Silvia Hostettler · Eileen Hazboun
Jean-Claude Bolay *Editors*

Technologies for Development

What is Essential?

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Preface

Since the dawn of the industrial age, innovative technologies have been viewed as instrumental in enhancing productivity, generating economic growth, and transforming living conditions for billions of people. These technologies are a priority for North–South development cooperation, empowerment, and poverty reduction.

At the Ecole Polytechnique Fédérale de Lausanne (EPFL), we believe that technological innovation can be a pathway to sustainable development. Indeed, innovative and well-adapted technologies are very powerful tools that can render development effective on a large scale for disadvantaged people.

EPFL has been active in development cooperation for decades. This embodies the institution's open approach to the world: An outlook where humanist values and a scientific spirit are combined to produce research that is guided by a sense of responsibility toward the major problems faced by people in the Global South. It reflects the long-established ties between Switzerland and other countries, which are expressed in various, complementary ways: admission of students from the South, partnerships with universities and research centers in Africa, Asia, and Latin America, and numerous internationally recognized scientific and technical products. Development cooperation also complements Swiss government policies and relevant national legislation.

In 2007, UNESCO bestowed the Chair in Technologies for Development on the Cooperation & Development Center (CODEV), thus increasing the coherence and visibility of EPFL's development cooperation activities and reinforcing its existing research, education, and capacity building activities.

Through the UNESCO Chair, EPFL seeks to further utilize its know-how and international renown to establish partnerships with developing and emerging countries as: It is at the cutting edge in many scientific domains and can therefore function as a relay to developing countries; its acknowledged expertise brings it into contact with many projects funded by development cooperation organizations; and it has close links with national and international scientific networks and can thus express its viewpoint on various development issues.

The strength of the UNESCO Chair lies in its dual capacity to orient EPFL laboratories toward specific development objectives and to conduct research and

educational programs focused on international development. The biennial UNESCO Conferences on Technologies for Development, in particular, are rapidly turning into flagship events for CODEV, drawing an ever-increasing audience.

These conferences are highly successful in promoting research in technologies and innovation for developing countries. They create a platform for spirited discussion and scientific exchange, as well as increased awareness of state-of-the-art technologies and their potential in the Global South. North–South research partnerships are promoted, and diverse stakeholders and actors are encouraged to engage in cooperation projects by these events.

This volume brings together the best papers of the 2014 EPFL-UNESCO Conference on Technologies for Development (2014 Tech4Dev) and illustrates the key issues at the interface of technology, human, social, and economic growth. Case studies from Africa, Asia, and Latin America explore the development potential of technologies and discuss successful processes to develop and deploy them, as well as how to evaluate their impact.

EPFL envisions the future as a globalized society, where our responsibilities, as scientists and more broadly as academic institutions, are producing knowledge, innovative technologies, and high-level graduates that are aware, can adapt to global challenges, and are equipped to collaborate with our colleagues from the four corners of the world, especially where serious problems of survival, development, and progress remain to be solved.

Jean-Claude Bolay

Acknowledgments

The editors owe a debt of gratitude to many individuals and organizations who generously contributed their time, insight, and support. First, we would like to thank the members of the Scientific Committee and our Session Leaders who guided the conference preparation. They not only made the 2014 EPFL-UNESCO Conference on Technologies for Development (2014 Tech4Dev) a great success, but also laid the foundation for this publication.

We would also like to express our thanks to Prof. Philippe Gillet, Vice-President for Academic Affairs at the Ecole Polytechnique Fédérale de Lausanne (EPFL), for his presence at the Conference and unfailing support to the Cooperation & Development Center (CODEV).

By willingly sharing their considerable expertise and different outlooks, the speakers at the UNESCO Conference brought much food for thought to the table and substantially contributed to its success. Our heartfelt thanks go to Dr. Shashi Buluswar (LIGTT: Institute for Globally Transformative Technologies), Prof. Karen Scrivener (EPFL), Mr. Anil Sethi (Swiss Extension GmbH), Dr. Jean-Bernard Münch (Swiss Commission for UNESCO), Dr. Jean-Yves Pidoux (City of Lausanne), Dr. Christian Zurbrügg (Eawag: Swiss Federal Institute of Aquatic Science and Technology), and Dr. Jon-Andri Lys (KFPE) for their highly appreciated involvement and support.

Likewise, 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, the Scientific Committee evaluated over 140 papers and ultimately selected 125 to be presented at the Conference. Of these, 15 were finally chosen based on the following criteria: (1) Innovative concept and research questions versus an extension of existing work; (2) Originality of the methodology including North–South, South–South partnership; (3) Contribution to the discipline as whole and; (4) Clarity and understandability. We express our appreciation to all these authors, without whom this publication would not have been possible.

In addition, we would like to very warmly thank Mr. Emmanuel Estoppey and Ms. Jeanne Corthay from the Lavaux UNESCO World Heritage Site who went out of their way to welcome us for the social event. All of the Conference participants

greatly appreciated the opportunity to spend some time outside the conference halls and to experience the splendor of the Lavaux Vineyards.

Our sincere thanks also go to the team from Ingénieurs du Monde (IDM) and our colleagues at CODEV who contributed extensively to the organization of this conference.

Finally, we are very grateful for the generous patronage of the Swiss Agency for Development and Cooperation (SDC), the Canton de Vaud, the City of Lausanne, the Swiss National Science Foundation (SNSF), Cleantech Alps and the KFPE—Commission for Research Partnership with Developing Countries, the conference sponsors. Their support and their partnership is critical to the achievement of our common mission which is to identify innovative solutions that are able to reduce poverty and lead the way toward more sustainable development at a global level.

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Part I
Introduction

Chapter 1
Technologies for Development: What Really Matters?

Silvia Hostettler

Abstract Technological innovation is vital for finding solutions to key challenges the world is facing. Climate change, pollution, disease, rising inequalities, and chronic poverty all need to be addressed. We need renewable energy sources, efficient transport networks, functioning public health systems, well-designed infrastructure, improved agricultural systems, and access to quality education for everyone. Technologies for development play a key role as pathways to sustainable development. Developing and emerging countries can take advantage of technological leapfrogging in key domains such as health (mHealth), energy (solar, wind, and hydropower), education (massive open online courses [MOOCs]), urban development (smart cities), and agriculture (precision farming). Developing and emerging countries could even surpass high-income countries in the use of information and communication technology (ICTs). We can expect technological innovation to be increasingly developed in the Global South and to become a source of inspiration for the Global North. Living labs, open-source, and open innovation movements are growing trends that will support and accelerate the development of effective technologies. Standards are needed to guarantee the quality, reliability, and safety of technologies in the Global South, particularly for medical devices. International Standards Organization (ISO) and United States Food and Drug Administration (FDA) standards often prove to be slow, inaccessible, and expensive.

1.1 Introduction

The EPFL-UNESCO Conference on Technologies for Development (2014 Tech4Dev) focused on the question, "What is Essential?" Indeed, in a world in which we are permanently connected and bombarded with a wealth of information,

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there is undeniably a need to find out what is important and to set priorities. This is particularly true in the field of development in which so many challenges persist. How can we effectively reduce poverty? What is the role of technologies? How can they be successfully developed and deployed? How can their impact best be evaluated? We know that technologies must be developed in partnership with the intended beneficiaries and ideally in a local environment to be compatible with the socioeconomic and technological context (Hostettler and Bolay 2014). We also know that we have to integrate potential up-scaling from the beginning of technological development. This will allow us to manufacture a technology at a large scale at affordable cost once we have developed an appropriate prototype.

Successful technological innovation will depend on all these factors. However, in this introduction I wish to take a step back and focus on the question "What really matters?" It seems that what we need are technologies that support sustainable development in its social, environmental, economic, cultural, and political dimension. We need technologies that are energy efficient, accessible to all, and environmentally and financially sustainable in the long term.

1.2 Key Challenges

If we look at the world, we realize that we face very important developmental challenges indeed: unsustainable lifestyles, production and consumption patterns, the impact of population growth and climate change, to name just a few. Even though some significant progress has been made since 1990, 15 % of the global population still live in extreme poverty and 805 million people are still chronically undernourished (FAO et al. 2014). At the same time, roughly 30 % of all adults in the world are overweight (Sachs 2014). The global population continues to grow and is expected to reach nine billion in 2040 (UN DESA 2013). The demand for resources will rise dramatically. "*By 2030, the world will need at least 50 % more food, 45 % more energy and 30 % more water—all at a time when environmental boundaries are throwing up new limits to supply*" (United Nations 2012, p. 11). Clearly, the current global development model focused on short-term economic profit is unsustainable. We will need to make a consistent effort to find solutions to these challenges. Technological innovation is one pathway to sustainable development.

The potential of technologies for development has been particularly well illustrated by the technological leapfrogging that occurred in countries like Singapore, South Korea, Hong Kong, and Taiwan. These Asian governments realized the central role of technological innovation for development, and they started promoting research and development programs (Rowen et al. 2007). The Asian tigers were able to take over large parts of the technology industry between 1960 and 1990 and invested increased national income into education, health, and public transportation systems, thereby raising the standard of living for the entire population. However, the question of the sustainable use of resources and the pollution linked to technological progress needs to be part of the equation. Technological

progress needs to come from sustainable technologies (Sachs 2014). These technologies may, for instance, focus on energy efficiency in smart cities to using information technology for a range of applications from mHealth to precision farming. One key challenge is to achieve sustainability in the environmental, social, and economic sense. It is not sufficient if a technology is financially sustainable in the long term but its production is based on extensive use of fossil fuels or on social exploitation. In the same way, a technology that is appropriate but unaffordable will equally fail. An encouraging example is the Fairphone which is not only a technology that can potentially contribute to development by improving access to information, health and financial services, but is also produced by a social enterprise that aims to develop a smart phone with minimal harm to people and the planet. This brings us to yet another problem, a problem of scale. At what spatial and temporal scale do we measure sustainability?

The concept of planetary boundaries has emerged to define a "*safe operating space for humanity*" as a precondition for sustainable development. The nine planetary boundaries were first introduced in 2009 and apply to climate change, change in biosphere integrity, ocean acidification, stratospheric ozone depletion, biochemical flows, land system change, freshwater use, atmospheric aerosol loading, and introduction of novel entities (Steffen et al. 2015). The framework identified and quantified these planetary boundaries within which humanity can continue to develop for generations to come. Scientific research indicates that human actions have become the main driver behind global environmental change since the Industrial Revolution. The framework asserts that once human activity has passed certain thresholds defined as "planetary boundaries," there is a high risk of "*irreversible and abrupt environmental change*" (United Nations 2012). Four of these nine planetary boundaries have now been crossed, according to a group of 18 international scientists, driving the world into a much less hospitable state. Altering these "core boundaries" will most likely lead to a deterioration of human well-being in many parts of the world, including high-income countries (Steffen et al. 2015).

1.3 Technological Leapfrogging

What is clear is the preponderant role technologies will play in our efforts to identify pathways to sustainable development. Some technologies will allow emerging and developing countries to technologically leapfrog ahead in certain domains. This has already happened in the field of telecommunications. On average 75 % of the world population own a mobile phone (World Bank n.d.). Many countries will not install fixed telephone lines in all regions. A large part of the population moves directly to the stage of owning and using mobile phones and smart phones which opens enormous possibilities. For instance, the percentage of mobile cellular subscription users in Bolivia jumped from 71 in 2010 to 98 in 2014 (World Bank n.d.). Many countries are "skipping" the initial step and leveraging the development of cheaper, more advanced technology. This is particularly true for the

domains of health (mobile health), education (distance learning), and energy (solar, wind, and hydropower). Developing countries have the opportunity to technologically leapfrog to renewable energy solutions, thereby avoiding as much as possible dependence on fossil fuels. Seeing rapid urban development, emerging countries in particular should seize the opportunity to build smart cities wherever possible in these often resource-poor contexts. Developing and emerging countries could even surpass high-income countries in the use of information and communication technologies (ICTs) (Howitt et al. 2012).

What matters in the field of technologies for development is that the technology contributes to sustainable development and is in itself as sustainable as possible in terms of use of valuable resources, its contribution to pollution, and the social issues linked to its production. We can simply not afford to continue in a direction driven mainly by financial motives.

Although healthcare systems in low-income countries often lack the most fundamental drugs and devices, the potential of technological leapfrogging needs to be further explored. We need technologies that provide healthcare services to the largest possible number of people, technologies that increase energy efficiency, technologies that allow access to knowledge and information, technologies that increase food production and food storage. We need low-carbon energy infrastructure technologies that support the construction of adequate infrastructure with low CO_2 emissions.

However, before embarking on developing a technology, we should ask ourselves a few key questions: Will this technology help the world to remain within the planetary boundaries? Is it sustainable in the social, economic, environmental, cultural, and political dimensions? Is it safe? Are local stakeholders in the partnership, especially governments, willing to support it in the long term? Will it contribute to poverty reduction either directly or indirectly (improve health, increase access to education, create employment)? Does the technology contribute to endogenous development because the benefits will also remain as much as possible local? Will this technology be appropriate and affordable? Is the technology just the "next new thing," or will it have a lasting and maintained development impact?

We also need a financial system that supports the development of adequate technologies. We need social impact funding that supports social entrepreneurs as outlined in Chap. 2 by Jennifer Brant. We need trade reforms and changes in many national subsidy policies that will give developing and emerging markets the chance to catch up. We need proper development finance systems. We need continued financial support for low- and middle-income countries, specifically in the form of targeted aid programs in the public health sector, at least until a country has acquired the ability to finance a well-functioning health system independently. This is still a major challenge for many countries. In a low-income country such as Malawi, the annual income per capita amounts to only US$400. With a 20 % tax level, the income for the government per capita in taxes is US$80 annually (Sachs 2014). With these funds the government is supposed to cover the costs of government administration, legal courts, educational systems, infrastructure, roads,

power supply, and the public health system. Even if the total tax revenue was available for health, with US$80, the government cannot even cover the costs of an effective public health system with appropriate clinics and trained health staff, much less finance all the other development needs of the country. Knowing how crucial the health of a population is for a country's development, there is evidently a continued need for external support. By way of comparison, the public health budget in Europe and the United States amounts to US$3000 and US$4000 per person per year, respectively (Sachs 2014). In the long term, Zach Friedman and Walter Karlen (Chap. 11) argue that a multidisciplinary dialogue and public–private partnerships are essential to the integrity and success of low-cost health systems in small and fragmented markets.

And then there will always be challenges that cannot be resolved through technology. Most importantly, we need a redefinition of what quality of life and social inclusion mean. We need a set of values and ethics based on the knowledge that the world's resources are finite and a conviction that everyone has the right to a decent life.

The needs appear overwhelming at times, but the potentials are equally staggering. There is much cause for hope if we look at the tremendous development impact technologies can have as the papers of this publication illustrate. Consider only the case of mobile phones: They are able to increase access to health services (Chap. 6 by Balaji Parthasarathy et al.), facilitate financial services such as remittances (Chap. 5 by David M. Garrity) and enable farmers in Burkina Faso to conduct precision farming that saves irrigation water and increases food production (Chap. 3 by Clémence Ranquet Bouleau et al.). Mobile health using mobile communication technologies offers encouraging avenues for providing healthcare services to low-income countries. As trained personnel and infrastructure are often rare in developing countries, an mHealth solution can for instance consist in the implementation of antenatal care to improve the health of mothers and newborns via text messages. Smart phones even allow diagnosis via embedded biomedical sensors and phone-based diagnostic kits (Chap. 15 by Nicole Leeds et al.).

Another technology that is opening up new horizons is 3D printing. 3D printing of medical devices (see case study on Haiti by A. Dara Dotz in Chap. 4) can address immediate needs such as supplying umbilical cord clamps and oxygen splitters. This technology can potentially decrease the dependence of hospitals on commercial companies located in the Global North. Devices can be printed locally on demand and in the quantities needed at any time. 3D printing enables the production of individually tailored prosthetic arms, legs, and other human organs in an environment with limited resources. Although the initial investment in 3D printing technology is relatively high, costs of 3D printed medical devices quickly become much cheaper than if they were purchased from a company in the Global North. The sustainability of this technology can even be increased by using portable solar printers as has been done in Haiti.

Considering technological innovations in the Global South, what matters most at the end of the day is that they have a real impact. Therefore, being able to obtain data on the performance and impact of a developed technology is crucial. Emerging