

Jean-Claude Bolay · Magali Schmid
Gabriela Tejada · Eileen Hazboun *Editors*

Technologies and Innovations for Development

Scientific Cooperation
for a Sustainable Future



United Nations
Educational, Scientific and
Cultural Organization



UNESCO Chair in
technologies for development
Lausanne (Switzerland)



Springer

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ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

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Dr. Melissa Leach and Dr. Osman Benchikh, two of the keynote speakers at the International Scientific Conference on Technologies for Development in February 2010 in Lausanne, Switzerland, gave us the great privilege of contributing to this publication. We thank them very much.

Moreover, this project could not have succeeded without the quality and diversity of the contributions of the various authors and researchers. In response to the call for papers, a scientific committee composed of experts from EPFL and external institutions evaluated over 100 papers and ultimately selected 64 to be presented at the conference. Out of these, 18 were finally chosen for their scientific value as well as the originality of their approach to the publication's theme, "Technologies for Development." We express our gratitude to all these authors, without whom nothing would have been possible.

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Foreword

Science, technology, and innovation (STI) form essential pillars in our struggle to eradicate extreme poverty and promote sustainable development. However, despite some technological progress in developing countries, the technology gap between developed and emerging countries and developing countries is widening dramatically. We now realize that most developing countries will face serious challenges in meeting the Millennium Development Goals (MDGs) by 2015 unless they can build a solid STI base to address national needs and contribute to development effectively.

Indeed, according to the United Nations (UN) reports on progress in achieving the MDGs, many least developed countries, including 34 in Africa, could miss the boat unless there is significant investment in human resources and in STI, which are considered of crucial importance to stimulate sustained and inclusive development as a means of poverty alleviation. The Report of the Millennium Project's Task Force on Science, Technology, and Innovation, *Innovation: Applying Knowledge in Development*, is also very clear:

Meeting the Goals will require a substantial reorientation of development policies to focus on key sources of economic growth, including those associated with the use of new and established scientific and technological knowledge and related institutional adjustments. Countries will need to recognize the benefits from advances in science and technology and develop policies and strategies to harness the explosion in new knowledge.

Strengthening national channels of technology dissemination, and research and innovation applications adapted to the various socioeconomic contexts are pressing challenges which are not only facing developing countries. They are facing us all as the world we live in is an interlinked and interdependent one. They are a global challenge which requires a global response. UNESCO, through the activities of its Natural Sciences Sector, has a vitally important role to play in mobilizing the international scientific community to more effectively address the global development of STI capacity, particularly in the developing world. This mobilization requires solid and concerted interaction and dialogue between all stakeholders at all levels: Universities and other institutions of higher education must play an increasing role in facing major global challenges such as climate change,

freshwater management, biodiversity loss, and the use of renewable energy. What sets higher education apart from other institutions is not just its capacity to produce knowledge and human capital but, above all, its capacity to reason and work over the long term. This is not the case of political institutions that have often to work under short-term pressure. In an ever more complex world, it is crucial to rely on and give full place to higher education as higher education systems worldwide are at the heart of healthy STI ecosystems.

Universities are key sources of knowledge generation, yet in developing countries, faculty are often forced to take on a heavy teaching load to complement their modest income, leaving little time for research. As the *UNESCO Science Report 2010* demonstrates, this is the case in many Arab universities and in developing Asian countries like Nepal, for instance. Another hindrance to university research is the time faculties spend identifying funding for specific research projects. There is a general consensus that universities could overcome these handicaps by developing closer ties to the productive sector. However, the linear model prevails in many developing countries, leading to a science-push model rather than the demand-pull model that would be conducive to innovation. The report goes on to say that:

‘the region [Latin America] demonstrates a paradox in that countries possess an acceptable scientific sector . . . which produces valuable knowledge that is potentially applicable to the productive sector, yet their economies demand very little local knowledge and are scarcely innovative.’

Even the prestigious Indian Institutes of Technology, for instance, tend to be extremely teaching-intensive institutions. The Report notes that it is estimated that the entire higher education sector in India contributes no more than 5% of India’s gross expenditure on research and development.

Capacity development in higher education in developing countries is therefore crucial, and support to university and higher education institution networking is one strategy that UNESCO set up in the early 1990s through its UNESCO Chairs/UNITWIN Programme. It was conceived as a way to advance research, training, and program development by building university networks and encouraging inter-university cooperation through the transfer of knowledge across borders, notably North-South. The UNITWIN Programme now aims also to be forward-thinking and to impact socioeconomic development effectively, generating new ideas through research and reflection and facilitating the enrichment of existing university programs while respecting cultural diversity. A few years ago, emphasis was placed on transdisciplinary work and on the role of the Chairs as “bridge-builders” between academia, civil society, local communities, research, and policymaking.

The Chair in Technologies for Development, established in 2007 at the Ecole Polytechnique Fédérale de Lausanne (EPFL), belongs to this new generation of UNESCO Chairs which fully play the dual function of “think-tank” and “bridge-builder,” aiming at promoting transdisciplinary research in STI adapted to the context of developing countries through partnerships with local institutions, in order to develop innovative solutions for the most vulnerable populations. As a

UNESCO academic partner, the EPFL Chair is a seminal international platform for dialogue and exchange in this key area. The last international conference organized by the Chair in 2010 with UNESCO support focused on technologies for the sustainable development of habitat and cities, ICTs for the environment, science and technology for disaster risk reduction and technologies for sustainable energy production. This publication reflects the main outcomes of the conference and provides significant orientations and criteria of success for the effective implementation and use of innovative technologies, notably on the importance of stakeholder ownership and the creation of entrepreneurial ecosystems which will enable their sustainability.

Gretchen Kalonji
Assistant Director-General for the Natural Sciences
United Nations Educational, Scientific and Cultural Organization (UNESCO)

Foreword

Scientific Excellence and Appropriate Technology: A Global Challenge of Solidarity with Developing Countries

Knowledge is henceforth globalized: without borders, thanks to new means of communication and limitless thanks to constantly improving technological innovations. The challenges to be overcome are of major impact, whether in education, health, nutrition, or energy supply. And all of this is taking place against the backdrop of the Earth confronted with two fundamental issues: (1) climate change, which obliges us to review the foundations of our economic and industrial models to invent specific, sustainable solutions and (2) demographic growth resulting in a world population of some nine billion individuals by the year 2050, who need to be trained, fed, and housed to contribute to the development of new activities.

Science and technology thus have a major role to play in facing up to these challenges. We are all jointly responsible for ensuring that these innovations are as accessible as possible throughout the world. This is the very justification of scientific cooperation for development: to produce scientific excellence with positive significant impacts on sustainable development of less well-off countries.

The situation in the field remains of concern. Numerous studies demonstrate that economic growth is indispensable for the creation of wealth, but that it is not able to stamp out poverty on its own. Major disparities continue to exist. This is totally true in a number of African countries as is the case in certain Asian and Latin-American countries. According to the United Nations Conference on Trade and Development (UNCTAD) in 2005, 35% of the population of the least advanced countries was living in extreme poverty, and the number of persons living on less than a dollar a day had increased compared to the year 2000. Although there is positive integration of these countries in the world economy, interior and regional markets need to be developed and reoriented on satisfaction of the needs of their populations. When it is understood that emerging and developing countries currently group together 80% of the world's population, all these questions constitute important avenues of research. Furthermore, these countries, especially in Asia and Africa, are experiencing accelerated transition to increasingly more urban and technological societies.

Within this context, research and higher education play an essential role for international solidarity cooperation, even if application may sometimes seem arduous. Higher education is deemed useful to drive development, render public institutions more efficient, foster private enterprise, and ensure a nurturing environment. On the other hand, funding for both basic and applied research in African, Asian, and Latin American universities is all too often limited; public budgets are virtually inexistent, making countries and universities totally dependent on international aid. Young scientists emigrate and do not find an appropriate, stimulating environment should they ever return to their own country.

It is therefore imperative to found scientific cooperation on this training and research axiom and support academic institutions with their development initiatives. This is based on networks, as is the case of the RESCIF (Réseau d'excellence des sciences de l'ingénieur de la Francophonie),¹ with the setting up of joint laboratories and on postdisaster support for the two main universities in Port-au-Prince. Or alternatively it is based on scientific partnerships, such as the collaboration between the Edmond and Lily Safra International Institute of Neuroscience of Natal (ELS-IINN) and EPFL for the Blue Gene/L supercomputer and creation of the Brazilian "Brain Campus." Or it may be based on scientific collaboration agreements, as is the case for EPFL for more than 20 years with quality partners such as the Universidad del Valle, at Cali in Colombia, and the Institut International d'Ingénierie de l'Eau et de l'Environnement (2iE), in Burkina Faso, in the fields of water and energy.

The present publication highlights some concrete examples of North-South cooperation, leading to win-win partnerships for all parties concerned. For northern universities, this constitutes the opportunity for students and researchers to confront challenging contexts for which original technological solutions, tailored to these environments, must be provided. For southern universities, this constitutes the opportunity to directly enter the world of international research, enabling their Ph.D. students and young researchers to be trained in laboratories in western countries and write theses on priority subjects for their countries and their regions. All these facets thus contribute to the knowledge sharing strategy.

Faced with the extent of needs and the type of aims, the agenda is no longer simply to transfer technologies from the north to the south, even if that can sometimes be deemed an excellent progress vector in emerging and developing countries. Henceforth, this involves considering technical and social innovations, appropriate to physical, environmental, cultural, and economic conditions of receiving countries, and which can be appropriated by their potential users and are thus revealed as real technologies for fostering development.

Patrick Aebischer
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Ecole Polytechnique Fédérale de Lausanne (EPFL)

¹ Network of Excellence in Engineering Sciences of the French-speaking Community.

Editors

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Abbreviations

2IE	Institut International de l'Eau et de l'Environnement, Burkina Faso
AAS	African Academy of Sciences
ACCFP	African Climate Change Fellowship Program
ACCI	Agencia Presidencial para la Acción Social y la Cooperación Internacional
ADB	Asian Development Bank
ADPC	Asian Disaster Preparedness Center
AFIS	Advanced Fire Information System
AIACC	Assessments of Impacts and Adaptations to Climate Change
AIDS	Acquired Immune Deficiency Syndrome
AMS	African Maize Stress
ANN	Artificial Neural Networks
APEC	Asia-Pacific Economic Cooperation
ARCSSTE-E	African Regional Centre for Space Science and Technology Education in English
ARTP	Autorité de Régulation des Télécommunications et des Postes
ASPI	Australian Strategic Policy Institute
ATPS	African Technology Policy Studies
AVHRR	Advanced Very High Resolution Radiometer
CAU	Clay Activation Unit
CBD	Central Business District
CCAA	Climate Change Adaptation in Africa
CCB	Cement Concrete Blocks
CCFSC	Central Committee for Flood and Storm Control
CCIS	Comprehensive Crop Insurance Scheme
CDM	Clean Development Mechanism

CDRR	Certificate of Advanced Studies in Disaster Risk Reduction
CEDT	Centre for Electronics Design and Technology
CEEPA	Centre for Environmental Economics and Policy in Africa
CEPT	Center for Environmental Planning and Technology University
CFA	Franc de la Communauté Financière Africaine
CfRR	External Evaluation Report on the Cash for Repair and Reconstruction Project
CG06	Conseil Général des Alpes-Maritimes
CH ₄	Methane
CIAT	International Center for Tropical Agriculture
CICDA	Centre International de Coopération pour le Développement Agricole
CIDEM	Centro de Investigación y Desarrollo de Estructuras y Materiales (Center for Research and Development of Materials and Structures)
CIMMYT	Centro Internacional de Mejoramiento de Maíz y Trigo
CLTS	Community-Led Total Sanitation
CNAM	Conservatoire National des Arts et Métiers
CND	National Committee for Decentralization
CNIG	Conseil National de l'Information Géographique
CNRS	Centre National de la Recherche Scientifique
CO ₂	Carbon Dioxide
CODEV	Cooperation & Development Center
COLCIENCIAS	Departamento Administrativo de Ciencia, Tecnología e Innovación
COPE	Cooperative Orthotic and Prosthetic Enterprise
COPSOP	Country Strategic Opportunities Paper
CORPOICA	Corporación Colombiana de Investigación Agropecuaria
CoV	Coefficient of Variation
CPI	Consumer Price Index
CSEB	Compressed Stabilized Earth Block
CSERGE	Centre of Social and Economic Research on the Global Environment
CSI-CGIAR	Consortium for Spatial Information of the Consultative Group for International Agriculture Research
CSIR	Council for Scientific and Industrial Research
DDC	Direction du Développement et de la Coopération Suisse
DFID	UK Department for International Development

DfT	Department for Transport
DGIS	Distributed Geographic Information Systems
DRR	Disaster Risk Reduction
DTA	Differential Thermal Analysis
EACH-FOR	Environmental Change and Forced Migration Scenarios
EcoSur	Latin American Network for an Ecologically and Economically Sustainable Habitat
ECOWAS	Economic Community of West African States
EdL	Electricité du Laos
EFLUM	Environmental Fluid Mechanics and Hydrology Laboratory
ELS-IINN	Edmond and Lily Safra International Institute of Neuroscience of Natal
EM-DAT Database	The International Disaster Data Base
ENAC	School of Architecture, Civil and Environmental Engineering
EPCD	Commune Public Associations for Development
EPFL	Ecole Polytechnique Fédérale de Lausanne
ERACTION	Environmental Rights Action
ESRC STEPS	Social, Technological and Environmental Pathways to Sustainability Centre
ETM	Enhanced Thematic Mapper
FADEC	Support Fund for the Development of the Commune
FAO	Food and Agriculture Organization of the United Nations
FCT	Federal Capital Territory
FICCDC	Federal Interagency Coordinating Committee on Digital Cartography
FU	Functional Unit
GAMS	General Algebraic Modeling System
GDP	Gross Domestic Product
GHSOM	Growing Hierarchical Self-Organizing Map
GIMMS	Global Inventory Modeling and Mapping Studies
GIS	Geographical Information System
GLASOD	Global Assessment of the Status of Human-Induced Soil Degradation
GLC	Global Land Cover
GLCF	Global Land Cover Facility
GNG	Growing Neural Gas
GNI	Gross National Income
GOP	Government of Pondicherry
GOTN	Government of Tamil Nadu
GPRS	General Packet Radio Service
GPS	Global Positioning System

GRET	Groupe de Recherche et d'Échanges Technologiques
GSDMA	Gujarat State Disaster Management Authority
GSM	Global System for Mobile Communications, originally Groupe Spéciale Mobile
GSMA	GSM Association
GWP	Global Warming Potential
HCMC	Ho Chi Minh City
HDI	Human Development Index
HEC	Hautes Etudes Commerciales
HEIG-VD	Haute École d'Ingénierie et de Gestion du canton de Vaud
HEKS	Hilfswerk der Evangelischen Kirchen Schweiz
HIV	Human Immunodeficiency Virus
IAV	Institut Agronomique Vétérinaire Hassan II
IB	Index of Brilliance
IBGE	Brazilian Institute of Geography and Statistics
IBRD	International Bank for Reconstruction and Development
IC	School of Computer and Communication Sciences
ICT	Information and Communication Technology
ICTs	Information and Communication Technologies
IDB	International Data Base
IDNDR	International Decade for Natural Disaster Reduction
IDRC	International Development Research Centre
IDS	Institute of Development Studies
IEA	International Energy Agency
IEC	International Electrotechnical Commission
IES	Institute for Environmental Sustainability
IFAD	International Fund for Agricultural Development
IFEU	Institute for Energy and Environmental Research
IFPRI	International Food Policy Research Institute
IHDP	International Human Dimensions Programme on Global Environmental Change
IICT	Institute for Information & Communication Technologies
IIE	Environmental Engineering Institute
IIED	International Institute for Environment and Development
IISc	Indian Institute of Science
IMX	Institute of Materials
INFOSOLO	Mercado informal e o acesso dos pobres ao solo
INTER	Institute of Urban Studies
IPCC	Intergovernmental Panel on Climate Change
IRA	Institute for Resource Assessment
IRD	Institut de Recherche pour le Développement

ISDR	International Strategy for Disaster Reduction
ISIM	Institute of Computing and Multimedia Systems
ISO	International Organization for Standardization
ISODATA	Iterative Self-Organizing Data
ISRIC	International Soil Reference and Information Centre
ITU	International Telecommunication Union
IUCN	International Union for Conservation of Nature
KFH	Swiss Universities of Applied Sciences
kW	Kilowatt
LAO PDR	Lao People's Democratic Republic
LASUR	Urban Sociology Laboratory
LBL	Lawrence Berkeley National Laboratory
LCA	Life Cycle Assessment
LDCs	Least Developed Countries
LDM	Media and Design Laboratory
LED	Light-Emitting Diode
LIRE	Lao Institute for Renewable Energy
LMC	Laboratory of Construction Materials
LME	Electrical Machines Laboratory
MaDePro	Certificate of Advanced Studies in Management of Development Projects
MADR	Ministerio de Agricultura y Desarrollo Rural
MAP	Maximum A Prior Probability
MCM	Multicriteria Mapping
MDGs	Millennium Development Goals
MEERP	Maharashtra Emergency Earthquake Rehabilitation Programme
MGIS	Mobile Geographic Information Systems
MJ	Megajoule
MK	Metakaolin
ML	Maximum Likelihood
MLP	Multilayer Perceptron
MOFA	Ministry of Food and Agriculture
NAIS	National Agricultural Insurance Scheme
NASA	National Aeronautics and Space Administration
NCCR	National Centers of Competence in Research
NDVI	Normalized Differential Vegetation Index
NGOs	Non-Governmental Organizations
NIAS	Nordic Institute of Asian Studies
NICTs	New Information and Communication Technologies
NMR	Nuclear Magnetic Resonance
NOAA	US National Oceanic and Atmospheric Administration
NPP	Net Primary Productivity

NRE	Non Renewable Energy
OCA	Observatoire de Côte d'Azur
OCHA	Office for the Coordination of Humanitarian Affairs
ODIHPN	Overseas Development Institute Humanitarian Practice Network
OECD	Organisation for Economic Co-Operation and Development
ONE	Office National d'Electricité
ORNL	Oak Ridge National Library
OST	Observatoire des Sciences et des Techniques
PCA	Principal Component Analysis
PCIS	Pilot Crop Insurance Scheme
PDVM	Development Program for Medium-sized Towns
PNUD	Programme des Nations Unies pour le développement
PPP	Purchasing Power Parity
PR	Public Relations
PU	Pastoral Unit
PV	Solar Photovoltaic
R&D	Research and Development
RAND	National Defense Research Institute
RASTA	Rapid Soil and Terrain Assessment
RCC	Reinforced Cement Concrete
RCMRD	Regional Center for the Mapping of Resources for Development
RE	Renewable Energy
RESCIF	Réseau d'excellence des sciences de l'ingénieur de la Francophonie
RESTREND	Residual Trend of RUE
RHA	Rice Husk Ash
RUE	Rain Use Efficiency
S&T	Science and Technology
SAGMO	Independent Ouahigouya Market Management Service
SCBA	Sugar Cane Bagasse Ash
SCMs	Supplementary Cementitious Materials
SCSA	Sugar Cane Straw Ash
SCU	System Control Unit
SDC	Swiss Agency for Development and Cooperation
SECTRA	Secretaría Nacional de Transporte
SER	State Secretariat for Education and Research
SEU	Social Exclusion Unit
SFB	Solid Fuel Block
SHS	Solar Home Systems
SLRS	Solar Lantern Rental System

SMS	Short Message Service
SNSF	Swiss National Science Foundation
SOM	Self-Organizing Map
SRTM	Shuttle Radar Topography Mission
STD	Standard Deviation
STI	Science, Technology and Innovation
STI	School of Engineering
SUPSI	University of Applied Sciences of Southern Switzerland
SVG	Scalable Vector Graphics
TERI	The Energy and Resource Institute
TERP	Tsunami Emergency Reconstruction Programme
TGA	Thermogravimetric Analysis
TM	Thematic Mapper
TOD	Decentralization Guidelines
TRMM	Tropical Rainfall Measuring Mission
UCLV	Universidad Central de las Villas
UCR	Uncoursed Random Masonry
UKCDS	UK Collaborative on Development Sciences
UMR	Unité Mixte de Recherche
UN	United Nations
UN DESA	United Nations Department of Economic and Social Affairs
UNCCD	Nations Convention to Combat Desertification
UNCED	United Nations Conference on Environment and Development
UNCHS	United Nations Centre for Human Settlements – Habitat
UNCTAD	United Nations Conference on Trade and Development
UNDP	United Nations Development Programme
UNECA	United Nations Economic Commission for Africa
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNESCO GREET	UNESCO’s Global Renewable Energy Education and Training Programme
UNFCC	United Nations Framework Convention on Climate Change
UN-Habitat	United Nations Centre for Human Settlements – Habitat
UNISDR	United Nations International Strategy for Disaster Reduction
UNITWIN	University Twinning and Networking Programme
UNS	Université de Nice – Sophia Antipolis