4 Where do we go from here?

Meeting the Millennium Development Goals is a daunting task, even with the benefits of ICT. In fact, ICT as it stands today is not well engineered for sustainable development. Making it appropriately scaled, budgeted, and usable will require extensive research and development. In this chapter, we make the case that to meet the MDGs, ICT for SD requires a serious commitment as a globally supported enterprise. In order to define the scope of this enterprise, we discuss research ideas and suggestions for testbed demonstrations, the need for metrics for ICT for SD, the role of stakeholders, and a new R&D model that adds feedback and stakeholder participation.

ICT for SD R&D – Projects and Testbeds

Table 17 summarizes a number of specific examples of suggested research and development. Workshop participants recognized that undertaking such research would require extensive time, effort, and funding. At a macro-level, these R&D tasks can be can be broken into:

- Short-term agenda – ICT exists and needs to be applied
- Medium-term agenda – ICT needs modification to be applicable
- Long-term agenda – Appropriate ICT needs to be developed

Some of these tasks are discussed below in more detail.

1. *Make ICT universally available, accessible, and affordable.* Ending the digital divide should be a policy imperative. At the very least, basic information, primary educational programs and government services should be accessible to all citizens within convenient distance, at zero or near zero cost.

   In addition to connectivity, research is required to make ICT accessible for those who do not use the major languages (esp. English) and/or have limited literacy. In addition to innovations based on language translation and speech recognition technologies, creation of localized content will help spur the user demand for ICT.

   a. *Village Connectivity Networks.* The combination of wireless access with optical fibers can be cost-effective for improving connectivity. Detailed studies at Carnegie Mellon suggest that such leapfrog design options could provide broadband connectivity for the majority of Africans within walking or cycling distance for roughly $1 billion one-time capital costs.[54] Several clusters of villages can be targeted for such connectivity experiments to prove the concept, but wireless innovations (including modified WiFi, WiMax, etc.) need to be deployed in the field to assess their technical and business viability.

[54] This excludes end-user equipment such as computers or receivers (modems). Further details available online at http://www.contrib.andrew.cmu.edu/~tongia/FiberAfrica--ending_a_digital_divide.pdf

b. *Advanced Wireless Technologies.* Regulatory hurdles often limit the potential of new wireless technologies. There is a need to develop software defined radios, which can operate in any frequency, or even "cognitive radios." [55] This versatility would help produce the global volume required for dramatically lower costs as all countries could use the same equipment. Additional research is also required into mesh networking, which can reduce uplinking costs significantly, and smart array antennas (called Multiple Input, Multiple Output – MIMO – systems) that can improve the performance manifold.

2. *Make ICT usable and applicable.* Complex systems like trucks and cars demand very little advanced skills from their users. On the other hand, end-user ICT is complex, user-unfriendly and difficult to operate and maintain. Considering even professionals struggle to use and maintain computer systems, how can we expect the archetypal village grandmother to use a computer? It needs to be made simpler and more robust, akin to a television or mobile phone.

   A way to judge the level and success of computer penetration in society is by assessing how ubiquitous it has become. Television has crossed this threshold; as have mobile phones, and computers must follow this trajectory to make an impact.

   One unanswered question is whether ICT solutions should be as powerful and general-purpose as possible, allowing vast economies of scale, utilizing shared components such as cheap memory, open software, etc., *or* should ICT solutions be as purpose-built and application–specific as possible, allowing lower production costs and easier interfaces. The growth of ICT ensures that even a "simple" PC is capable of immense processing power. However, most people only use a fraction of this capability, as is the case with many electronic devices. An intriguing possibility is for ICT developers to design distributed computing systems that can tap into such power when required, but remain simple and easy-to-use most of the time. There are a few examples of such usage from the science world where parallel processing is done using a large number of computers that have spare processing power. Specific development tasks and fields amenable for such distributed computing include healthcare/bioinformatics, supply-chain and logistical management, language translation, and multimedia processing.

3. *Integrate ICT into development issues and economic growth*. Research is needed to identify how much of a difference ICT can make in a particular field, and how much investment and other inputs are required for the field itself. For instance, Sub-Saharan agricultural productivity is tens of times lower than that of the Netherlands or Belgium. Much of that is due to the poor physical condition of the soil, which demands nutrients and water. ICT can help in choosing the appropriate crops and helping to time and optimize the inputs. It can also help the farmer receive greater value for his/her output. But, ICT alone will not improve the yield or the farmer's earnings.

   a. *Knowledge Networks.* Many information networks, though meant to benefit the end-user, are designed only to be used by professionals. This is in part due to difficulties at the end-user's end, his or her illiteracy combined with lack of connectivity. Advances in connectivity and creation of specialized knowledge networks that reach up to end-users are therefore necessary. A practical option would be through the use of intermediaries that translate information into useable formats and levels. The e-*Choupal* initiative by the Indian firm ITC provides such an example. It is essential

[55] In addition to being frequency variable and agile, cognitive radios sense their operating environment and choose the optimal band, modulation, power level, etc.

to build educational knowledge networks for anyone, anywhere, to access information in any language. Digital libraries must be expanded, with language translation capabilities.

b. *Remote and field diagnosis, leading to "Lab on a chip"*. Given the endemic nature of a number of diseases (HIV, malaria, etc.) and health conditions (anemia, malnutrition, etc.), it is important to inexpensively diagnose and monitor the vulnerable population. This is the first step to improved healthcare.

   Medical diagnostic tests are generally quite expensive. Even when diagnosed, many health conditions require regular follow-ups during treatment, notably HIV/AIDS. The only treatment, Highly Active Antiretroviral Therapy (HAART), requires regular screenings to determine the efficacy of the medicines and to check against side effects. There is a scarcity of healthcare professionals in developing countries, especially in rural areas. Here, ICT can be an invaluable tool through the development of appropriate and robust diagnostic and monitoring solutions.

c. *Micro irrigation for agriculture.* Agriculture is the primary consumer of fresh water that is in short supply in many developing countries. Learning from the experience of farmers in Australia and Israel, it is possible to optimize delivery of water and fertilizers through drip irrigation systems. This can reduce water consumption by almost 50% and improve the yield. The challenge is to make such systems robust for developing country deployment and cost-effective.

d. *Smart meters for energy and electricity.* Energy is a critical input for economic growth, especially in the form of electricity. Unfortunately, most developing countries (with some exceptions like in E. Asia) face very high transmission and distribution losses and theft, affecting the economic viability of the utilities. ICT can help reduce theft significantly with smart meters that can communicate and be controlled remotely. Such systems will also help improve the overall efficiency through options such as load control and demand side management. Given their limited deployment of metering in some regions, this represents a leap-frog opportunity for developing countries.

e. *Sensor Networks.* This catch-all term spans the range of sensors covering environmental monitoring to equipment operating conditions. The latter are widely used in industrial settings, but not so in the field because of size and robustness limitations, power requirements, connectivity shortcomings, and cost. There is a clearly defined need to make sensors relevant for sustainable development.

In addition to basic research, it is also necessary to design "test-bed" experiments that mimic field conditions to validate the scalability and viability of the solutions.

Defining the Scope of the ICT for Sustainable Development Enterprise

If one mentions ICT for Sustainable Development, there is a general tendency to associate this with digital divide issues, especially on how to make the Internet available to more people. ICT for SD is about more than mere connectivity. It is the special intersection of diverse fields of enquiry and application, spanning technology, economics, sociology, and policy, amongst others. Research in ICT for SD therefore needs legitimacy and promoters within the academic, research, and development communities. We believe that now is an

appropriate time to structure and build ICT for SD as a distinct enterprise drawing participation from technologists, social scientists, and development professionals.

ICT for SD requires global collaboration, specialized research, and testbeds, perhaps using a network of centers and institutions

Such interdisciplinary collaboration requires interaction between existing research and development institutions, as well as the creation of a network of collaborating academic institutions, national labs, development organizations, etc. Just like the Consultative Group for International Agricultural Research (CGIAR) was established by multilateral support as "a strategic alliance of members, partners and international agricultural centers that mobilizes science to benefit the poor,"[56] ICT for SD requires similar collaboration, funding, and effort. In fact, given the requirement for localization of information and feedback from end-users, it requires even deeper penetration into global societies and greater interaction amongst stakeholders.

A focused endeavor brings its own advantages such as a better stratification and synthesis of information and knowledge. This will diffuse the individual anecdotes that today clog information channels on ICT for SD, and often do not stand up to critical scrutiny or emulation.

Metrics and Rigorous Analysis

There are as many success stories in ICT for SD as there are failed projects, and we often don't know the details of the latter. Even some successes do not come up to the original expectations or they continue to depend on subsidies. At the Bangalore Workshop, Tom Kalil referred to this field as being full of "Potemkin Villages."[57] ICT for SD requires formalization of measures for success, standardization of evaluation, and rigorous critical analysis.

Analysis of ICT for SD must extend beyond single projects. The global scale of challenges requires replicability, scalability and economic sustainability. Analysis must also cover the cost-effectiveness of the solutions, including opportunity costs and alternative solutions.

Related to the issue of metrics is standardization of information and its quality. The World Wide Web has exacerbated information overload, and insufficient attention is paid to the accuracy, assumptions behind, or timeliness of the information.

Role of Stakeholders

The pantheon of stakeholders in the ICT for SD network is vast, and their linkages are many. We highlight the role of the stakeholders in the ICT and the sustainable development processes.

End-users need to integrate ICT into their personal and professional life to harness its capabilities for human development. Their needs should ultimately drive the entire development process. Of course, integration and demand is critically dependant on ICT's usability and affordability. However, all other things being equal, an informed consumer is better able to articulate his or her needs, to use ICT as given, and also apply ICT to new uses.

ICT Companies must continue to invest and innovate in ICT development for it to be applicable to SD. The challenge is one of matching investments and efforts along a

[56] CGIAR website: http://www.cigar.org

[57] Refers to a facade covering up undesirable facts or conditions.

sustainable path, avoiding booms and busts. Another difficulty is that the scale of investments varies with projects and technologies; some developments necessarily require large expenditure, especially where more basic R&D is required, such as for language translation solutions.

Companies, Corporations and Industry are natural consumers of ICT, and their use provides the volume for spreading ICT further into the market supply chain. If large companies demand electronic transactions from their suppliers/distributors/etc., even smaller companies will have to adopt ICT. In turn, they may then use ICT as an interface to their clients.

Entrepreneurs are a special case of commercial entities. In developing countries, they often focus on service delivery instead of R&D. Cable TV in India grew rapidly not merely because of the affordability of the services for consumers (initially a few dollars per month) but also because of thousands of franchisee or small-scale operators who found providing services a profitable venture. The same has been the case for many ICT kiosks worldwide and the GrameenPhone in Bangladesh.

Development Service Providers (water, electricity, etc.) are often part of the government (or private companies), but they form a distinct set of stakeholders. This group is likely to require greater assistance in using ICT than private companies or even many governments. Better provision of services will require specialized ICT solutions that are easy to implement and also politically acceptable.

Governments have an enormous role in ICT for SD, just as they have an overarching presence in most facets of development and commerce in developing countries. They not only provide many development services, including ICT services, they also set the policies that lay the ground rules for deployments. The government is also the regulator of ICT and other services, and shapes innovation and R&D in a country.

National ICT policies have often taken two somewhat distinct tracks, focusing on ICT as a sector in and of itself or focusing on ICT as an enabler. The former splits into a domestic focus (like Brazil) or an export focus (like India in the 1990s), while the latter splits into a global position focus (like Ireland) or a development goals focus (like Estonia or South Africa in the 1990s).[58]

Some professionals argue for minimal intervention from the government, especially in the software sector. However, as Joseph Stiglitz highlighted in his Keynote Address at Bangalore, the role of the government is important, covering education, infrastructure, and directed support (such as creating “islands” for export promotion, appropriate tax incentives, etc.) Public funding is typically the norm for significant “basic research” whose benefits may not be appropriable by a single firm. After all, the Internet itself came from ARPA (US Government) funding. In addition, the government should intervene where markets fail, are inefficient, or where it is socially important to intervene.

[58] “The Role of Information and Communication Technologies In Global Development: Analyses and Policy Recommendations” (2003), UN ICT Task Force Series 3, edited and with introduction by Abdul Basit Haqqani.

One important government role (which requires research determining optimal strategies) is universal service provision (of both ICT services and other development services). Some countries choose general tax funds, others establish industry-specific taxes, and some rely on extensive cross-subsidies. One promising model has been the Chilean "reverse auction" where auctions were held amongst private providers for bids for the lowest subsidy required to serve rural areas (including through pay telephones). Through this program, started in the mid-1990s, Chile went from 85% telephony access (at a community level) to 99% by 2002.[59]

Funding agencies have a vital role to play in ICT for SD research, but this is complicated by their current boundaries (i.e., basic science vs. applied research, science/engineering vs. social sciences, etc.) Linkages between different development themes further complicate funding availability (e.g, is ICT for agriculture a technical, social, or economic issue?), but this might also make it easier to secure funding from different kinds of agencies. As ICT for SD becomes a recognized discipline, different entities should fund work in this area, ideally in concert with complementary groups. It would be beneficial to have the equivalent of a DARPA for this field, an agency that funds long-term and even exploratory research. This is necessary given the inherent risks and uncertainty in basic research, and the long timeframes these would entail.

Academic Institutions can provide a steadying force given the uncertainties and unknowns in this emerging discipline. In addition to the research they specialize in, they can provide unbiased and public analyses of various technologies. Unlike companies, academic research results are generally shared openly. They can also help steer the directions of the field, and crystallize challenges and opportunities in the field. Often universities establish exclusive research and development centers or institutes to explore new and emerging areas of enquiry. ICT for SD is now a fertile discipline for such initiatives. These would provide the scale and critical mass required for long-term analysis and wide-scale testbeds and demonstrations. Such centers would also enhance the training of multidisciplinary professionals, with programs integrating facets such as technology, policy, finance, regulation, and ethics.

New ICT-SD Model: Need for Research, Development, & Demonstration (RD&D)

Business as usual models, with their attendant trickle-down approach, may not help meet the MDGs, especially in the proposed timeframes. New models of research and sharing research findings (intellectual property) are required to spur R&D and also prevent people from reinventing the wheel. Suggestions include clearinghouses and portals, which should do more than store information or allow simple searches.

At a business end, new models, with appropriate regulatory clearances, will be required for innovators and entrepreneurs. Flexible (micro) financing and micro-franchising models will also be important for achieving scalability. Presently, there are no accepted best practice models for either human development or for ICT for sustainable development, and there are wide variances in local social and cultural norms and requirements. Based on sharing experiences, researchers, development specialists, and practitioners can build solutions that are contextually relevant.

The research challenges in ICT for SD can be overwhelming, given the large human development needs these are trying to address. There have been multiple studies and recommendations on how to do IT research to make it more societally relevant. For

[59] "ICT and MDGs: World Bank Group Perspective," December 2003

example, in the US National Academies report *Making IT Better: Expanding Information Technology Research to Meet Society's Needs* (2000), the authors highlighted the need for new specialization, collaboration, and scaling. However, these recommendations have not yet been adopted. In particular, the issue of funding remains a challenge, made worse by the bursting of the IT “bubble” in the early part of this decade.

Who will pay for the research? This is not merely the age-old question associated with all research (and heightened by the target – developing countries). This question relates to the different stages of research required for successful ICT for sustainable development. ICT-SD is not simply an issue of making ICT cheaper and faster, and then letting its effects trickle down until there is widespread usage. Rather, ICT that is available, accessible, and affordable requires interaction between the stakeholders, with feedback loops that are largely missing today (Figure 13).

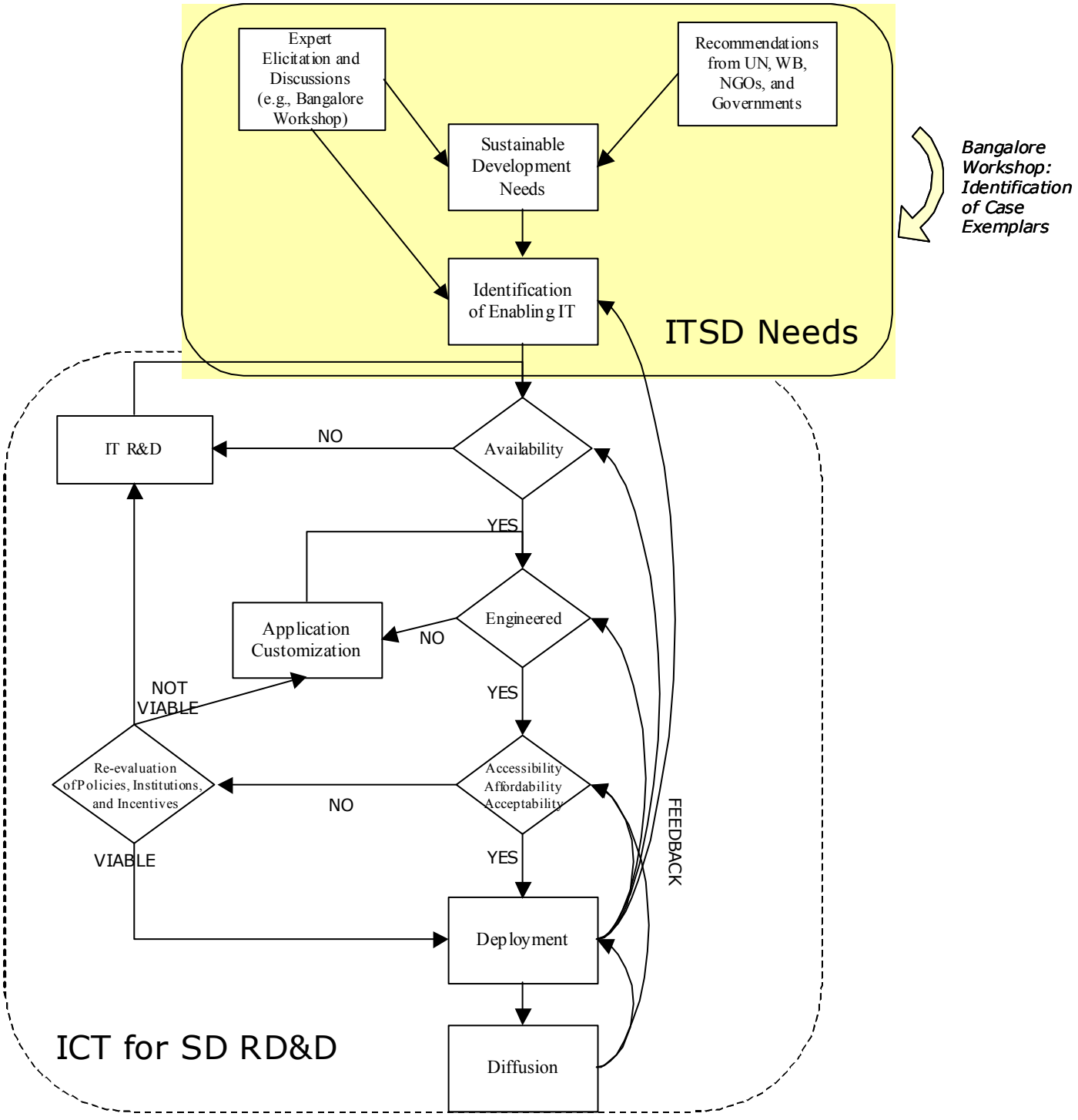

Figure 13: Process Flow Diagram for ICT for Sustainable Development. Issues of appropriateness, affordability, and impact are central to ICT research and design, instead of merely affecting penetration and deployment.

Successful ICT for SD requires feedback loops between stakeholders at all stages of development

Technical bodies and funding agencies such as Science Foundations concern themselves largely with technology issues. Development Agencies focus mainly on development, and ICT is not fully internalized into their planning, projections, and policies for development. We propose that traditional "linear" R&D needs to be superceded by RD&D – Research,

Development, and Demonstration. Demonstration as we propose is not simply a pilot project, but deployment in the field, demonstrating scalability and viability. This last step would ensure human, social, and economic factors (such as cultural acceptability, business models, etc.) are part of the entire development process. Otherwise, the outputs of ICT face major hurdles in their deployment.

Challenges and Lessons Learned

At the Washington and Bangalore Workshops, Carlos Braga presented some cautionary advice to technologists, who often are "techno-optimists": expect the unexpected, and move beyond lab or pilot projects.

Other key challenges and issues discussed at the Workshops include:

- Scalability/replicability, combined with viability, is a key metric for success. Extrapolation, even from real-world deployments, can be misleading or erroneous.
- ICT is good for enhancing development programs, but frequently solutions are geared to supercede existing programs. The focus has often remained exclusively on ICT instead of enhanced delivery of services.[60] ICT is a means, and not an end.
- Capacity building and education are keys to inclusiveness and sustainable demand.
- ICT for development programs cannot be established as charity; while subsidies may be required, long-term viability is key to replicability, and thus, global penetration.
- The market will not necessarily provide societally optimal price and incentive signals, and one should not wait for trickle down growth.
- The elite and upwardly mobile have exit strategies around poor services, through options such as private healthcare and education, diesel generation, bottled water, etc. These further remove market demand for improved services. Even the poor, in spite of the high costs, opt for such options demonstrating their willingness to pay for services they consider important.
- ICT solutions must be shared – we don't want to reinvent the wheel. Often, different countries, industries, or funding agencies expend resources testing the same underlying technology.
- Will ICT create new divides, or exacerbate existing ones?

The workshops have raised more questions than answers. The intersection between ICT and development is indeed complex. The stakeholders are many and diverse, the metrics for assessment are unavailable, and the seamless integration of ICT with other tools for development has not yet taken place.

We see the contribution of the Workshops at two levels. At the first level, we have identified specific research areas based on the intersection of technologies and development needs, bringing together experts in all the appropriate disciplines and domains. At another level, we have created a framework for ICT to help address the Millennium Development Goals by identifying the relationship between technologies, example applications and potential research areas. We propose a new paradigm for research (which we term Research,

[60] "Rethinking the European ICT Agenda: Ten ICT-breakthroughs for reaching Lisbon goals" (August 2004), prepared by PriceWaterhouseCoopers for the Dutch Ministry of Economic Affairs, highlights this issue, as well as a number of policy breakthroughs required to reaching the Lisbon goals. The Lisbon goals were formulated in March 2000 by the European Council, stating their ambition to become 'the most competitive and dynamic knowledge-based economy in the world by 2010.' Similar cooperative targets and agreements are required for ICT for SD.

Development, and Demonstration – RD&D) that is sensitive to the goals of the stakeholders and the efficacy of development.

A knowledge-based economy requires transparency and easy exchange of ideas in a public or semi-public space. The goal is making technology ubiquitous enough for it to become integral to people's daily lives. The Workshops are, we hope, a step in making information and communication technologies an integral part of sustainable development.