88–89, 97*n*1
See also skill development; technical and vocational education and training (TVET)
transport
in food-processing industry, 34
status of appropriate technologies for, 47–48
TVET. *See* technical and vocational education and training (TVET)

U
unemployment, KIST food science graduates, 28
United Nations Industrial Development Organization (UNIDO), 39
United Nations University Geothermal Training Program, Iceland, 82*n*3
University of Auckland, Geothermal Institute, 83*n*3
urban areas, and vocational and technical training centers, 40
U.S. Agency for International Development (USAID), 7, 39
user needs, 84
U.S. Geological Energy Association, 71
UTEXRWA textile factory, 39

V
value-added exports
needs assessment, 37–39
public–private partnerships for capacity building in, 40–46
situation analysis, 37–39
value chains, 87, 89–90
commercial, 84, 91, 97*n*2
high-value export in, 93
investment in modernization of, 92
Vi-Life, 44
vocational training, 53–54
KIST link to, 69
vocational training centers, 59–60, 62*n*2
See also technical and vocational education and training (TVET)
vocational training colleges (VTC), 32

W
Wageningen Agricultural University, 97*n*1
water sector, 5
background documents for NAAP studies, 100
management of, 68, 69
recommended capacity-building activities in, 66*t*5.1
status of appropriate technologies for, 47–48
water resource development, 78–79
water supply, 63, 64, 69
See also clean drinking water
water technicians, training of, 65–67
workshops, 49, 51
World Bank, 1
World Bank-UNEP East Africa Rift Geothermal Energy Facility, 6
World Trade Organization, 90

Eco-Audit

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- 3 million BTUs of total energy

Building Science, Technology, and Innovation Capacity in Rwanda presents the methodology, policy conclusions, and detailed action plans that emerged from a World Bank science, technology, and innovation (STI) capacity-building program in Rwanda in 2006–07. This book illustrates that even an economy dominated by subsistence agriculture such as Rwanda's needs to develop STI capacity to address everyday issues such as providing energy and clean water to rural areas, and to compete in the global economy.

This book provides new insights into the STI capacity-building process and shows that this process is not an activity solely for wealthy countries, but is, in fact, a necessity for poorer countries that want to improve their economy. The methodology presented can be used to help poor countries achieve the Millennium Development Goals and increase their competitiveness, while helping middle-income countries to compete on the basis of innovation and quality.

Building Science, Technology, and Innovation Capacity in Rwanda will be useful for policy makers and those in nongovernmental organizations in developing countries working to promote agribusiness, economic policy, and education, to reduce poverty, and to develop rural economic strategies.

ISBN: 978-0-8213-7356-9

SKU: 17356

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