3 Thematic Groups – ICT and Sustainable Development

The two Workshops (Washington, D.C., and Bangalore) focused on ICT and sustainable development, and the discussions were segmented into four broad (and sometimes overlapping) thematic topics, along with several suggested sub-groupings:

1) Infrastructure Development
   a. Energy
   b. Water
   c. Transportation
2) Basic Human Needs and Development
   a. Food
   b. Healthcare
   c. Drinking water
   d. Primary education
3) Economic Growth and Poverty Reduction
   a. Agriculture growth
   b. Higher education
   c. Job creation
   d. e-Commerce
4) Alienation, Empowerment, and Governance
   a. National and International Inclusiveness
   b. Democracy
   c. e-Governance

In addition to overlap and linkage, some issues—such as environmental—cut across individual themes. Given such overlap between some topics, and differences in formats between sessions, this report doesn't strictly adhere to the order or segmentation given above.[31] Preparations for the Bangalore Workshop included a series of questionnaires (Appendix 5) we sent to a number of professionals working in these fields seeking their comments and suggestions on what they see as challenges in the field and how ICT could play a role.

[31] As a large number of Bangalore participants focused on Education, a separate working group on Education was formed, and its recommendations are presented in this report.

Infrastructure Development

Water and Sanitation

Overview

Water is a precious resource with uneven global distribution ... people worry it will be the reason for major global conflicts

Freshwater is necessary for virtually all life on earth. Humans require clean water not only for drinking but also for cooking, personal hygiene, and reducing disease. It is also a vital component of industrial and economic growth, to say nothing of being central to agriculture. The UN Committee on Economic, Social, and Cultural Rights at their 29th Session (11-29 November 2002) brought forth the following declaration: "The human right to water entitles everyone to sufficient, affordable, physically accessible, safe and acceptable water for personal and domestic uses."

Unfortunately, much of the world lacks water and sanitation (Table 5). Target 10 of the MDGs is to halve, by 2015, the proportion of people without sustainable access to safe drinking water and basic sanitation. Challenges in sanitation are deeper than drinking water, and this affects healthcare, quality of life, and urbanization.

Region	Percentage Within Region Without Access to Improved Water			Percentage Within Region Without Access to Improved Sanitation		
	Urban	Rural	Total	Urban	Rural	Total
Sub-Saharan Africa	17	56	34	27	57	47
Middle East/North Africa	5	23	13	7	30	17
South Asia	6	20	15	33	78	66
East Asia/Pacific	7	33	24	27	65	52
Latin America & Caribbean	6	34	14	14	48	23
CEE/CIS & Baltic States	5	18	9	3	19	9
Industrialized Countries	0	0	0	0	0	0
Developing Countries	8	31	22	23	65	48
Least Developed Countries	18	45	38	29	65	56
World	5	29	18	15	60	39

Source: WHO/UNICEF Joint Monitoring Program, 2001

Table 5: Percentage without Access to Improved Water Supply and Sanitation, by Region (2000 data)

The above table suggests that by 2015, every year an additional 60 million people will need to gain access to drinking water and 120 million people to sanitation! At the current level of investments, there is an annual funding gap of over $100 billion to achieve these targets (Table 6).

(billions of US$)	Current Annual Investments in 2000	Estimated Annual Investments to Achieve Goals	Estimated Annual Funding Gap
Access to drinking water	13.0	13.0	0
Sanitation and hygiene	1.0	17.0	16.0
Municipal waste water treatment	14.0	70.0	56.0
Industrial effluent	7.0	30.0	23.0
Agriculture	32.5	40.0	7.5
Environmental Protection	7.5	10.0	2.5
Total	**75.0**	**180.0**	**105.0**

Source: WHO/UNICEF Joint Monitoring Program, 2001

Table 6: Estimates of Funding Needs for Water and Sanitation in Developing Countries.
Only a fifth of countries appear to be on track to meeting the Water and Sanitation MDG, one of the most difficult of the MDGs.

Not only is there a funding gap, since the mid/late 1990s, investments in international infrastructure projects have dropped dramatically. Water was never a favored investment target for the private sector because of its very poor financial viability. Compared to telecom, the only truly profitable sector in most developing countries, tariffs of gas and power generally do not cover the full costs, and water lies at the extreme, with cost recoveries only on the order of 30%! Thus, this sector requires large upfront and continual public support for its sustenance. In addition, investors face a multitude of risks (similar to all international infrastructure investments) such as currency risk, regulatory risks, sovereignty risks, etc.

A saving feature is that the demand for water is not limitless. There are indications that through technological improvements in consumption and distribution, demand can be stabilized, if not reduced. Even in the US, in spite of its GNP growth and demand for more energy, water usage peaked at the end of the 1970s, and has dropped since then. In absolute numbers, however, US consumption remains far higher than the world average.

Incorporating feedback from participants and questionnaire respondents, we present a summary of the challenges, barriers, and metrics for success in the thematic groups.

Challenges

1) Provide drinking water to the world's population; about 1.5 billion will lack sustainable access by 2015 (under business-as-usual assumptions). This includes the problem of local access nearby, if not in-home
2) Provide improved sanitation access to the world's population; about 2 billion will lack sustainable access by 2015 (under business-as-usual assumptions)
3) Ensure water quality and health standards are met for water consumption
4) Ensure sustainability of water supplies, e.g., without depleting groundwater resources. This might include technologies for reusing and recycling water for different uses
5) Make water available for non-drinking uses, primarily agriculture, but also commercial and other economic uses
6) Improve the efficiency of utilization for non-drinking uses such as agriculture, which accounts for the majority of the consumption
7) Reduce water losses and improve tariff collection

Barriers

1) Water is overwhelmingly subsidized, even in developed countries. The average cost recovery worldwide is estimated to be around 30%. Poor pricing signals can lead to wasteful usage and over-usage. The poor often lack public supply of water, and pay a heavy burden for water gathering
2) Lack of accountability and poor decision-making by public officials. Ignorance of mid- and long-term consequences of decision-making; the short-term view overwhelming long-term planning and investment. Unavailability of data and non-transparency in decision-making
3) The linkages between water, agriculture, healthcare, energy, and economic growth are not well articulated, especially from a planning perspective
4) Planning for water must correlate to the resource base, i.e., the micro and macro watersheds. However, most decision making and even data collection is based on political or other artificial boundaries and, consequently, decisions are not based on sustainable supply
5) Lack of data on water uses, users, alternative supplies, etc., with a temporal and spatial granularity needed for optimal decision-making
6) A system that allows the elite to seek exit strategies that do not scale, e.g., through individual filtering units, tanker supplied water, individual tube wells, etc.

Measures for Success and Failure

1) Reducing the number of persons who lack water and sanitation, especially with reliable data of sufficiently detailed granularity (household, rural/urban, regional, etc.)
2) Defined and achieved metrics on local access to water and sanitation – whether in-home or within a 5 minute walk, etc.
3) Measured improvements in the quality of drinking and discharged water
4) Stabilization or rise in water tables
5) Publicly available data on water resources, reserves, and their quality for local users, who are empowered to seek redress or other interventions as required
6) Improvement in soil conditions for agriculture, especially related to salinity, chemicals, and other issues dependent on water

Role of ICT

ICT can help in the following areas:

- Assess supply adequacy, modeling different supply and technology alternatives, and factor in different usage technologies. This can include the development of dynamic Geographic Information Systems (GIS) for identifying water availability, storage, transmission, and distribution
- Quality monitoring, especially through low-cost sensors. Quality of water impacts healthcare, agriculture and industry
- Optimize the allocation between different uses of water (e.g., treated drinking water, water for industrial usage, agriculture, etc.) via market and non-market mechanisms
- Water use management at a societal level, including distribution systems—which incorporates loss reduction, equity, etc.—and utilization efficiency

To make a meaningful impact, stakeholders must have access to information for informed decision-making, and they must have open access to range of different models and

solutions. ICT can also help with education regarding efficiency, loss reduction, and new technologies. Reducing losses is especially important for expanding water coverage and availability. Many large developing country cities only provide water supply for a few hours per day, and 25 – 50% of the water remains unaccounted for (either lost through poor infrastructure or pilferage).[32]

Examples of Needed Research

1) Low-cost approaches to quality assessment and modeling, including:
   a. Sensors
   b. Data collection (including ad-hoc networks) and sensor integration
   c. Analysis
   d. Dissemination
2) Systems analysis of supply adequacy across a range of uses, technologies, etc., which:
   a. Demands adequate data (e.g., GIS (Geographic Information Systems) based, point-of-use data entry, etc.)
   b. Requires flexible and robust models

Energy

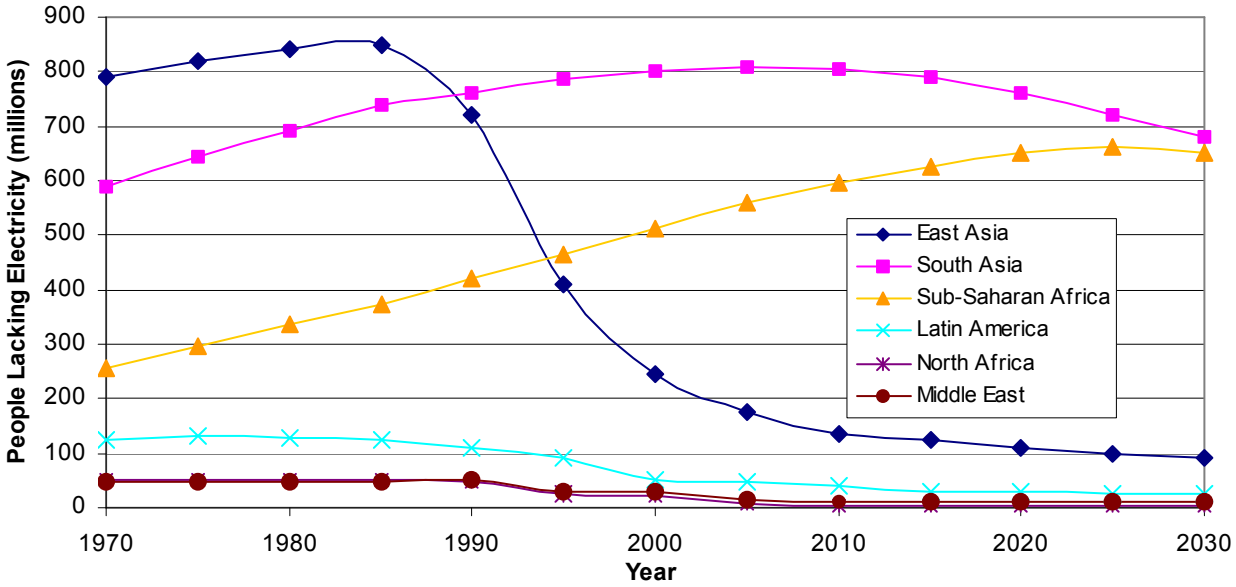
Overview

The linkage between energy use and economic development is well-recognized

Energy use is the engine for development, and its correlation with economic output is well documented. Energy is used in every area of human endeavor, from cooking to manufacturing, from transportation to entertainment. In developing countries, there is a large dependence on non-commercial fuels, such as agricultural and animal wastes, and these do not enter most official statistics on energy consumption. Electricity is a unique form of energy that is clean, amenable for virtually all applications and transportable with appropriate networks. Indeed ICT depends on the availability of electric power. However, there is an acute shortage of reliable electric power in developing countries.

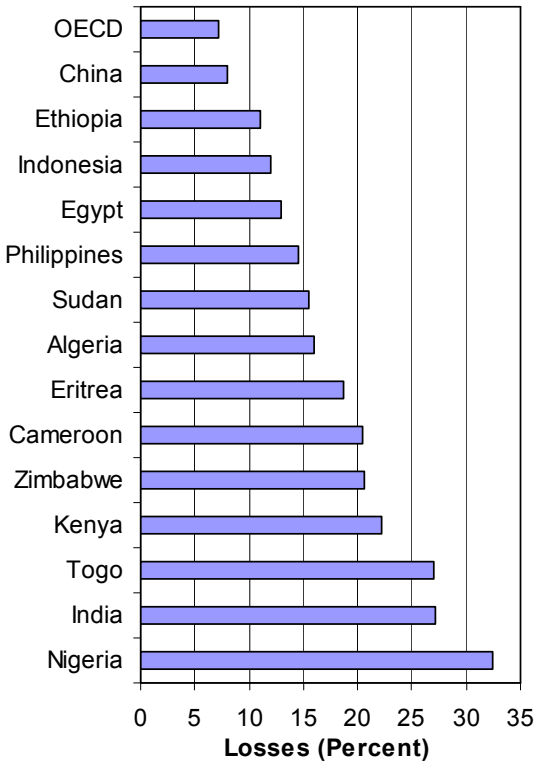
The pattern of electricity consumption in developing countries is very different from the developed ones. For a start, the level of electrification is low (Figure 7), and some two billion people worldwide lack electricity. Consumption varies dramatically, e.g., the annual per capita consumption in India is around 380 kWh compared to the US with annual per capita consumption of over 11,000 kWh! What electricity is available is often intermittent (blackouts and brownouts), and of poor quality. It is generally subsidized, but for some sectors that are economically productive, the prices can be very high. Agriculture can be a large consumer in many developing countries—mainly for pumping underground water—and the losses due to transmission, distribution and theft are also typically very high (Figure 8). In many developing countries, energy industries—as the overall economy—are state-centered. This leads to weak, but rigid, formal institutions including regulatory bodies, courts, and corporate governance, and makes the introduction of innovations difficult. Innovations based on ICT are especially vulnerable as they have the potential to challenge the very established patterns of supply and distribution.

[32] World Development Report 2004 (World Bank)



Source: World Energy Outlook (2002)

Figure 7: People Lacking Electricity. South Asia (largely India) represents the largest absolute share of unelectrified population, but Africa shows slower improvement. A large part of the worldwide gain achieved in the last 20 years came from China, whose electrification grew in parallel with economic growth.



Source: World Development Report 2004, World Bank

Figure 8: Electricity Losses (Select Countries). These losses include both technical as well as theft. Roughly 10% of losses may be largely unavoidable (technical losses, which depend on system design), but the remainder is theft. This is one area where ICT can play a major role – loss reduction.

While much of the discussions focused on the power sector, fuels are also required for heating and cooking. The latter is largely based on biomass in developing countries, though official statistics often do not capture such non-commercial fuels. ICT will be required to adequately quantify energy flows of all types. Given much of the non-electricity energy consumption in the world is for, cooking, transportation and heating, ICT can have a major role to play in consumer education. In addition, it can indirectly help financing and microfinancing plans. It is widely accepted that many small-scale (household or commercial) energy savings investments—such as upgrading insulation—have a high Return on Investment (ROI), but are often not undertaken due to lack of financing or lack of knowledge. ICT can increase the market efficiency and perhaps help create a system for funding energy efficiency and upgrades. This same system would also be beneficial for increasing the penetration of modern energy services, where the payback would also be societal in addition to monetary.

The Workshop discussions explicitly did not factor in carbon dioxide (CO_2) and climate change issues, as participants felt that though this was an important issue, it was not central to developing country needs. While a large fraction of the growth of emissions might occur in developing countries, especially China, the absolute growth and total from the developed countries and Former Soviet Union/Eastern Europe will remain higher for the coming decades.

Challenges

1) Provide energy and electricity services to all households who lack access today; this number is at least several hundred million. Increasing electricity penetration and consumption would also require increasing supply of electricity and generation
2) Increase the use of environmentally appropriate and sustainable fuels, such as renewables
3) Reduce the losses in energy systems, both technical as well as theft. Devise alternative technologies (both supply and consumption) that have higher efficiencies and can enable options such as energy storage, demand side management, etc.
4) Reduce the impact of energy usage on the environment, ranging from locally (down to the home level, e.g., indoor air pollution by cooking using biomass) to globally (CO_2 and greenhouse gases)
5) Provide energy security for users and nations, including price stability/predictability
6) Provide security and environmental safeguards when using fissile (nuclear) materials
7) Develop appropriate adaptation strategies to climate change and sea-level rise, which may impact developing countries disproportionately, in addition to mechanisms for reducing greenhouse gas emissions

Barriers

1) Limited financial resources to help provide commercial energy services, especially electricity. Distortionary pricing of energy, encouraging wasteful usage by many classes of users
2) Poor understanding of linkages between energy and other areas of human and economic development
3) Widespread theft/tampering of electricity and other energy services
4) Conventional wisdom and economies of scale that favors large, centralized power generation plants over decentralized and renewable technologies, which may be more appropriate to rural areas

5) Current technological limits in renewable and storage technologies, with relatively low R&D funding for such options
6) Users unaware of options available for improving their pattern of consumption or unwilling to modify it. Options are also limited due to long life-span of capital stock
7) Limited enforcement of technical and environmental standards
8) Utilities and providers rewarded economically for increased production and sales, and not for energy saving initiatives
9) A system that allows the elite to exit poor supply through the use of decentralized (individual) generation systems such as diesel power generators

Measures for Success and Failure

1) Improving the penetration of modern energy services, measured by households accessing such services. Increased use of energy services for improved quality of life
2) Improving the efficiency of energy consumption with consequent increase in economic output for every unit of energy consumed
3) Consistent improvement in system net availability, including reduction in losses (technical as well as theft)
4) Increased use of sustainable energy sources
5) Improved environmental metrics, varying from local particulate counts to global CO_2 levels
6) Improvements in the availability of quality electricity, measured by voltage profiles, downtimes, faults, safety records, etc.

Role of ICT

The role of ICT can be for:

- Data collection and system level use
  - Metering at all levels (e.g. digital meters that are cheaper than electro-mechanical and can incorporate control and communications)
  - Real time T&D status data
  - Supervisory Control and Data Acquisition (SCADA) systems; new protocols for smart control
  - T&D efficiency and loss reduction
  - Smart control of distributed resources and microgrids
- Resource and needs assessment
  - Viability of alternative market structural arrangements
  - Analysis of network vulnerabilities & interdependencies including during / after extreme events (storms, floods earthquakes) and non-extreme events
  - Search for robust strategies and redundancies
  - Control of loads, load shedding, load management, etc.

Examples of Needed Research

1) Low cost, reliable digital meters, with ICT enhancements such as control and communications
2) Convenient low-cost efficient end-use devices with options for demand management

Transportation

Overview

Transportation needs range from the local to the global, and impact the economy, environment, and quality of life

About half the world's population lives in cities, and rapid urbanization has led to over 300 cities in developing countries of over one million people. By 2015, there are likely to be about 23 megacities with a population of over 10 million. This represents a major challenge for planners. In the Washington Workshop, Nancy Kete presented several examples of large cities in developing countries that have built or are building out advanced public transport networks. These projects have incorporated many advanced technologies such as sensors, communications and GIS, and have had a major impact on urban development and overall city "livability."

Transportation affects not only public safety and healthcare (pollution) but also the quality of life (commuting), economic opportunities, and productivity. Transportation falls under several categories, by mode (bus, car, rail, etc.), ownership (public vs. private), and goods transported along with their characteristics (people, raw materials, finished products, perishables, etc.)

The Workshops focused primarily on two types of transportation, segmented as private and public transportation. While energy usage is part of planning for transportation, it did not form a major part of the transportation deliberations. Nonetheless, such issues are important given the large fraction of energy used for transportation. In particular, the strategically important oil is primarily used for transportation. ICT can have medium to long term benefits on energy reduction through "smart" cars. Today, some 80% of energy in cars is lost as heat, and 18+% is consumed moving the vehicle itself. Only 1-2% is actually spent moving the passenger(s). One improvement from an energy perspective would be to make vehicles lighter. Ironically, marketing and misguided public perceptions of safety are pushing for heavier vehicles. The use of ICT, sensors, and inter-vehicle coordination (such as using technologies based on dynamic cruise control) can allow for lighter vehicles while maintaining or enhancing safety.

Challenges

1) Reduce congestion and overcrowding in all transportation systems and on the roads within cities
2) Improve public transportation systems including affordability, and deploy innovative solutions for meeting both peak and off-peak transportation needs
3) Build safe and efficient rapid transport options between urban centers, including the development of modern port facilities
4) Connect rural areas with urban centers with all-weather roads and other transportation systems. Improve connectivity between areas of greatest demand
5) Improve inland waterway usage for low-cost bulk transportation
6) Improve the environment in urban (and rural) areas, as affected by transportation
7) Increase the safety of transportation systems
8) Improve the sustainability of transportation systems, especially vis-à-vis fuel usage
9) Improve access for those with special needs

Barriers

1) Limited financial resources for public and private transportation

2) Corruption and high transaction costs in public works
3) Poor quality of designs, materials, construction, and maintenance. Lack of enforceable standards for construction and materials. Lack of planning tools and testing centers with authenticated credentials
4) Limited space and ability to effect fundamental redesigns of highways, roads and streets, only allowing for incremental improvements
5) Perceptions and incentives favoring individual transportation options; increased affluence allowing greater individual transportation modes
6) Limited enforcement of existing laws, varying from safety to environmental to encroachment
7) Limited incorporation of externalities into system design and pricing
8) Urban layouts that often relegate the poorest to the most remote or underserved areas
9) Perception that "bigger is safer" when it comes to passenger vehicles
10) Partial improvements negated by signals that encourage further utilization of infrastructure (i.e., more roads bring even more users, including new residents – urbanization)

Measures for Success and Failure

1) Reduced crowding and congestion in public transportation systems and roads
2) Reduction in time spent commuting
3) Improvement in air quality
4) Increase in use of public transportation and ride-sharing options, as well as alternatives such as bicycling, across all socio-economic strata
5) Improvement in passenger transportation per unit energy input
6) Increase in safety and reliability of transportation systems

Role of ICT

Air, Rail, and Bus Transportation (Shared transportation systems)

- Universal access to on line reservations & purchase for public transportation, with real-time information; this must be device/platform independent, e.g., through mobile phones
- Mechanisms for improved safety, fuel monitoring/consumption, etc.
- Optimized use of assets and facilities, including efficient load tracking
- Distributed approaches to rail/air traffic control
    - Can enhance safety and allow greater capacity utilization

Private and Road Transportation

- Transportation planning models
    - Focus on life cycle costs
    - Adequate treatment of mixed vehicle types
- Air quality data collection and advanced air pollution models
- Monitoring of infrastructure conditions, e.g. use of low-cost sensors
- Transparency/clarification of decision authority for ongoing operations
- ICT enabled externality metering, such as congestion pricing (*but* there are equity issues)

Examples of Needed Research

1) GPS based rail traffic control and improved low-cost load tracking (e.g., use of RFIDs[33])
2) Low-cost air quality monitors combined with advanced air pollution models (e.g., including photochemistry)
3) Optimization of public and private transportation based on GIS and the use of innovative options such as congestion monitoring and pricing that integrate urban planning

ICT and Infrastructure – General Observations

The Workshop participants determined a number of commonalities between the infrastructure sectors, and made some observations about the overall role and potential of ICT.

To aid planners and researchers, the Working Group developed a generalized framework for energy, water, etc., with applicability to nearly any resource-based system (with appropriate modifications as necessary). This can be used for even non-infrastructure systems, such as agriculture or labor (Table 7).

Availability / Supply / Production (A)	How much is available, where, when, to whom? Is it in an appropriate form, or does it need processing or conversion?
Transmission and Storage (T)	Where does it flow, with human intervention or naturally? What timeframes and contingency plans are available?
Distribution (D)	This is where end-users receive the resource, and is often the segment with the highest losses, due to poor designs and technical and man-made losses.
Consumption (C)	Affects overall demand and sustainability. Lifetime of capital stock is a barrier to change, but greenfield designs and growth models can allow leapfrogging technologies and solutions. Carefully introduced social changes can modify consumption.

Table 7: Generalized Model for Infrastructure/Resources

ICT can help manage and optimize infrastructure development and natural resources usage

The entire ATDC model above can obviously benefit from ICT, especially with fine granularity and appropriate dissemination of information to the stakeholders. In addition, ICT can help optimize resource utilization, not only saving money but also allowing increasing penetration of infrastructure services.

It is important to recognize that just putting information on the web is often not enough. For a start, how many stakeholders have access to the web, and what opportunities are there for effecting feedback? Increasingly, raw data is being made available to outsiders, which can aid analysis and accuracy. However, even the raw data is subject to assumptions, and, in many instances, unreliable.

Most infrastructures consist of networks and systems, which can be end-user/individual devices or shared facilities. One area for R&D would be the application of network and systems theory, especially integrating ICT, which might lead to valuable insights and ideas. In addition, not all good solutions need to be centralized or hierarchical, which underscores the need for bottom-up development.

[33] Radio Frequency Identification – very low cost and often passive sensors for identifying and tracking goods. These will likely become embedded into most commercial goods over the coming few years. Critics worry about privacy issues, but some uses for supply chain management appear less controversial.

Infrastructure projects often require both public and private resources

In terms of finance, infrastructure projects require large investments, and the debate on public vs. private needs to be transparent and more informed. Public projects often have a large private component, if not outright outsourcing, and private projects in turn are often beneficiaries of public policies and specialized funding, and are generally subject to public regulation. An additional financing challenge is the process by which solutions are chosen for public projects in most countries – tendering. While this provides the impression of transparency, it severely limits the introduction of ICT and other new technologies into infrastructure or other projects. No vendor or service provider unilaterally adds ICT if it is not in the requested "spec" since their solution is likely to be more expensive, regardless of the fact the use of ICT would provide additional benefits and even turn out to be less expensive.

ICT has the potential to positively impact infrastructure, but it does not function in a vacuum. Organizational, institutional, and structural issues can often impede the realizations possible from ICT, and without appropriate reforms or new implementation models ICT's value can be diminished. However, there are instances where ICT can sometimes help overcome institutional rigidities, e.g., by allowing outsourcing of specific tasks and diminishing the power of unions intransigent to change.

ICT can increase transparency, provide better information for decision-making and operations, and increase public pressure for reforms. Transparency alone doesn't always *speed* decision-making, as in many processes there are dislocations amongst stakeholders—some winners and some losers. To realize the full benefits of ICT requires the active participation of all stakeholders and this, in turn, needs human capacity building. In addition, all solutions should be adapted to local circumstances and needs. Externally imposed solutions have usually not been effective or sustainable.

Basic Human Needs and Development

Food and Agriculture

Overview

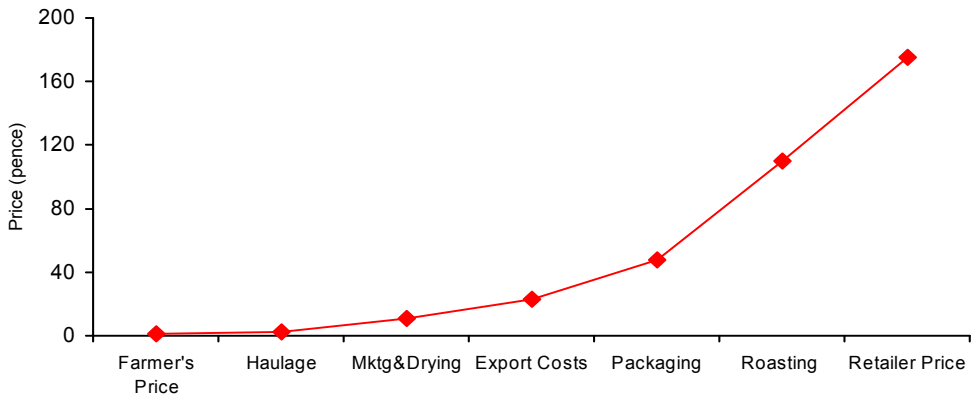
Food supplies have grown with population, but local and regional shortages remain a concern

Food is a basic human need, and agriculture (including fisheries, farming, livestock, etc.) employs the bulk of the global population. Technological improvements have kept pace with population growth, averting global shortages of food, but regional imbalances and lags remain, especially in Sub-Saharan Africa.

The MDG target of halving the number of undernourished by 2015 is difficult to realize at the current rate of reduction of hungry individuals (estimated at ~8 million a year on average). The task requires paying concurrent attention to increase in farm productivity, increased employment/livelihood opportunities in rural areas and improved conservation of natural resources. Greater investment in biotechnological research in relation to agriculture and trade is widely acknowledged to be a key factor in ensuring food security for all.[34] A number of professionals cite unbalanced global trade practices as a major impediment to improving the lives of farmers in developing countries; developed countries maintain their subsidies, tariffs, and interventions are necessary to maintain rural quality of life, if not lifestyles.

[34] Biotechnology doesn't necessarily mean genetically engineered crops; the green revolution involved biotechnology without genetic engineering.

Even within national borders, systems for price discovery and supply chain improvements can be vital for farmers, increasing their share of the retail price from the 5-25% they often receive for products (or lower, for the retail example of coffee, Figure 9).



Source: "Earth" Special, The Guardian (2002)

Figure 9: Value-chain for a Cup of Coffee (UK)

Agricultural output depends on both the land available as well as the productivity (yield). The availability of arable land has reached a plateau, and, combined with a rising population, leads to lower per capita land for grain production (Table 8). The only solution is increasing the output from the land—improving productivity.

Year	Arable land (10^6 ha)	Per capita arable land (ha)	Per capita grain harvested area (ha)
1700	265	0.44	n.a.
1850	537	0.44	n.a.
1920	913	0.45	n.a.
1950	1,170	0.47	0.23
1980	1,500	0.33	0.16
2000	1,450	0.23	0.12
2025	1,300*	0.16	?
2050	1,200*	0.13	?

Source: Rattan Lal (2003) Washington Workshop

* Different methodology; rounded estimate

Table 8: World Agricultural Land Availability

Agriculture needs to be sustainable – environmentally and economically

Soil cannot produce more than the inputs it takes in – else it will degrade and require ever greater inputs up to the point of unusability.[35] *Sustainability* is a fundamental part of long-term agriculture, which is based on:

- Preserving the natural resource base
- Maintaining the soil's productivity
- Maintaining environmental quality
- Alleviating human drudgery and suffering – making agriculture a viable and respected livelihood

[35] "Lal's Law of Marginality: Marginal soils cultivated with marginal inputs produce marginal yields and support marginal living."

The Green Revolution of the 1960s was realized by growing input-responsive varieties of grains on fertile soils significantly enhanced by fertilizers and irrigation. About 40% of the global food production comes from the 17% of farmland that is irrigated.[36] However, the growth of irrigation is slowing, and is now under 1% growth annually. In addition, nutrient input to the soil, which grew six-fold between 1960-1990 (25 million nutrient tons to 150 million tons), is only expected to grow by 50% in the subsequent three decades. The regional disparities highlight the importance of inputs. Fertilizer use in Tropical Africa is between 2-19 kg/ha, or only 2.5% of the world's consumption. Asia uses 73 kg/ha, which is lower than what the western nations consume. To compound matters, only 2% of irrigable land area in Africa is presently irrigated. Differences in inputs explain, in part, the enormous disparity in productivity (Table 9).

	World Cereal Yield (tons/ha)
World average yield	3.31
Highest yield (Belgium)	8.48
Lowest yield (Botswana)*	0.24

Source: FAOSTAT data (2004)

**Data for Cape Verde appear incomplete, showing 0.2000 tons/ha for the last two years, a dramatic decline over 5 years prior.*

Table 9: World Cereal Productivity

The answer is not merely increasing inputs to the soil. In fact, over-irrigation can lead to dramatic soil degradation such as water saturation, reduced aeration, salinity, runoff of nutrients, proliferation of weeds, etc. Soil degradation might be a physical process, but it is fueled by extended neglect and misuse of natural resources and not utilizing the scientific findings that could have saved the land from degradation.

Enough information and knowledge in agricultural sciences are now available to grow sufficient food with reasonable geographic and economic equity. Unfortunately, in many developing countries, technical know-how is not easily translated into practical strategies, especially not in the context of economic, social, cultural, political and ethnic realities. This is where ICT can play an important role, beginning with education, but extending to soil analysis, weather analysis, market analysis, etc. Looking at how different forms of farming affect land requirements per capita, technology and practices are the differentiating factor (Table 10).

[36] Data and information in this section draw extensively from Rattan Lal, Washington, D.C., Workshop Presentation (2003).

Farming System/input level	Ha/person
Shifting cultivation	2.65
Low traditional	1.20
Moderate traditional	0.60
Improved traditional	0.17
Moderate technological	0.11
High technological	0.08
Special technological	0.05

Source: Rattan Lal Washington Workshop Presentation (2003)

Table 10: Typical Land Requirements for Different Farming Systems. Increasing productivity in higher technology systems includes use of ICT.

Challenges

1) Increase the rate of reduction in the number of hungry individuals from the current rate of about 8 millions per annum to over 22 millions per annum
2) Improve food production for enhanced nutrition and health
3) Preserve natural resources including water
4) Prevent land erosion and stabilize land quality
5) Increase access to markets
6) Value addition through agro-products and food processing
7) Enhance and make available education about best practices solutions for improved output and incomes
8) Improve agricultural practices, including appropriate use of biotechnology
9) Increase livelihood options in rural areas, taking out a substantial fraction from a sole dependence on agriculture
10) Help to minimize suffering from catastrophic failures in agriculture, which causes human suffering as well as increases pressure for urbanization. Establish adequate safety nets (public and/or private) to protect the rural population affected by crop failures
11) Reduce wastage and spoilage of produce
12) Development of hygienic and non-perishable storage and packaging systems, while maintaining environmental compatibility

Barriers

1) Limited institutional accountability and capacity, and lack of dedicated effort and political will to end hunger anytime soon (through actions and funding)
2) Poor access to education in agricultural practices; limited ability to participate in exchange of knowledge between experts and farmers as well as farmer to farmer exchanges
3) Limited rural infrastructure for food processing and other value addition
4) Lack of appropriate technologies and organizational structures for monitoring water usage, contamination, drought prediction and other resource control mechanisms
5) Lack of access to regional/national and global markets for goods; limited price and other information on other regional/national markets for agricultural products. No consensus

on allowing gradual integration of global commodity trade and markets; simultaneous fragmentation of local markets

6) Existence of "perverse" subsidies that compensate (ecologically as well as economically) inefficient production practices
7) Actual or perceived corporate dominance and of advanced technologies, with monopolistic effects on farmers
8) Declining investment in application of frontier technologies in agricultural research and lack of investment in research on technologies for off-farm enterprises
9) Globalization unmindful of local concerns

Measures for Success and Failure

1) Increased nutritional levels across the population, with increased food production
2) Increased access to regional/national and global markets, with improved share of end-user price going to the farmer
3) Reduction in spoilage of food at the source and in transport
4) Development of systems for monitoring of land usage, water usage, drought prediction and other resource control mechanisms
5) Development and use of ICT for knowledge networks in agricultural practices
6) Ability to process food and provide value-addition
7) Viability of farming as profession, with a reduction in urbanization
8) Enhanced adoption of ecologically sound production practices on the small farm

Role of ICT

ICT can help with both the physical production of food, as well as improving agriculture as a livelihood.

- Sensors and Information Systems – to optimize inputs based on soil, water, crop, and environmental conditions
- Interaction with specialists – two way audio-visual communications for pest management, e.g., diagnosis of diseases through digital images and expert advice
- Marketing and logistics enhancement – price discovery, bargaining power, and supply chain efficiency

Examples of Needed Research

1) Drip and advanced irrigation systems – this will impact sustainability and reduce water needs
2) Solutions to match inputs and effort (fertilizer, pesticides, sowing timing, etc.) with soil, crop, weather and other conditions, which can also be linked to advanced irrigation systems
3) Determine role and potential for ICT vis-à-vis physical inputs required for productivity
4) Making agriculture related information available and compatible with available hardware and communications technologies (e.g., cell-phones – as a hardware platform and communications means)

One major issue with increased use of ICT (common to many aspects of development) is the asymmetric ability of stakeholders to benefit from ICT. Large buyers or traders of commodities are more likely to be able to squeeze farmers for lower prices than farmers are

able to bargain for better prices. This was seen in the case of coffee, where retail prices stayed flat or grew, while the prices paid to farmers declined. One suggestion has been to develop ICT based auctions, which can mitigate the market power of large buyers. However, auctions should be distance enabled, as ITC's e-*Choupal* system shows.

e-*Choupal*: ICT for rural agriculture[37]

e-*Choupal*[38] is the successful initiative developed by ITC Ltd., a major Indian conglomerate with an agribusiness arm. Within four years, ITC has established roughly 5,050 e-*Choupal* kiosks covering 31,000 villages and 3.1 million farmers. This allows the farmer a choice to sell directly to ITC or the traditional market (*mandi*) for produce. The first use was for soybean, but it is now extended to other foods. ITC pays for installing the system, which is operated by a local village farmer, the *Sanchalak.* (who is literate, respected in the community, but typically not e-literate).

The traditional *mandi* system, which was inefficient, produced high profits for the middleman, but farmers had to travel with their output to sell their crop. While there were auctions in place, the sunk cost of travel meant farmers typically took what they could get. Now, farmers are empowered within the village with free information on pricing, independent of any transaction they may choose. In addition, the system provides real-time and other information such as weather, best practices, etc., and provides e-commerce transactions with better pricing and quality for seeds, fertilizer, etc., as well as other goods and services that have been quality-controlled.

This has been successful because ITC brings a ready market and transformed supply chain system for farmers. In addition, they have the farmer's trust, and the *Sanchalak* takes a public oath to serve the villagers. *Sanchalaks* provide the housing for the equipment and the operating costs of ~$100/year (power, telecom usage, etc.—the latter is decreasing with deployment of VSAT systems by ITC), and gain prestige, a working computer, and a commission from ITC on all completed transactions (but browsing and the information is free for farmers).

The e-*Choupals* have been established within walking or cycling distance for a farmer (one per cluster of 5-6 villages), and the multipurpose warehouses/processing centers (where the grain is delivered) are within tractor driving distance. The 2003 transactions, without spanning many crops, were $100 million and over the next decade, ITC aims to extend this system to 100,000 villages (20,000 installations), or 10 million farmers, and transactions of over $2.5B. The system works because the farmers find upto 20% higher prices for their grain, and also reduced costs overall, and ITC has reduced their transaction costs by 75% (Table 11). ITC also increases its quality control and can offer traceability to its customer base, important due to the small farm sizes in India.

[37] This section draws from: Digital Dividends Case Study, "What Works: ITC'S e-*Choupal* and Profitable Rural Transformation," Kuttayan Annamalai and Sachin Rao, August 2003; "Going Direct to the Farmer: ITC's e-*Choupal* Initiative," Ravi Anupindi, presented at SCTL Roundtable July 2004; information from ITC through personal discussions.

[38] Hindi term for a rural meeting place; it is different from a *mandi*, or market-yard.

Mandi Chain				e-*Choupal* Chain			
Farmer's Costs		**Processor's Costs**		**Farmer's Costs**		**Processor's Costs**	
Trolley Freight to *Mandi*	100	Commission to Agent	100	~~Trolley Freight to *Mandi*~~	~~100~~	Commission to ~~Agent~~ *Sanchalak*	~~100~~ 50
Labor – Filling & Weighing	70	Cost of Gunny Bags (net)	75	~~Filling & Weighing Labour~~	~~70~~	~~Cost of Gunny Bags (net)~~	~~75~~
Labor – *Khadi Karai* (holding)	50	Labor – Stitching, Loading	35	~~Labor – *Khadi Karai* (holding)~~	~~50~~	~~Labor – Stitching, Loading~~	~~35~~
Handling Loss	50	Labor at Factory (Unload)	35	~~Handling Loss~~	~~50~~	Labor at Factory (Unload)	35
		Freight to Factory	250			Freight to Factory	~~250~~ 100
		Transit Losses	10			~~Transit Losses~~	~~10~~
Totals	**270**		**505**		**0**		**185**

Source: *ITC (2005)*

Table 11: Costs for Mandi vs. e-Choupal (Rs../ton, e.g., soybeans)

Some lessons from the system are:

- A local stakeholder is vital to ensuring trust and alignment of incentives – the *Sanchalak.*
- Competition and choices for the farmer are key (for e-commerce/suppliers/trade fulfillment) – ensuring efficiency and that farmers benefit.
- The system must be tailored to the crop at hand and its specific supply chain needs.
- Telecommunications are a large fraction of the cost, both operating and capital; one needs to innovate to find less expensive last-mile connectivity solutions.

(Rs.)	Printer	Power Related	VSAT	PC	Total
2003-04 Costs	7,000	15,000	70,000	30,000	122,000

Source: Digital Dividends: "What Works: ITC'S e-Choupal and Profitable Rural Transformation" (2003)

Table 12: ITC's e-Choupal Capital Costs per Kiosk (2003-04)
[One US$ ~ 45 Rupees]

- e-Literacy is not an issue – a local person can learn this (any) technology as long as he/she has a stake in it and benefits from it. In fact, *Sanchalaks* learned to transliterate Hindi using an English keyboard as the most efficient manner of communicating (Hindi script can be cumbersome, requiring multiple keystrokes per character).
- There are synergies for this infrastructure (for agriculture and for general education, retailing, e-commerce, e-governance, etc.) ITC is extending e-health and e-education into rural areas through this platform, and partnering with NGOs for micro-credit facilities, soil and water conservation, etc.
- There are certainly some "losers" – e.g., the *mandi* middlemen; ITC still pays *mandi* taxes to the government, but there may be other regulatory concerns with growth.

Healthcare

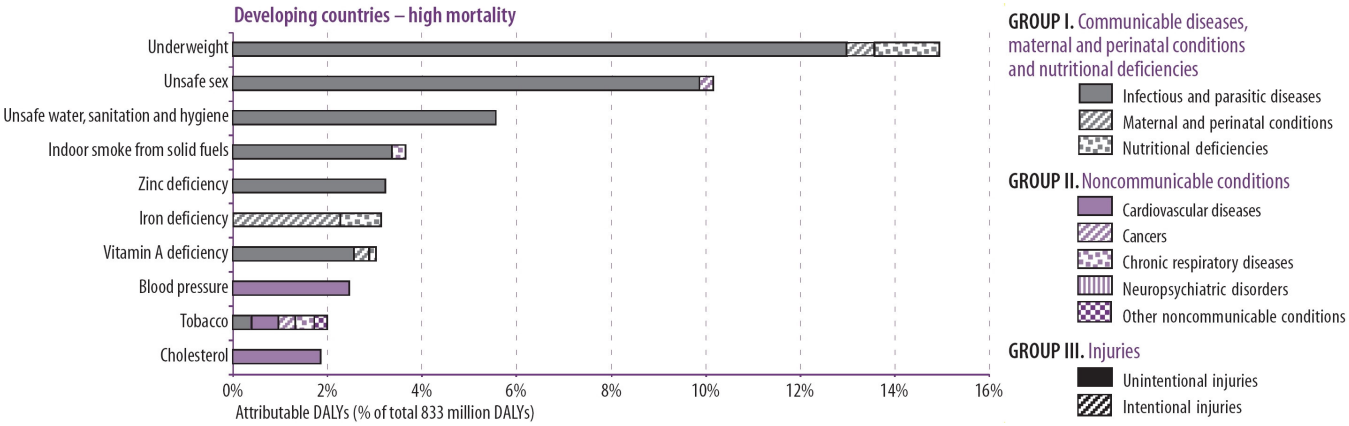
Overview

Three major diseases now take a heavy toll of lives in developing countries, especially in Africa: HIV/AIDS, tuberculosis (TB), and malaria. These add up to almost 6.5 million deaths a year with AIDS deaths totaling almost 3 million (2.3 million in Africa alone) closely followed by TB with 2 million deaths (1.5 million in Africa) and malaria with 1.5 million (960,000 in Africa). Deaths from two of these are largely preventable today with appropriate drugs and precautions, and the ravages caused by AIDS can at least be minimized. Infant mortality deaths, largely due to water-borne diseases, malnutrition, and lack of post-natal care, have also reduced the life expectancy in many developing countries. Diarrhea alone kills an estimated 2.2 million people annually, mostly children. Indoor air pollution has become a major killer in developing countries (while urban air pollution has reduced in middle and high income countries). Other major diseases in developing countries, especially from a growth rate perspective, are cardiovascular, diabetes, and hepatitis, deaths from which are preventable to varying degrees.

There is a well-established inverse relationship between overall development and burden of disease. However, even for a given level of income (a proxy for development), indicators such as malnutrition vary significantly amongst countries. This suggests that there is more to health than mere economic wellbeing.

Successful healthcare, like other areas of development, requires improvements outside the domain, such as in energy, water and sanitation, etc.

Globally, healthcare is an enormous sector of the economy, roughly double that of agriculture in size (and relatively much larger in developed countries). Most modern systems of healthcare focus on government policies and formal healthcare provision. However, if we examine the causes of disease in developing countries, and their associated reduction in life-years, we can immediately recognize the need for increased expenditure on determinants outside the modern health system, especially the household and community (Figure 10).[39]



Source: World Health Report 2002: Reducing Risks, Promoting Healthy Life, WHO

Note : DALY – disability-adjusted life year

Figure 10: Burden of Disease Attributable to 10 Selected Leading Risk Factors in High Mortality Developing Countries

[39] Portions of this section draw from Washington, D.C., Workshop presentation by W. Henry Mosley, 2003.

Most factors that lead to disease in developing countries lie outside the modern healthcare system. Even their diagnosis is not integral to many systems, and aggressive prevention is not systematized (the notable exception being vaccination). If we study some of the causes in greater detail, we clearly see the *household* is the primary agent for promoting health (Table 13).

Undernutrition	Food production/purchase and storage; Dietary selection and meal preparation; Family food allocation; Dietary practices in pregnancy and postpartum; Breastfeeding and complementary feeding practices; *etc.*
Unsafe sex	Negotiating gender roles and sexual relationships; "Protecting" unmarried daughters (and sons), delaying sexual debut, arranging marriages, secluding women, limiting sexual partners, utilizing condoms; *etc.*
Unsafe water, sanitation and hygiene	Collection, storage, utilization of water; Bathing, washing clothing, bedding, utensils, use of soap; Food preparation (incl. Infant formula) and storage; Latrine practices and waste disposal; *etc.*
Indoor smoke from solid fuel	Use of biomass for fuel; Use of (inefficient) open indoor fires; Lack of windows/ventilation, *etc.*

Source: W. Henry Mosley, Washington Workshop Presentation (2003)

Table 13: Household Activities and Burden of Disease

Given the prominence of the household in determining health, the female is the de-facto healthcare provider for most rural underserved communities. She is not only involved or responsible for the above activities, but is also the first line of defense, providing triage and rudimentary care. One requirement would thus be to empower her with information both medical as well as relating to common household activities and how these impact health. This also relates to overall gender empowerment and related social issues.

A number of developing countries, especially in Latin America, have found visible success in utilizing social networks to improve healthcare. In some countries, trained healthcare workers are assigned to small groups of families, visiting them regularly to provide pre-natal and other basic care. This has had a significant impact in reducing maternal and early childhood mortality.

Ultimately, as with many aspects of development, outside factors not within the domain determine the overall level of development; in healthcare there are inherent linkages to infrastructure such as water/sanitation and to agriculture. Nutritionists now point out that merely growing enough food (calories) is not the only challenge. Carbohydrates have grown dramatically in supply and so many of the global poor, though not suffering from starvation, lack adequate proteins (including dairy), vitamins, micronutrients, etc. for improved health and productive capability.

Challenges

1) Increase longevity and survival statistics
2) Reach the entire population and educate them in a persuasive manner on health issues

3) Ensure that malaria and TB are eradicated and the affected cured
4) Make educational information universally available on how to prevent the spread of AIDS and help the victims from being ostracized
5) Provide health care and health information to people in difficult-to-reach rural areas, including through outreach programs
6) Make telemedicine systems routinely available in all remote areas
7) Minimize deaths from water-borne diseases and poor sanitation
8) Provide education on pre-natal and post-natal care
9) Improve healthy lifestyles (diet, exercise, etc.)
10) Incorporate traditional and so-called alternative medicine in a scientific manner.

Barriers

1) Lack of available and affordable healthcare
2) Poor governmental investments for healthcare
3) Acute scarcity of hospitals and healthcare facilities, and overcrowding in existing ones
4) Scarcity of lifesaving drugs and equipment, and their high cost
5) Poor water sanitation and hygiene, and limited availability of infrastructure such as electricity, telecommunications etc.
6) Lack of information on healthcare options, hygiene, and personal health
7) Lack of clean fuels for cooking and limited enforcement of urban air quality standards
8) Shortage of well-trained health professionals, especially in rural and economically depressed areas
9) Spurious medicines and quacks
10) Modern lifestyles with increased stress and pollution, unhealthy diets, and reduced exercise
11) Increasing tobacco consumption, especially in developing countries
12) Ostracizing people with infectious diseases
13) Gender discrimination and disparities due to income
14) Increased resistance to drugs by pathogens due to indiscriminate usage
15) Lack of insurance options or safety nets
16) Lack of incentives for health care practitioners to move to rural areas
17) Lack of well-defined measures or data on quality of life, especially for the elderly
18) A system that emphasizes cures over prevention, and also sets research priorities based on “market,” effectively shutting out developing country diseases

Measures for Success and Failure

1) Increases in life expectancy
2) Reduction in infant mortality and maternal deaths
3) Millennium goals for reducing the spread of TB, Malaria and AIDS
4) Immunization of all children under 5
5) Gender equality in healthcare
6) Sustainability in percentage of GDP devoted to healthcare

Role of ICT

ICT can play an important role in healthcare around the world, both in developing and developed countries. Healthcare can be 10+% of the GDP in some countries, and simply using ICT for streamlining logistics and operations alone can lead to significant returns. Telemedicine can extend the availability of medical specialists to rural and other underserved areas. ICT can also play a role in societal health issues, including diseases that are communicable or that affect a segment of the population (especially epidemics). Some funding and efforts might be directed towards epidemiological detection of malicious biological incidents (bio-terrorism), but the general principles and systems can apply. One of the primary roles ICT can play in developing regions is on education: An ounce of prevention is worth a pound of cure.[40]

Questions for stakeholders who aim to integrate ICT into modern healthcare systems include:[41]

- Is there a functioning information system that would *gain in performance* with new ICT?
- Are there growing operational needs, e.g. logistics, finance, personnel, services, that ICT systems could *more easily manage*?
- Are there new data gathering and analytical needs that ICT systems could *simplify*?
- Are there knowledge and skill building needs that can be *efficiently facilitated* by ICT?
- Are there global and local interaction needs that would be *best met* by ICT systems?

ICT's impact has been easier to find within modern healthcare systems, which is often beyond the reach of a large fraction of the population

There are many successful examples of ICT for healthcare projects, such as the use of hydrologic sensors, satellite imagery, and forecasting software to help eradicate the black fly—which causes river blindness—across parts of West Africa. Optimized insecticide spraying protects 30,000,000 people, and frees up 100,000 square miles of land. However, most cases are niche and ICT has yet to become integrated into societal healthcare, especially not to the extent the technologies could allow. Some gaps include: [42]

- Lack of stakeholder participation, especially those that are directly afflicted
- Poor integration of local information and locally relevant information
- Overemphasis on top-down decision-making and management
- Limited integration of ICT into existing programs
- Limited integration of various high and low-tech solutions, such as mobile phones, TV, radio, etc.
- Insufficient thought given to barriers to ICT use (outside the healthcare domain)
- Insufficient attention paid to the role of intermediaries in ICT for healthcare

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[40] ICT need not be computers and the Internet. In the case of HIV/AIDS, the most common source of information for laypeople, by far, was radio *(HIV/AIDS and Behavior Report*, June 2002, United Nations).

[41] Presented by W. Henry Mosley at the Washington Workshop.

[42] Adapted from *The Digital Pulse: The Current and Future Applications of Information and Communication Technologies for Developmental Health Priorities*; Chapter 1: State of Health ICT4D: Issues and Gaps by Communication Initiative (January 5, 2004).

Examples of Needed Research

ICT is already being integrated into modern healthcare systems, but ICT needs to be appropriately scaled for the provider at hand (who might be an semi-literate midwife).

1) Making healthcare information available and compatible with available hardware and communications technologies (e.g., cell-phones – as a hardware platform and communications means)
2) ICT solutions that are user-centric and user driven, and don't require ICT specialists to operate or maintain

Education

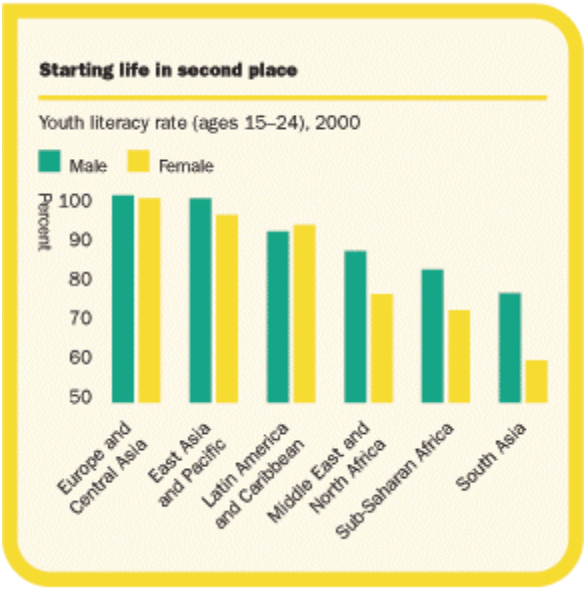
Overview

ICT can enhance education at all levels, but there is also a need for improved education for developing and improving ICT skills

Education has two components, basic education (literacy) and advanced (which may or may not include specialized or ICT training). Education highlights a number of divides, including gender (Figure 11). Much of the deliberations at the Bangalore Workshop were on basic education and eradicating illiteracy.

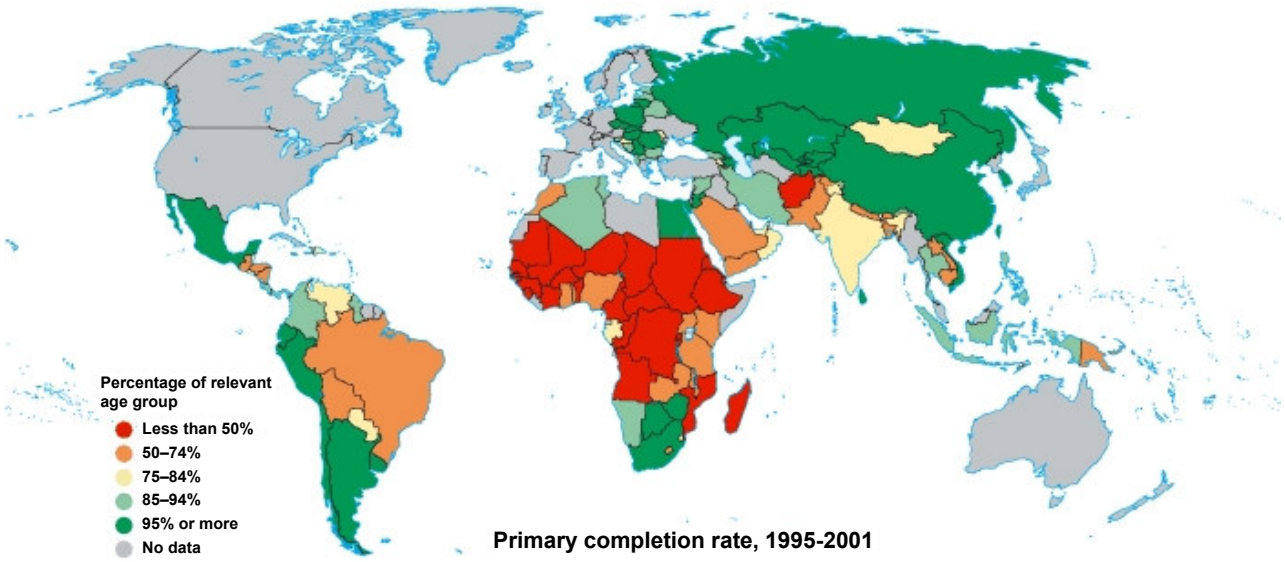
At present, over 120 million children are not in school. Many governments have statutes for universal basic education, but limitations of infrastructure prevent them from fulfilling this mission. In addition, families themselves face (and impose) constraints on sending children to school, especially girls (who are put to household and outside work). Efforts towards complementary development may have a strong "free rider" benefit in increasing school enrollments. In the Indian state of Himachal Pradesh, almost 100% of appropriate age children are in primary school. This was achieved not just by an increased budget for education but also by the government improving availability of piped water into villages and small sized bottled gas cylinders for cooking. This freed the children up from having to fetch water or cut down firewood for cooking. In the Indian state of Tamil Nadu, a midday meal scheme at schools drew in the large majority of children, and has even led to virtually zero population growth rate.[43]

[43] Demographers expected declines in fertility after a generation, as girls would go to school, become empowered, marry later in life, etc. To their pleasant surprise, families began having less children very soon, as the girls—who went to school in part for the meals—were no longer available as baby-sitters for the mothers, who have to work in the field.



Source : UNESCO and World Bank staff estimates

Figure 11a (above) and Figure 11b (below): Gender Education and Primary School Completion Inequalities. MDG 3 is to eliminate gender disparity in primary and secondary education, preferably by 2005, and to all levels of education no later than 2015.



Primary completion rate, 1995-2001

Source: Millennium Development Goals Website

Note: Western Europe, Australia, US and Canada all have nearly universal primary completion rates, making the map appear much more “green.”

Challenges

1) Universal literacy, including adult literacy
2) Increasing female education levels to parity, beyond just literacy concerns

3) Establishing vocational and technical education programs, with curriculum relevance for employability
4) Make contents rich, affordable and available at all levels of learning, including a Universal Digital Library
5) Make contents available in different languages
6) Develop computer simulated experiments in sciences for students to perform and learn
7) Develop and disseminate programs to help children with learning difficulties or physical disabilities
8) Assist and empower teachers and provide them with tools for providing quality education
9) Modernize curricula to be relevant and worthwhile for students
10) Establish standards and certification procedures for education

Barriers

1) Lack of adequate governmental budgetary provision for education and training
2) Lack of governmental support and encouragement for learning; no mandate for universal literacy supported through action and funding
3) Limited checks on student achievement or capability levels; poor enforcement of standards
4) Curricula that are outdated and provide limited value to students; inertia or vested interests preventing change
5) Lack of qualified and motivated teachers; few incentives for choosing teaching as a profession
6) Overworked and underpaid teachers who have no incentives, resources or time to devote to learning and then using ICT
7) Competing claims from families to withdraw children from school (e.g., working in the fields)
8) Mistaken belief that ICT can “fix” education on its own, leading to misallocation of resources

Measures for Success and Failure

1) Universal literacy, especially with meaningful measures (“functional literacy”)
2) Increasing employment for women
3) Well-trained workforce with hands-on (learning-by-doing) experience
4) Increase in teachers and funding for education
5) Ability for anyone to access any educational content at very little or no cost
6) Reflection of increased education through overall economic growth
7) Increased patenting and innovation from developing countries

Role of ICT

ICT can help education and literacy, as it has the technological prowess of extensive reach, and provides options to tailor the output to meet individual needs at anytime of his or her choosing. More than such conveniences, ICT can overcome some of the major handicaps inherent in conventional education. For instance, it can provide quality education with appropriate graphics and experimental presentations that are today available only in a few select urban schools; it doesn’t discriminate on the basis of

gender or income, and can be made available in any language. These characteristics of ICT enabled education are available at any level including for courses in practical training, adult education or continuing education. Government programs are often required to bring ICT to under-funded schools. Chile's educational reforms of the 1990s included integrating ICT, and the *Enlaces* program of providing computers, connectivity, and software now reaches over 90% of students in government-assisted schools.[44]

ICT should enhance or supplement traditional education, not replace it

ICT can be used to enhance education and supplement traditional education. ICT for education need not be real-time interactive or online; television, radio, and post have all played a major role in education in countries ranging from Australia to China (where 44% of higher education students in the 1980s were using radio or TV based distance education (in combination with post)[45].

Workshop Participants were unanimous that while ICT can enhance education, it isn't a quick-fix for the institutional shortcomings of many current educational systems. These include the obvious issues such as under-funding, lack of teachers, etc., but also deeper issues such as lack of specialized or customized education for underrepresented segments of society. Given resource constraints, it is important for educators and planners to coordinate efforts and learn from what works and what doesn't, both within and across borders.

ICT should not become an additional burden for teachers

One of the main issues relates to capacity building for educators. ICT should not become another burden, in fact, another divide, upon teachers. They need hardware, software, training, and connectivity. One special potential for ICT is to allow easier customization and specialization of content, especially geared towards special classes of underserved or disadvantaged users (gender, age, disabilities, etc.) In addition, ICT can help reach those outside formal school systems, such as through TV, radio, and videos. One challenge is incorporating such non-traditional delivery mechanisms into funded and certified educational programs.

While education, especially primary education, remains the responsibility of the state, there is significant evidence that people not only want better education than that often available in public institutions, they are willing to pay the private sector for such services. This raises not only equity and class issues, but issues of quality and standards. Governments should regulate or monitor such private providers, but, at the same time, support them when they play a complementary role. The NGO developers of *Tarahaat*, the pioneering rural consumer online portal and solution, found education to be one of their most demanded and viable offerings. This provides evidence that rural consumers are capable of benefiting from ICT enabled education and services.

Examples of Needed Research

1) National and international coordination on education, perhaps through an International Liaison Committee
2) Solutions for easy scalability of ICT, especially teaching the teachers
3) Development of appropriate content, with access and availability (this includes digital libraries)
4) Efficient feedback systems that make expert teachers and advanced learning available to all students

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[44] ICT and MDGs: World Bank Group Perspective, December 2003.

[45] ICT and MDGs: World Bank Group Perspective, December 2003.

e-Books and Digital Libraries

Carnegie Mellon, working with partners such as the Indian Institute of Science, is working on a Universal Digital Library project. The aim is to have online, with free access, one million books by 2005-06, and by 2020, have a large fraction of the world's books online. The global libraries have roughly 70 million unique books between them, in all languages (excluding journals and magazines), and the cost to digitize them is modest, ~$25/book—this is the cost to not simply digitize them as a picture but convert them to searchable text, that too in local languages.[46] The biggest bottleneck remains copyright, which is why the initial thrust has been on classics and other books out of copyright.

Most publications or media are not profitable (but a few are blockbusters), and many publications are out of print but still in copyright. One proposed model is for society to appreciate creative works and compensate authors in return for permitting open public access to their works. Libraries serve this function, but only a few countries like the UK have a compensation scheme to pay royalties to authors for lost revenues from free access to their books in libraries. If a government-funded payment scheme were to become universally accepted, we can create a global digital library that contains all out-of-copyright and out-of-print and out-of-money books, music and movies. This would lead to a win-win situation – the public would have access to works that would otherwise be inaccessible, and the author would have the pleasure of (and money from) knowing that his or her work is of value and relevance to society. A parallel model,[47] not mutually exclusive to public access models, would be for online digital publications to be an additional stage of publishing. Just like hardcover books are the most expensive (and released first), followed by paperback and then versions exclusively for sale in developing countries, "digitalback" versions could be offered at even lower prices, but after an appropriate delay of 6-18 months to prevent conflict with traditional sales.

Public funding of access to information is not a new idea. 100 years ago there were few public libraries. Until Andrew Carnegie made it a worldwide mission, a library as a "public good" was not widely acknowledged or acted upon. Today, it is estimated that global public spending on libraries is in excess of 40 billion dollars and that the US alone spends over 12 billion dollars annually in support of libraries. In the 21st century, since much of the information is likely to be digital and accessed via the Internet, it seems appropriate that an amount equivalent to the annual library expenditures should be set aside from public funds (perhaps gradually reaching parity over 25 years) to enable digital access to information and knowledge. But unlike physical libraries, where much of the costs are for buildings and people, in a digital library a significant portion of the funds (say 25%) could be set aside as royalty payments to authors and artists of creative works to be paid based on number of accesses rather than number of copies. The savings from not requiring as much physical space or maintenance might alone justify such a transition.

Basic Human Needs and Development – General Observations

In their daily lives, people recognize the need for information. Today, they mainly seek information as facts (prices, weather, etc.). From data we can extract information, and this can be analyzed and synthesized and, ultimately, we can achieve knowledge. Humans today perform these tasks using various modes of communication. In future some of these tasks can be done by machines, or at least humans aided by expert systems.

To foster such collaboration (and archive knowledge for future use) requires appropriately designed ICT that is available, accessible, and affordable. Across all the

[46] While there are several other large projects on digital libraries, CMU has a special focus on international languages and content.

[47] *Sustainable ICT for Emerging Economies: Mythology and Reality of the Digital Divide Problem – A Discussion Note (*2004). Raj Reddy, V. S. Arunachalam, Rahul Tongia, Eswaran Subrahmanian, and N. Balakrishnan.

domains for human development, appropriate content (dubbed “Content customization for cultural context” at the Workshops) requires innovations in ICT to make contents more inclusive for local stakeholders. Given infrastructural constraints, this might require solutions such as local caching and distributed storage. Even with governmental support, these activities would require new business models and creative financing to help sustain them. In addition to traditional participants (government, business, individual end-users, and philanthropists), collective ownership models (co-ops) or community systems were suggested as attractive models. These can also help empower women if they are targeted as stakeholders, a model used by the Grameen Bank and Grameen Phone in Bangladesh. Microfinance and affordable credit have been recognized as vital to helping ICT penetrate into underserved areas.

The Human Development Working Group proposed several activities over varying timeframes (Table 14).

Timeframe	*Activities*
2 Years	• Initiate several projects on customization
	• Foster courses targeted at ICT facilitators, etc.
	• Educate technologists about actual potential users and their behaviors
	• Educate potential users about the possibilities
	• Start to build the database of recent successful and failed case studies
	• Sensitize policymakers to issues
	• Initiate several projects on customization
5 Years	• Reports on existing deployments
	• Have graduated several advanced degrees in ICT for SD
	• Have established forum(s) where these issues are dealt with
	• Replication to other developing region(s)
	• Influence worldwide designs/processes
10 Years	• Products originate from developing (now developed?) communities
	• Customized content ubiquitous
	• Access to remote (geo and socially) regions
	• Government/private partnerships facilitate equity
	• Government seeds new ICT initiatives

Table 14: Action Plan and Activities – ICT for Human Development – Bangalore Workshop Working Group Recommendations

Economic Growth and Employment

Overview

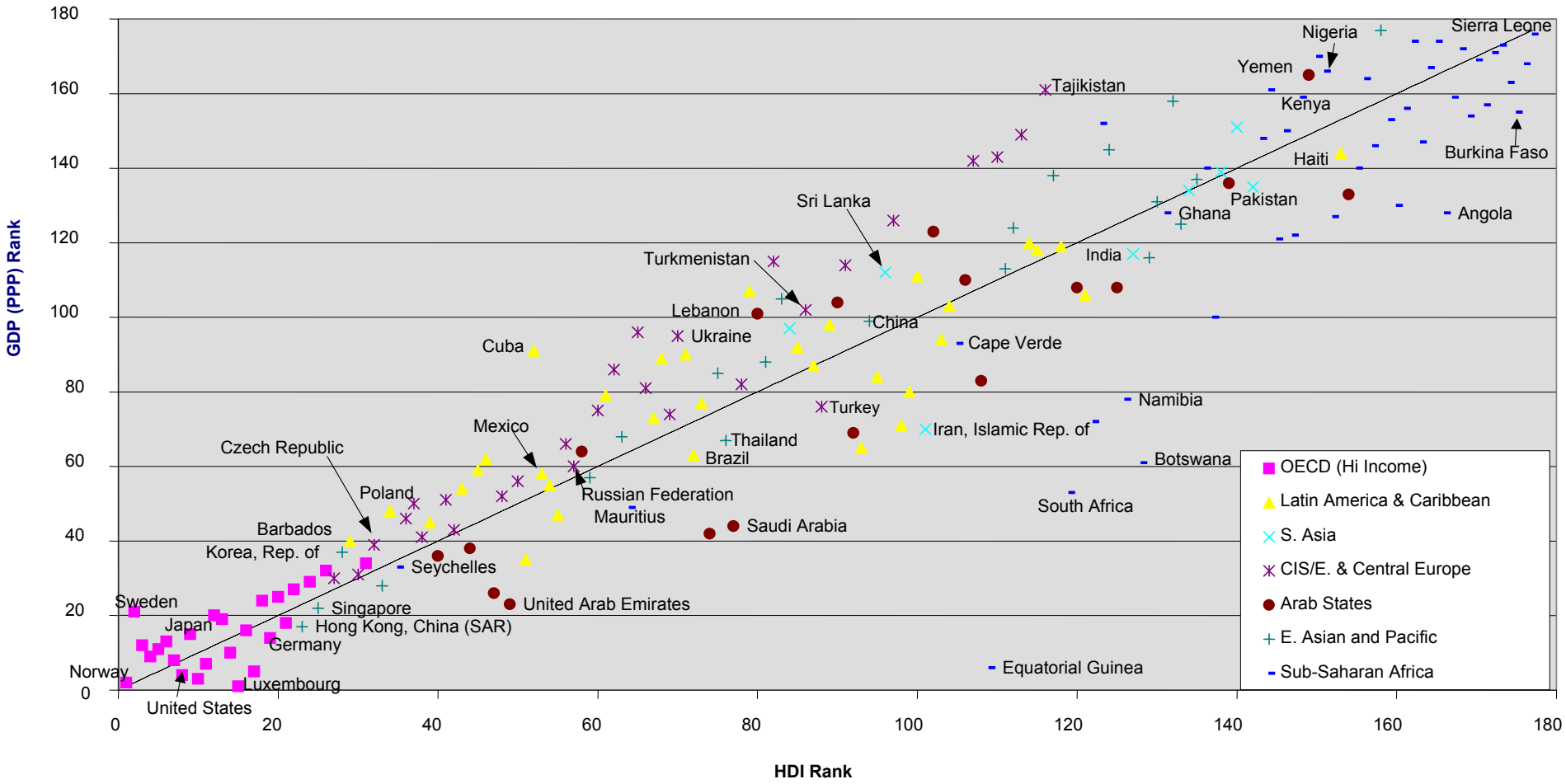
Economic growth is recognized as one of the key factors to improved quality of life, though the Human Development Index (HDI) doesn’t perfectly correlate with GDP (Figure 12). The differences become starker when we compare the variance within a region, but regions as a whole tend to follow the trend.

Distribution of wealth, captured by the Gini Coefficient,[48] provides one view of inequality, but such data as published rarely incorporate sub-regional granularity, or breakdowns paralleling other divides (gender, age, community, rural/urban, etc.)

While HDI has become an accepted metric for development, much of the attention of policy-makers focuses on economic measures, such as GDP. In addition to concerns over data accuracy and granularity, such measures fail to capture much of the activity in many developing regions, which occurs in the informal sector. One of the key challenges is to ensure that economic growth is inclusive and broad-based.[49]

[48] Gini Coefficient – a metric of income inequality based on the distribution of income by households or individuals. Its computation is based on shape of the Lorenz Curve, which plots the cumulative income by individual or household, from 0 to 100% of the population.

[49] One school of thought, captured in Kuznet's Curve, is that "development" (economic growth) will initially worsen income inequality, taking many years to stabilize and trickle down.



*GDP data is for 2002, PPP
Created from UNDP Human Development Report 2004 Data

**Country groupings are per Human Development Report 2004, except Turkey and Cyprus, which are bundled into CIS/E. & Central Europe

Figure 12: Difference Between HDI Rank and GDP (PPP) Rank. These are rankings only and cannot be compared between GDP and HDI. Higher numbers indicate poorer performance.

There are numerous studies that show the *correlation* between economic development and ICT or networking penetration. However, these do not necessarily show *causality*. If a group cannot pay for certain ICT, the facilities either require continuous subsidy, or fall into disuse. Data from the Sustainable Access for Rural India (SARI) project in Tamil Nadu, India, showed that with a 1% increase in earning, people increased ICT usage by 1.4%. It is unclear how much the increased ICT usage led to increase in incomes. Many reports or figures are only anecdotal or case specific, e.g., using ICT for crop price discovery.

ICT and economic development can be categorized into two categories:
[1] servicing and development of ICT technologies and industries such as call centers, back office services, hardware, software and process development, and [2] using ICT enabled processes and services to enhance efficiency, create more opportunities and generate new avenues for employment.

In terms of ICT Services (Type [1]), there is a backlash from developed countries against such offshoring—indeed it was an issue in the 2004 US presidential elections. In his Keynote Address, Joseph Stiglitz argued this fear is overblown, despite the vast labor pool in developing countries. One reason is the number of developed country jobs (especially ICT enabled or based) that are "contestable" today is a fraction of a percent of the employment needs. From a developing country perspective, this is a yet smaller percentage of the workforce that can find such employment. While India, Philippines, and even Ghana have had some success in ICT services for global (Western) needs, developing countries must expand their domestic markets to make ICT growth driven by local needs and opportunities, as Brazil has done.

The services sector is almost $^2/_3$ of the world economy, and is increasingly dependent on ICT

Even though the fraction of the population servicing the West through ICT may be small, the trickle-down and spin-off effects are significant. The developing country ICT professionals (typically young), whether they work in their native countries or abroad, interact closely with the West, absorbing part of its culture and some of the business practices as well. They, in turn, demand better quality services – from their governments and their private sectors. While the brain drain still continues to be relevant, there is a perceptible change with professionals from China and India returning to their own countries.[50] It remains to be seen whether the reverse brain drain grows not only in China and India but in other countries as well. This would depend critically on available opportunities, modernization of the infrastructure and business practices in developing countries.

An immediate and ultimately greater benefit from ICT may be in traditional industries, in increasing efficiency and competitiveness. Globalization, recent hiccups aside, is not slowing down, and developing countries can use ICT to become globally competitive, instead of becoming only importers of products. In addition to logistics and supply chain improvements, ICT can enhance transparency; corruption is cited as a major barrier to increased economic trade and output.

While the late 1990s saw increased hype over Business to Consumer (B2C) e-commerce, Business to Business (B2B) is roughly 95% of e-commerce.[51] While the split is not known for developing countries, given the lower penetration of computers with consumers, it is likely that businesses, government, and services (schools, hospitals, etc.) would be the major users of both computers as well as computer based transactions. In spite of this lack

[50] China has had the most success in bringing back its professionals after periods abroad—spanning most segments of the economy, not just ICT—with hundreds of thousands returning.

[51] E-commerce and Development Report 2003, UNCTAD (2003)

of local demand, businesses in developing countries are learning to use e-commerce for trading in developed country markets. While larger orders are now being executed through electronic exchanges or portals, some products (such as handicrafts) are being sold in the West through online marketplaces or auction services (equivalent to Ebay).

In many developed countries, the private sector, especially small and medium enterprises, are the engine for economic and employment growth. In contrast, most developing countries continue to have state-centered economies, with Government directly providing many services that in the West are often in the hands of private, but regulated, companies. While there is increased pressure for privatization and reforms, externally enforced reforms have rarely produced expected outcomes. At the Bangalore Workshop, Joseph Stiglitz summarized the lessons of East Asian and other rapidly developing economies where the role of government is at its best as an enabler, focusing on services such as infrastructure and education.

Almost all developing countries have created national Poverty Reduction Strategies under consultation with the World Bank. These documents have become the primary instrument for financing development by such agencies, increasingly to the governments directly instead of to the individual projects. Virtually no Poverty Reduction Strategy Paper by any country mentions the use of ICT in development or poverty reduction. Some development professionals feel this imposes limitations on financing ICT based or enhanced development or poverty reduction projects, at least until there is explicit discussion and introduction of such wording into these documents.[52]

Economic Growth and Poverty Reduction through Servicing ICT Industries [1]

Challenges

1) Develop human resources with appropriate skill sets for technology needs
2) Targeted training to use ICT to meet different cultural and social needs
3) Create appropriate organizational structures and business processes to benefit from ICT created opportunities
4) Develop appropriate governmental policies for transparent commercial practices and for creating fiscal incentives to enhance ICT opportunities

Barriers

1) Poor literacy levels, lack of opportunities and environment for universal secondary and affordable tertiary education in many regions of developing countries; poor quality of education and training, even which is unaffordable to a large population; lack of opportunities for continuing education and life-long training
2) Lack of institutions to train people for addressing local/regional needs, coupled with neglect of local needs by industry
3) Brain drain of talented people to urban areas and developed countries
4) Absence of business intelligence units to inform of opportunities and provide linkages
5) Lack of tradition/experience in running businesses that interact globally
6) Lack of governmental experience in nurturing ICT industries with appropriate fiscal incentives
7) Concerns in developed countries over loss of jobs to developing countries (outsourcing)

[52] UN ICT Task Force Global Forum deliberations, Dublin, Ireland, April 13-14, 2005.

Measures for Success and Failure

1) Increase in the share and growth of ICT and related services in the economy
2) Creation of governmental programs and incentives for ICT education and other relevant areas for ICT enabled growth such as e-commerce
3) Increased use of appropriate standards for ICT enabled services
4) Establishing a number of training as well as collaborative programs in ICT both within the country and abroad (developing and developed countries)
5) Bottom-up demand for ICT based services for local and domestic needs

ICT Enabled or Enhanced Employment Generation and Poverty Reduction [2]

Challenges

1) Identify areas to utilize if not substitute IC technologies in business and government processes to improve the reach, volume and quality of services, and minimize transactions costs. This especially applies to agriculture, which employs the largest fraction of the world's population
2) Develop new opportunities for meeting local needs
3) Identify new avenues for ICT that substitute mass production by catering to individually customized needs (mass customization)
4) Develop new business models and processes to harness the opportunities in the global market place
5) Identify opportunities that substitute labor-intensive production by computer controlled/technology based processes, taking note of the local genius of the people. This extends to reduced use of natural resources
6) Provide appropriate financial services and tax incentives to promote entrepreneurs focused on the local/regional/domestic economy
7) Eliminate gender and other disparities in training, employment, and opportunities
8) Improve transparency in economic transactions and culture of awareness for the need for transparency

Barriers

1) Ignorance of new ICT opportunities in various areas of the economy
2) Scarcity of people trained in ICT and business opportunities
3) Lack of affordable and adequate infrastructure; poor planning for its growth
4) Governmental lethargy to change existing structures and rules of business to quickly respond to innovators needs
5) Fear of unemployment and objections by vested interests
6) Absence of incentives for change
7) Absence of independent investor community and regulated financial institutions
8) Geographically and otherwise uneven development and opportunities
9) Barriers to free and equitable global trade
10) Globalization that is asymmetric, leading to "winners take all" economies

Measures for Success and Failure

1) Increase in number of areas and organizations using ICT enabled services in all areas of human development and economy

2) Greater global competitiveness of developing countries and improved economic and human development
3) Scalability and transferability of ICT enabled sustainable development projects
4) Increased number of people in the formal sector of the economy
5) Improving the quality of education at all levels from primary to tertiary with attention paid to local contexts and needs
6) Increased capital generation for development and infrastructure from the economy
7) Increased level of credit availability across socio-economic classes, extending to foreign direct investment as required
8) Increased access of modern amenities and infrastructure
9) Increased use of transparent services and increase in level of use and types of transparent transactions
10) Increase in IPR filing from developing economies
11) Economic intelligence sharing in developing countries, with reliable data

Role of ICT [1&2]

- Creation of new hitherto new industries and sources of employment
- Increasing the competitiveness of existing and traditional industries
- Providing an equitable balance to globalization
- Reduce transaction costs and related burdens on the population, freeing them to undertake productive activities

Examples of Needed Research [1&2]

1) Training packages for ICT education, for all levels of users
2) Increasing interconnectivity to and within developing countries (through new technologies such as wireless) – to allow ICT and ICT enabled/enhanced services to flourish
3) Improving software, hardware, and their integration so that solutions are robust, easy to use and maintain, and have low total costs of ownership.
4) Solutions for low-cost and secure money transfer; corresponding systems for financial credit and risk management

Alienation, Empowerment, and Governance

Alienation Issues and Empowerment [1]

Overview

The 20th century saw dramatic changes in social institutions and hierarchies, and technologies that shrank distances were cited as a major factor. While in the past this was transportation, it is now instantaneous communications technologies driving such changes.

ICT has been described as a great equalizer, if not a democratizer

ICT can be a powerful means for empowerment, especially for women and minorities. Earlier technologies for information dissemination, such as the radio, were extensions of traditional information networks, with a centralized "authority" spreading information. The Internet can fundamentally alter this balance of power, allowing new and multiple layers of interactions between individuals and groups. Giving stakeholders a voice is more than a manifestation of empowerment. It also relates to participation and efficiency – many people are outside modern service delivery systems, and they often don't know their rights or what is meant to be available from public and private providers.

Lack of empowerment and opportunities can be a driver for alienation, which might result in increased anti-social tendencies. This is a particular challenge considering most developing countries have a population pyramid with a very large number of youths, who can learn of and perceive greater disparity than ever before due to ICT and the media.

However, the more chronic issue than extreme alienation is the subtle alienation of many segments of the population, especially as relates to issues of identity and diversity. There are many cultural divides, such as gender, rural/urban, religion, age, etc. Exacerbating this is the very large increase in migration, both within and across countries, especially from developing countries to developed. International migration and changes in population makeup themselves are driven by underlying demographic changes. Not only is the population growth rate of many OECD countries very low, within these the immigrant communities often have high birth rates, at least for one generation. If we consider the various dimensions of disempowerment and alienation, the exclusion is often not explicit, but places one group at a social, economic, religious and political disadvantage. One example is the unavoidable integration faced by many communities (Table 15).

Region or Group	Number of spoken languages	Population with access to education in mother tongue in 2000	Total population (millions)
Sub-Saharan Africa	2,632	13%	641
East Asia and the Pacific	2,815	62%	1,918
South Asia*	811	66%	1,480
Central and Eastern Europe and the CIS	625	74%	409
High-Income OECD	1,299	87%	912
Latin America and the Caribbean	1,086	91%	530

Source: "Human Development Report 2004 – Comments and Contributions from SIL" (2004)

* Editors' note: South Asia has many more languages and dialects than indicated—India alone cites some 2,000—but many might be geographically limited or considered similar enough to be amalgamated.

Table 15: Population Lacking Access to Primary Education in their Mother Tongue

The UNDP Human Development Report 2004 extensively deals with the issue of cultural liberty, laying to rest several myths regarding cultural identity, peace and development:

- *Myth 1*. People's ethnic identities compete with their attachment to the state, so there is a trade-off between recognizing diversity and unifying the state.
- *Myth 2*. Ethnic groups are prone to violent conflict with each other in clashes of values, so there is a trade-off between respecting diversity and sustaining peace.
- *Myth 3*. Cultural liberty requires defending traditional practices, so there could be a trade-off between recognizing cultural diversity and other human development priorities such as progress in development, democracy and human rights.
- *Myth 4*. Ethnically diverse countries are less able to develop, so there is a trade-off between respecting diversity and promoting development.
- *Myth 5*. Some cultures are more likely to make developmental progress than others, and some cultures have inherent democratic values while others do not, so there is a trade-off between accommodating certain cultures and promoting development and democracy.

Governance and e-Governance [2]

Overview

Governance occurs within a framework that is both formal (legislated/statutory) and implicit (socio-cultural norms). In addition to "good governance" citizens require complementary support from an independent judiciary, a free press, land reforms, etc., and also seek a greater say in their future (democracy).

E-governance is a much talked about application of ICT, and it holds great promise. One aspect of e-governance is the computerization of government activities, both for internal efficiency and for increasing the ability of citizens to receive information, especially under a "single window." Computerized land records in parts of India, e.g., the *Bhoomi* project, have reduced the costs of transactions down to cents, instead of the many dollars (and days) citizens used to spend before. A second and related aspect is the establishment of linkages and connections between citizen-government as well as citizen-citizen. This means not only can they receive a particular form or document with ease, they can also participate in decision-making and provide feedback to the government.

E-governance faces many difficulties, and, though project success rates might have improved over time (and there is enormous variance between countries), as per one study as low as only 15% of e-government for development projects succeed,[53] with little post-project analysis or contribution to the state of knowledge. At the Washington Workshop, several developing country participants spoke about their lack of infrastructure—even as senior government officials, they lacked appropriate hardware or a government intranet. Even if there were hardware, the data (content) is not computerized. Implementing such changes requires not only resources, but also a willingness to share information and accept transparency as an essential element of good governance.

Governments should continue with appropriate e-governance programs even if their citizens have limited ICT access

As is the case with e-commerce, e-governance is also limited by infrastructure, especially amongst end-users. It is interesting to compare what the Government's e-governance efforts are, independent of end-user facilities (Table 16). We can note that several Latin American countries (especially Chile and Mexico) score highly in e-governance ratings. One takeaway would be for governments worldwide to continue their e-governance programs, without waiting for citizens to become wired and ready to demand such services.

[53] "Most eGovernment-for-Development Projects Fail: How Can Risks be Reduced?" John Heeks (2003). Institute for Development Policy and Management, University of Manchester, Working Paper 14.

In fact, the desire of citizens to avail of improved government and social services can become the so-called "killer app" driving demand for ICT. However, ICT-based efforts must not come at the expense of traditional service delivery mechanisms, considering the majority of citizens still lack ICT access.

E-Government Readiness Index[a]			Web Measure Index[b]			E-participation Index[c]		
1	United States	0.9132	*1*	United States	1.0000	*1*	United Kingdom	1.000
2	Denmark	0.9047	*2*	United Kingdom	0.9730	*2*	United States	0.934
3	United Kingdom	0.8852	*3*	Singapore	0.9691	*3*	Canada	0.902
4	Sweden	0.8741	*4*	Republic of Korea	0.9459	*4*	Singapore	0.836
5	Republic of Korea	0.8575	*5*	Denmark	0.9344	*5*	Netherlands	0.803
6	Australia	0.8377	*6*	Chile	0.8842	*6*	Mexico	0.770
7	Canada	0.8369	*7*	Canada	0.8726	*7*	New Zealand	0.770
8	Singapore	0.8340	*8*	Australia	0.8301	*8*	Republic of Korea	0.770
9	Finland	0.8239	*9*	Finland	0.8069	*9*	Denmark	0.738
10	Norway	0.8178	*10*	Germany	0.7954	*10*	Australia	0.672
11	Netherlands	0.8026	*11*	Mexico	0.7838	*11*	Estonia	0.639
12	Germany	0.7873	*12*	Sweden	0.7722	*12*	Colombia	0.623
13	New Zealand	0.7811	*13*	Belgium	0.7722	*13*	Belgium	0.607
14	Iceland	0.7699	*14*	New Zealand	0.7413	*14*	Chile	0.607
15	Switzerland	0.7538	*15*	Malta	0.7375	*15*	Germany	0.590
16	Belgium	0.7525	*16*	Netherlands	0.7181	*16*	Finland	0.574
17	Austria	0.7487	*17*	Estonia	0.6988	*17*	Sweden	0.574
18	Japan	0.7260	*18*	Austria	0.6988	*18*	France	0.459
19	Ireland	0.7058	*19*	Israel	0.6911	*19*	Malta	0.459
20	Estonia	0.7029	*20*	Norway	0.6873	*20*	Austria	0.443
21	Malta	0.6877	*21*	Ireland	0.6564			
22	Chile	0.6835	*22*	Argentina	0.6429			
23	Israel	0.6805	*23*	Columbia	0.6409			
24	France	0.6687	*24*	Brazil	0.6371			
25	Luxembourg	0.6600	*25*	Japan	0.6293			
	Average	0.7798						
	World Average	0.4127						
	North America	0.8751						
	Europe	0.5866						
	South and Eastern Asia	0.4603						
	South and Central America	0.4558						
	Caribbean	0.4106						
	Oceania	0.3006						
	Africa	0.2528						

Source: UN Global E-Government Readiness Report 2004: Towards Access for Opportunity

[a] Measure of e-governance readiness spanning users, infrastructure, and government's on-line activity

[b] Similar to [a] but excludes access measures (thus more a function of government actions)

[c] Measure of "usefulness" of e-government services and how frequently they are available

Table 16: E-government Readiness Indices 2004. The Chilean Government does well in offering e-governance, independent of relatively lower connectivity, and Mexico's citizens find value from the available e-government services.

Challenges [1&2]

1) Increase transparency in governance; reduce transaction costs
2) Enhance citizen participation (local and national policy making, Elections and polls), reducing vagaries of the process and opportunities for manipulation or biasing
3) Reduce the Digital Divide (geographic, socio-economic status, age and gender)
4) Allow for open discussion of governmental goals, strategies, targets and processes
5) Foster free, fair, and enlightened media
6) Increase co-ordination among local/regional/national government agencies
7) Develop appropriate legal systems to legitimize ICT enabled services
8) Allow migration paths and hybrid systems that maintain consistency between electronic and physical information (such as records)
9) Ensure security and privacy of information

Barriers [1&2]

1) Governmental inertia against innovation, modernization, or adapting
2) Presence of vested interests interfering with government and other institutions effecting changes
3) Lack of infrastructure and support systems within the Government and for access by end-users
4) Lack of access to relevant information in local and regional languages
5) Rapid obsolescence of hardware and software products resulting in high costs and continual retraining; incompatible and non-integrated ICT platforms
6) Deployment of technology or other changes without an integrated assessment of the relevant issues and opportunities
7) Lack of transparency in governmental transactions
8) Lack of a legal framework for ICT based commerce and governance
9) Lack of communications or common base between bureaucrats, technologists and customers of ICT services that hinders collaboration
10) Limited democratization of information dissemination

Measures for Success and Failure [1&2]

1) Democratization of information dissemination
2) Increased voter registration/participation in polls and reduction in voter fraud
3) Increased participation of women in all sectors of human and economic development
4) Inclusiveness of persons with disabilities and functional illiterates
5) Increased involvement of young people in education and services
6) Increased delivery of Government services online (local, regional, and national services)
7) Increased efficiency (time and quality) of government services
8) Greater availability and use of ombudsmen to all sectors of society to ensure good and fair governance
9) Increased level of IT education among bureaucrats
10) Enhanced number of communities connected by knowledge networks for economic and human development

Role of ICT [1&2]

- Increasing connections between citizens and citizens to institutions (including the government)
- Improving governance through streamlined, hassle-free interactions, with transparency in decision-making
- Providing a voice for the underrepresented and alienated

ICT can be an equalizer, making more people producers of content and information than mere consumers. With a little effort, this can include minorities and other underrepresented segments of society. This fundamental shift in terms of who can impart information requires building awareness among the population, who in many regions today receive their information from limited sources (because of media consolidation and/or governmental control).

ICT can also help in *rapid* dissemination of information (warnings) under emergency or disaster conditions, such as probable earthquakes, storms, or floods. While some of this is done today through television and radio, purpose-built systems have been proposed, especially for location-specific scenarios, such as Tsunamis.

Examples of Needed Research [1&2]

1) IT solutions that can facilitate and integrate all levels of data collection, storage, analysis, and dissemination – ranging from large (governmental) to micro (grassroots) systems
2) Technologies to maintain and enhance privacy and control over personal information

ICT for SD – Linking Needs to Solutions

The integration of ICT into all aspects of human activity is inexorable. Governments, service providers, and companies are adopting such technologies, often unbeknownst to their end-users or clients. What was decades ago the wondrous act of listening to voices from miles away (radio) has become replaced by even children accepting (and demanding) instantaneous interaction at almost any location (mobile telephony). The challenge for professionals is to link ICT to specific human and economic development needs, as was attempted in the Workshops. Table 17 summarizes the Workshop findings and recommendations for ICT research as linked to development needs.

Thematic Area	Group/Sub-Group	Development Need	Key Recommended Research	*Primary ICT Mapping:* Sensors (S) Communication (C) Databases/Information Systems (DB/IS) Controllers/Actuators/ Effectors (CTRL) Human-Computer Interaction (HCI)
Infrastructure	Water	Better models and assessment of supply and quality	Low-cost sensors; GIS models, data dissemination solutions, and integration into user frameworks	S, C, DB/IS, HCI
	Energy	Improved measurement, theft-control, and control (including demand-side management)	Tamper-proof digital electricity meters with control and communications, with integration into efficient end-use appliances for load control	S, C, DB/IS, CTRL
	Transportation	Optimization of public and private transport along with enhanced safety (e.g., trains)	Integration of sensors, GIS, GPS, and other technologies	S, C, DB/IS, HCI
Basic Human Development	Food and Agriculture	Optimize inputs to the soil and improve productivity; Improve farmers' stake in the supply-chain	Sensors and Information Systems for optimizing irrigation [e.g., drip irrigation], fertilizers, pesticides, etc.; developing accessible and affordable solutions for access to market, weather, and other information	S, C, DB/IS, CTRL, HCI
	Healthcare	Improve delivery of healthcare services; make systems more participatory	ICT solutions integrated with existing systems; develop easy-to-use and robust interfaces and platforms	C, DB/IS, HCI
	Education	Improve literacy and student skills; meet varying needs of different levels of students (age, gender, specialization, etc.)	Easy-to-use and scalable solutions for education; customized content and delivery systems, with feedback	C, DB/IS, HCI
Economic Growth and Employment	ICT-based and ICT-enabled job creation and poverty reduction	Improve awareness and skills in ICT; integrate ICT into economic activity; create solutions for low-cost money transfer, (micro)credit, and risk management	Easy-to-use and scalable solutions for education; (open) easy-to-implement standards for ICT integration; secure, flexible and inexpensive systems to manage and move money	C, DB/IS, HCI
Alienation, Empowerment, and e-Governance	Alienation issues and empowerment; e-Governance	Easier sharing of information (within norms of privacy and individual control)	Solutions that make it easy to create, monitor, search, and apply information, while maintaining end-user privacy and control	C, DB/IS, HCI

Table 17: Mapping of Development Needs to R&D Requirements in ICT, Based on Bangalore Workshop Deliberations