ICT and knowledge framework for sustainable development

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Abstract *During the last 15 years, there have been numerous global programs for development supported by international bodies. However, the world is still undergoing inequality and slow human welfare development, or even, in some countries, reversal in human development. In this paper, causes for unsustained development are analyzed using the Fishbone Diagram. The analysis shows that - other than political crisis, warfare, and international tensions - unsustained development may be attributed to more than one cause. Strategic planners in ICT fields and in other development fields are almost working separately. Many ICT applications for development are not scaled-up according to preset national strategies and action plans. The ICT applications are of similar nature in developing countries, while their culture, social, economic, infrastructure, and institutional themes are different. Most important is the under-estimated human dimension in its broad definition, such as insufficient human knowledge, particularly the conversion of tacit to explicit knowledge, and culture resistance. Recognizing this, the paper presents a framework based on knowledge (taking into consideration tacit type) and online learning for sustained development. The proposed framework integrates human capital with ICT to overcome the obstacles of sustained development in developing countries.*

Introduction

For development to be sustained, it must integrate environmental, economic development and the well-being of all people, not just for today, but also for countless generations to come. This is the challenge facing governments, non-governmental organizations, private enterprises, communities and individuals (IISD, 2005). The "Theme Indicator Framework" of CSD (Commission of Sustainable Development of the United Nations) is classified into four areas. Each theme is subdivided further into subsystems, and indicators are assigned to each of these subsystems, with 57 indicators (CSD, 2005). Only two indicators of Information and Communication Technology (ICT) are incorporated, i.e. information access and communication structures in the institutional theme. The human role is bounded to education level and literacy indicators in the education theme. Knowledge is expressed by expenditure on R&D, only in the institutional theme. It is more likely that the weight of human capital is underestimated as a prime drive force in sustainable development. Although education level and literacy is necessary indicators for sustained development, yet it is believed that they are not sufficient. In addition, there is a strategic and policy gap between the ICT and Sustainable Development.

The potential and role of ICT as a tool for contributing to development is limitless and well established. It is accepted that ICT supports the neural system of complex societies and can benefit various fields of development (Sandro M. R., 2002), especially with the global trend of rapid growth of people accessing the internet (information access), number of websites (more information) and at fast declining cost (HDR, 2001). Though there are considerable researches and initiatives on utilizing ICT for sustainable development on national level, yet it was almost focused in already developed countries, such as the NII in USA [1], Europe 2002 and 2005[2], and e-Japan [3]. On the other hand, there are some pilot ICT projects and researches for development in developing countries. Examples are: Sustainable Development of Local Content using ICT, Using ICT for Poverty Reduction and Environmental Protection, Gender Gap in the IS for Economic and Social Sustainability, Capturing Grassroots Voices in the IS and SD Policy Dialogue, Socialization of Knowledge and Reduction of Regional inequality, GIS to Support Natural Resources (Willard and Andjelkovic, 2005). Other examples are, IR Telemetry for Data Acquisition & Tele-control in Automatic Irrigation Scheduling in Arid Region (Al-Amoud, 1989), and Air Conditioning in Arid Zones using Dual Absorption Solar system without Cooling Water (Sofrata H., 1983). The used ICT tools are the internet, computers, databases, communication, sensors, relays and actuators, and information system.

The Problem of the Current Sustainable Development

Since 1990, there have been numerous global programs for development from international bodies such as, UNDP, United Nations Division for Sustainable Development, WSIS, and recently the

Millennium Development Goals (HDR, 2003). However, during the last 15 years, the world is still undergoing inequality and slow human welfare, even reversal in human development. Figure (1) illustrates this trend by the trend of the Human development index (HDI) over the period from 1975 to 2003. This HDI is a composite index measuring the average achievement in three basic dimensions- a long and healthy life (measured by life expectancy, knowledge (measured by adult literacy and gross enrollment ratio) and decent standard of living (measured by GDP per Capita), (HDR 2005). The gap in technology diffusion and creation (HDR, 2000-2005), and in Science and Technology is still wide and persevered between low and high-income regions. For example, during the period from 2000 to 2003 the sustained gaps are about 22, 65, and 17 times in fixed and mobile phones subscribers, personal computers, and internet users, respectively. The number of researchers and scientific and technical journals are negligible in low-income region if compared to high-income region (World Bank Development Indicators, 2005).

The trend in human development shows a retreat in some countries. Crisis of income poverty, hunger, survival, water, sanitation, education, literacy are sustained for years. For example, in 2000, out of the 6.1 billion world population, about 19% lived on less than poverty line [4] (mostly in Africa and Latin America), which does not change much in 2005. Child mortality is the highest in Africa (about 20%) and it remains almost the same as 25 years ago, while poverty has increased. Youth illiteracy varies considerably as low as about 0.2% in Central and Eastern Europe and the Commonwealth of Independent States, any of the former Soviet Republics (CIS), to about 30% in Sub-Saharan Africa (HDR, 2005). The pilot programs and researches in developing regions did not scale-up to be sustained. Deteriorating indices of development, increasing inequalities, disparities in incomes, shrinking sources of livelihood, increasing poverty, escalating conflicts, and inter- and intra-state violence cannot be ignored in hindering sustainable development (SDPI, 2004). Warfare is inherently destructive of sustainable development. Promotion of peaceful settlement of dispute is therefore an important contribution to sustainable development (WSSD, 2002). It has been reported that there is a real danger that the next 10 years, like the last 15 years, will deliver far less for human development than has been set by the Millennium Goals (HDR, 2005).

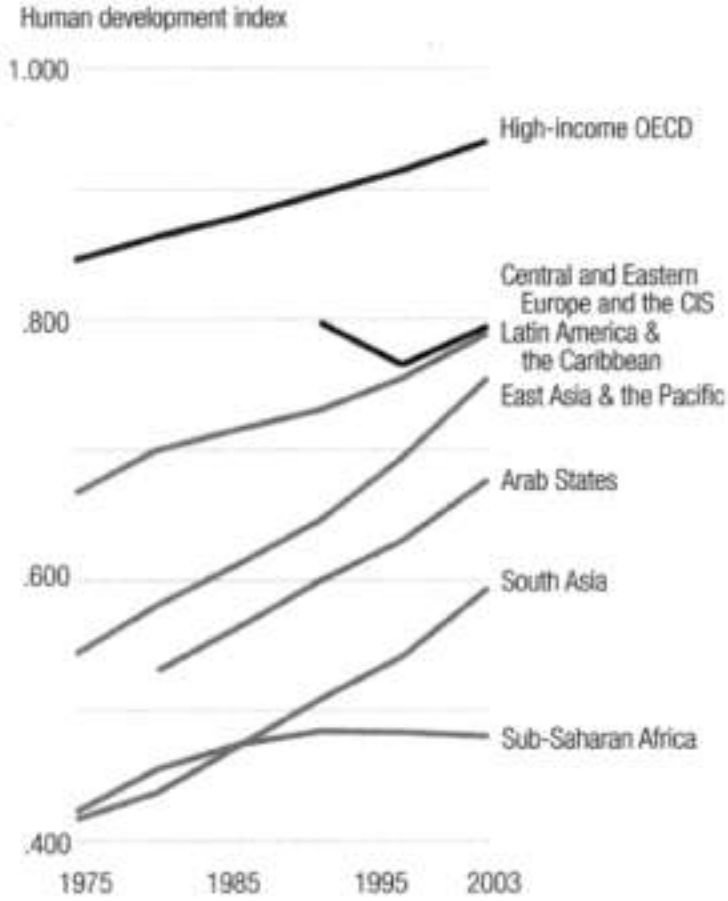

Figure 1. Gap and reversal of human development index (HDR, 2005)

Therefore, recently, the World Summit on Sustainable Development (WSSD, 2002) and the first phase of the World Summit on Information Society (WSIS, 2003) brought the challenge of ICT for sustainable development internationally to include the developing countries for linking policies in

both areas of ICT and sustainable development. The second phase of WSIS (WSIS, 2005) called upon the international community to promote the transfer of technology (including ICT) on mutually agreed terms. It also asked for adopting policies and programs with a view to assisting developing countries in efforts to bridge the digital and development divides.

The problem of the unsustained development in developing countries may be attributed - other than political crisis, warfare, and international tensions - to the following causes illustrated in Figure (2):

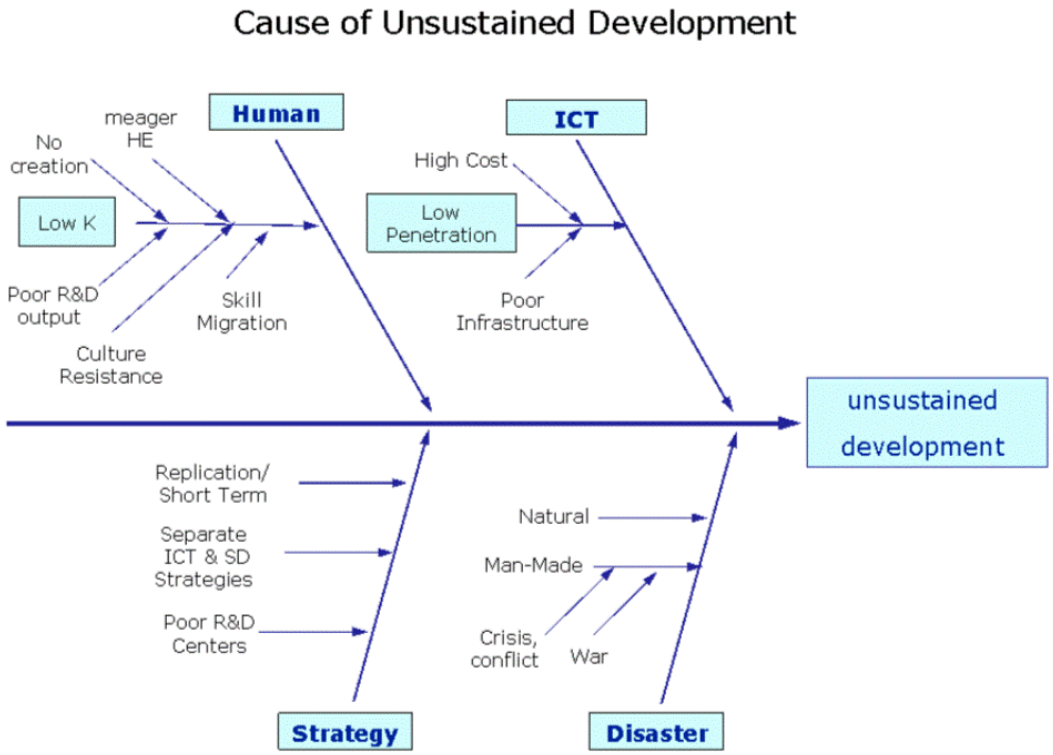

Figure 2. Study of the problem of unsustained development to determine the root causes using the Fishbone Diagram (Kauro Ishikawa, 1986)

1. Strategy: Strategic planners in the fields of ICT and development are almost working separately. Almost many ICT applications for development are not scaled-up according to preset national strategy and action plan. The ICT applications are replica from the developed countries, while the culture, social, economic, infrastructure, and institutional themes are different.
2. ICT: Low penetration.
3. Human: Lower human knowledge, and culture resistance.

The internet is a powerful and enabling tool to promote knowledge acquiring (education and continuous learning) and creation (R&D). Low penetration of the ICT is attached to either poor infrastructure and/or higher cost of services. It has been observed that the number of internet users increases significantly with the decrease of the cost of connections to the internet (OECD, 2002), this is illustrated Figure (3). It is believed the building human capacity of individual through creating and utilizing knowledge (in its wide-ranging definition, i.e. neither just formal education nor learning) is an influential factor in stainable development, which has been overlooked so far. The issues of culture resistance to share tacit knowledge and personal independence are complicated and difficult to measure, since it involves social and physiological elements.

Knowledge for Sustainable Development

The World Bank has developed a framework for knowledge Assessment (KAM) consisting of four pillars to help countries asses their Knowledge Economy Index (KEI) or Knowledge Index (KI) and therefore can articulate strategies for their transition to a knowledge society (World Bank, 2004):
1. An economic and institutional regime that provides incentives for the efficient use of existing and new knowledge and the flourishing of entrepreneurship.
2. Educated and skilled populations that can create, share, and use knowledge well.
3. A dynamic information infrastructure that can facilitate the effective communication, dissemination, and processing of information.

4. An efficient innovation system of firms, research centers, universities, consultants and other organizations that can tap into the growing stock of global knowledge, assimilate and adapt it to local needs, and create new technology.

Figure (4) depicts the KI by regions for most recent data versus the data of 1995, which shows unnoticed improvement in most developing countries. The selected key variables for the KI pillars are:

- Innovation (researchers in R&D, patent applications granted by US Trademark and Patent office per million population, and scientific and technical journal articles)
- Education (adult literacy rate, second enrollment, and tertiary enrollment).
- Information infrastructure (telephone per 1,000 people, computers per 1,000 people, and internet users per 10,000 people).

Knowledge is not confined to education only, yet knowledge may be defined as facts or ideas acquired by study, investigation, observation, or experience of human nature. Information is data provided with significance and purpose, while knowledge is required to convert data into useful information (Drucker, 1994). Education or learning applies to knowledge acquired especially through formal, often advanced, schooling. Learning lessons from Newly Industrializing Economies (NIE), such as Korea, India, China, and Finland, shows a common feature, which is strategic objective of building human capital through knowledge. It includes - but not limited to - innovation, R&D centers, higher education, and think tanks.

Analytical models on knowledge and endogenous growth showed that knowledge is the main engine of economic development. The models explained that long run growth rate of an economy is proportionate to the growth rate of human capital.

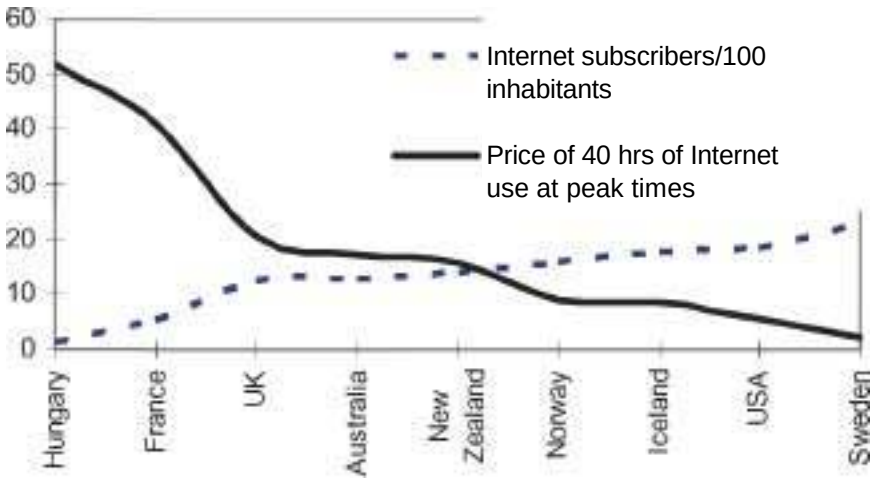

Figure 3. Lowering the cost[5] of internet connection will increase the internet users (OECD, 2002)

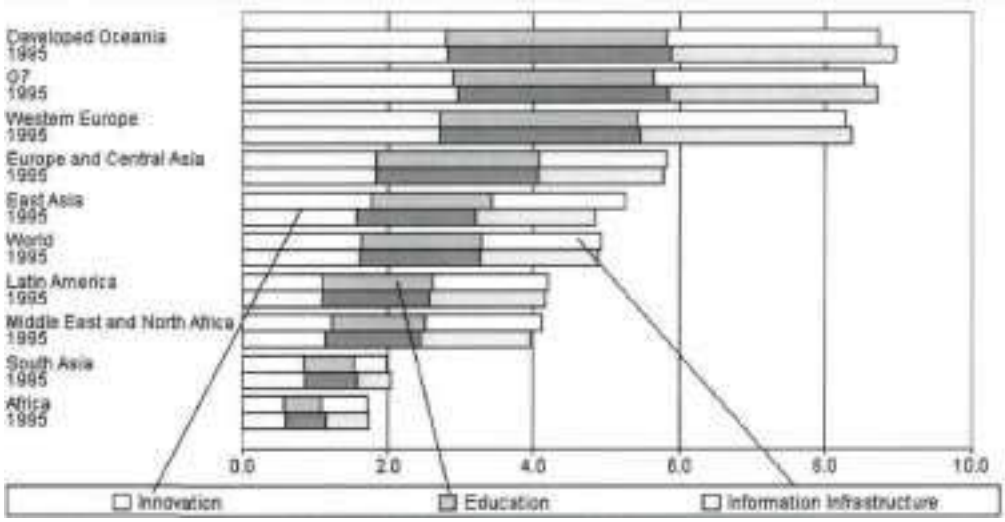

Figure 4. KIby regions: most recent data viz. 1995 (World Bank, 2004)

This is consistent with the experience of NIE, where education and R&D sector were developed tremendously to accumulate knowledge from within. Moreover, it has been confirmed that the augmented flow of information and knowledge, because of the enhancement in ICT infrastructure, allows the efficient production of innovation (Derek H. C, Chen, and Hiau Looi Kee, 2005). The large gaps between low and high HDI ranking regions were usually attributed to an indicator of structural inequalities that block the transmission from wealth creation to human development **(**HDR**,** 2005). However, it is believed that structural inequalities are not only the cause, but knowledge capital contributes largely to human development. For example, Guatemala has almost double the average income of Vietnam and about 1.5 times India, but exhibits a lower HDI. The similarity in Knowledge index with different income emphasizes the role of knowledge in human development.

In the 21st century, "knowledge", not the classic labor, raw material, or capital, becomes the corner stone of a new economy, knowledge, and competitiveness. Employment is moving fast from manual and clerical workers to knowledge workers who resist the command-and-control management that business took from military 100 years ago (Drucker, P. E., 1988). Knowledge, not labor, material, or capital, becomes the key resource and policy for solving social and economic problems (Drucker, P. E., 1994). The growing value of knowledge has created both a challenge and an opportunity for developing countries to help them achieve long-term goals. If properly adapted to circumstance and effectively deployed, knowledge can be a key driver of sustained development. Knowledge has two dimensions, the tacit (embedded in human minds, self-experiences, perceptions...etc) and explicit knowledge (embedded in documents or repository). Knowledge creation is a spiraling process of interactions between explicit and tacit knowledge. Organization and individual's culture plays an important role in making tacit knowledge explicit (Polanyi, M., 2004). To realize the strategic resource of knowledge, conversions between tacit and explicit knowledge may be realized using different "Ba" of the SECI [6] model (Nonaka I., and Konno N., 1998). "Ba" is a Japanese word for place, space, or field. In this context, it refers to physical, mental, virtual relationships in which knowledge is created, shared, utilized, and stored. It may take many forms, Table (1). One form of the "Ba" is the Learning Organization (Marqurdt, M.J, 2002), where adaptive learning is joined by generative learning. Another form of implementing "Ba" may be office spaces, teams, communities, forums, human networks, shared experiences and so on.

Type of "Ba"	Description
Creative	Relatively informal sharing of experiences.
Interactive	Discussion in a meeting room.
Systematic	Relatively formal mapping out strategy by different groups using IT.
Practical	Community programs where participants are involved in knowledge work while learning.

Table 1. Types of "Ba"

Proposed Framework

Figure (5a and b) summarizes a proposed framework for making development sustainable, where a general high level is viewed in (a) while the sub-issues are detailed in (b) . The framework does not replace other themes, but it is an augment. The framework emphasizes the knowledge resources of the human capital, which has been overlooked in the studies of sustainable development. The problem of tacit knowledge is complicated since it involves human culture, which may resist collaboration in converting tacit knowledge to explicit knowledge for utilization in the development plan. In addition, problems facing knowledge growth are the migration of talent and Diasporas of highly skilled workers to from developing to developed countries.

These risks may be reduced by non-technical means, such as social and psychological studies, or by committed leadership to the long-term strategies, or revision of the environment that expels knowledgeable skills. A flourished ICT is imperative enablers or every component of the framework. This requires both extensive education on using ICT from the early levels and obligatory continuous life long learning on the job.

In the same time, eliminating (or at least reducing) the cost of connection to the internet will increase the internet users. It is a rewarding investment on the long term and empowers the human capital in all fields of development. The internet is an extremely important technology for knowledge acquiring, online learning and distant education for both the learners and course designers on the web. Traditional skills training will still exist, but ICT gives training or learning the possibility of one-on-one for every learner, the ability to simulate.

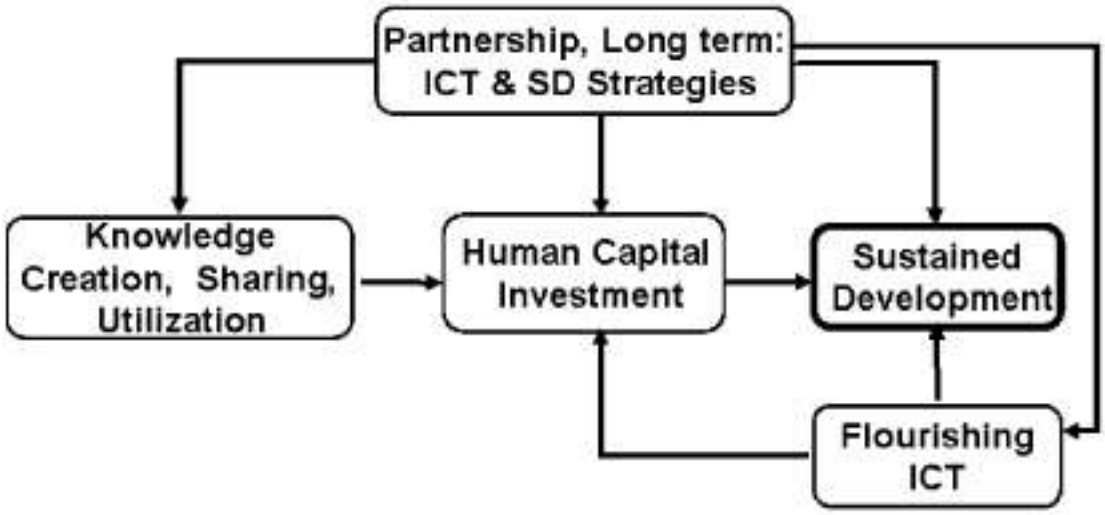

Figure 5(a). Knowledge framework for SD: general high-level issues

Online training overcomes the obstacle of preventing the employees from attending formal training during working hours outside the organization. The ICT provides many models of online learning technologies. Table (2) summarizes examples of ICT used for online technologies such as portal, streaming audio/video, audio chat/VoIP[7], Web White boarding (form of graphic conferencing), Instant Massaging (IM), the internet in wireless handheld devices (3G), and the new Semantic Web(Journal of Educational Technology and Society, 2004) . The practical application of each online technology fits certain objectives (McGreal and Elliott, 2004). The most crucial part is the conversion of tacit to explicit knowledge. The "Ba" concept or learning organization may be used to implement knowledge sharing, utilization, creation, and storage.

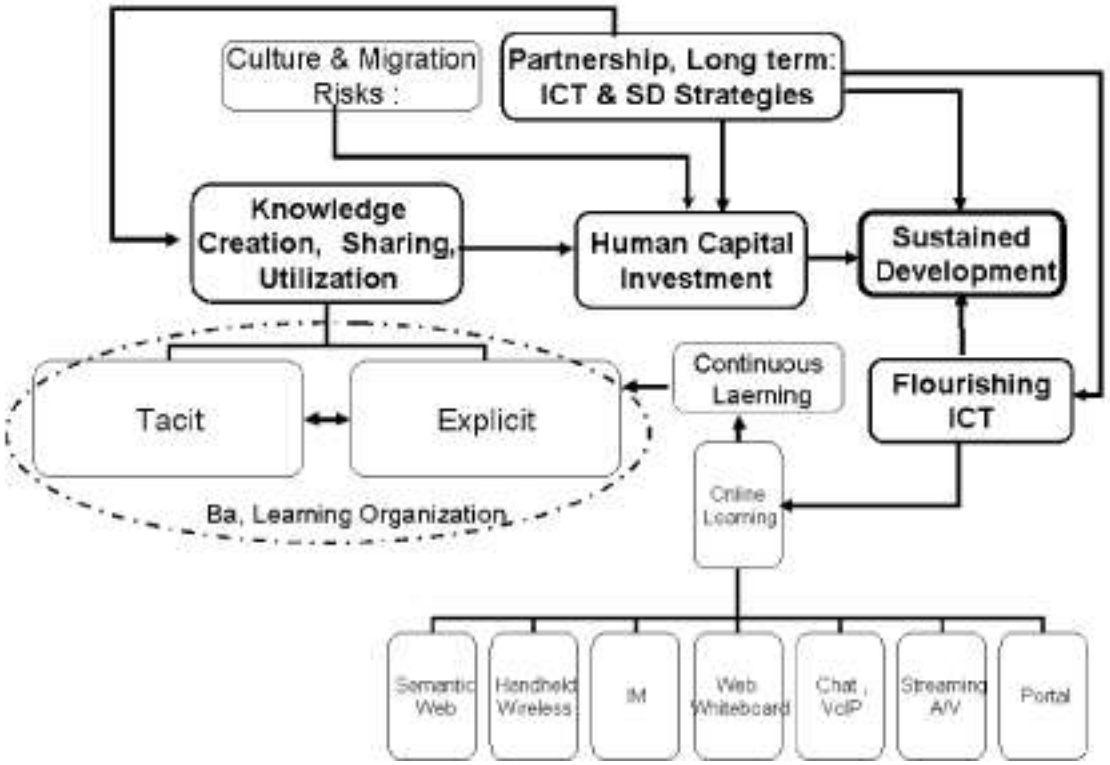

Figure 5(b). Knowledge framework for SD: detailed issues

Conclusions and Future Work

A study of causes of the unsustained development in developing countries has revealed that unsustainable development may be attributed - other than political crisis, warfare, and international tensions - to that ICT and development strategies are set independently from each other. In addition, almost many ICT applications for development are not scaled-up according to preset national strategy

and action plan. Poor penetration of ICT is moreover a prime cause. Lower human knowledge and culture resistance plays an important role in development.

A framework is proposed that sheds light on the imperative of human knowledge (tacit and explicit), which has been overlooked in the studies of sustainable development. The potential of ICT (as enabler) are employed for continuous online learning using various models. An indicator for measuring culture resistance is needed, which may be of value to strategy planners of development. In the future, a study, concerned with using ICT models to exchange tacit and explicit knowledge, is needed.

Technology	Applications	References/Providers
Portal	One-stop Online Curriculum Portals	▪ http://portal.acm.org/citation.cfm?id=1060745.1060792 ▪ http://www.trainup.com/Onlinelearning.aspx
Streaming Audio/Video	Prerecorded lecture, classroom interaction, hands-on	▪ http://www.lorman.com/online/ ▪ http://www.e-learningcentre.co.uk/eclipse/Resources/streaminglearning.htm ▪ http://www.streamx.com.au/ ▪ http://online.rit.edu/faculty/tools/av/
Chat, VoIP	Interactive discussions, foreign languages practice, audio-graphic teleconferencing	▪ http://www.marketdepot.com/marketdepot/ ▪ http://www.icuii.com/ ▪ http://www.microsoft.com/windows/netmeeting/
Web Whiteboard(Combined Graphic Conferencing &VoIP)	Emulsion pf Classroom lessons. Real-time \Teacher-student Collaboration of Graphic information, Brainstorming.	▪ http://buyersguide.eweek.com/product/SearchResults.asp_Q_sitename_E_eweek_webconferencing_A_cboCategory_E_716 ▪ http://www.-mice.cs.ucl.uk/multimedia/software/wbd ▪ http://www.vetmed.auburn.edu/index.pl/mailing_lists?proxiedUrl=http%3A%2F%
IM	Immediate contact with teaches, students, tutors	▪ http://www.top4sites.net/hp1/Instant%20Messaging/s.php?s=Instant%20Messaging ▪ MSN IM ▪ Yahoo IM ▪ AOL IM
Handheld 3G	Graphics & Video to Rural areas on Palm devices	▪ http://www.palm.com/us/education/ ▪ http://www.pdaed.com/vertical/features/OwlsProject.xml ▪ http://press.nokia.com/PR/200103/814270_5.html
Semantic Web	Machine-understandable, reasoning and Inference of data on the Web	▪ http://www.w3.org/TR/2005/WD-swbp-thesaurus-pubguide-20050510/ ▪ http://portal.acm.org/citation.cfm?id=1060745.1060792

Table 2. ICT technologies for online learning

References

- Al-Amoud, Ahmed I. (1989), "Water Irrigation by Automatic Scheduling via Soil Moisture Sensors for Center Pivots", Final Report for King AbdulAziz City for Science and Technology, Riyadh Saudi Arabia.
- CSD (2005), Commission of Sustainable Development. Available http://www.un.org/esa/sustdev/natlinfo/indicators/isdms2001/table_4.htm
- Derek H. C, Chen, and Hiau Looi Kee (2005), "A model on Knowledge and Endogenous Growth". Available http://info.worldbank.org/etools/library/latestversion.asp?135703
- Drucker, P. E. (1988), "The Coming of the New Organization", Harvard Business Review, January-February, pp. 45-53.
- Drucker, P. F. (1994), "The Age of Social Transformation". The Atlantic Monthly, pp: 53-78.
- eEurope (2005). Available http://europe.eu.int/information_society/eeurope/2005/index_en.htm

- HDR (2001), Human Development Report," Making New Technology Work for Human Development", UNDP.
- HDR (2002), Human Development Report, "Deepening Democracy in a Fragmented World", UNDP.
- HDR (2003), Human Development Report," Millennium Development Goals", UNDP.
- HDR (2004), Human Development Report, "Cultural Liberty in Today's Diverse World", UNDP.
- HDR (2005), Human Development Report, " International cooperation at a crossroads: Aid, trade and security in an unequal world", UNDP.
- IISD (2005), International Institute of Sustainable Development, Available http://www.iisd.org/
- Journal of Educational Technology & Society (2004), "Special Issue on "Ontologies and the Semantic Web for E-learning", Vol. 7, No 4. Available http://www.ifets.info/others/issues.php?id=25
- Ishikawa, K.(1986)" Guide to Quality Control", Asian Productivity Organization; 2nd Revised edition, Tokyo, Japan.
- Rory McGreal, R., and Elliott, M., (2004)," Technologies of Online Learning (E-learning)", Chapter 5 in "Theory and Practice of Online Learning", Anderson, T. & Elloumi, F (ed.), pp. 115-135. Athabasca University , AB, T9S 3A3, Canada
- Marqurdt, M.J (2002), "Building Learning Organization", Davis-Black Pub. Inc. Pal Alto, CA., USA
- Nonaka I., and Konno N. (1998) "The concept of "Ba': Building foundation for Knowledge Creation ", California Management Review Vol. 40, No.3, pp.40-54.
- OECD (2002), "Internet Users and Prices of 40 hours Connection", Telecommunications Database. Available http://www.oecd.org/statisticsdata/0,2643,en_2649_34449_1_119656_1_1_1,00.html
- Polanyi, M. (2000), "The Polanyi Society". Available: http://www.missouriwestern.edu/orgs/polanyi/
- Sandro M. Radicella (2002), "Role of ICT in Sustainable Development: our Experience, Sustainable Alternatives", Trieste, 4-5 October 2002. Avaialblehttp://www.ictp.trieste.it/~ejds/seminars2002/Sandro_Radicella/PresentationRSANDROxEJDS.ppt
- SDPI (2004), " Sustainable Development Policy Institute" , Seventh Sustainable Development Conference ,8-10 December, 2004, Holiday Inn, Islamabad. Available http://www.sdpi.org/sdc_2004/sdcMain.htm
- Sofrata, H. (1983), "Air Conditioning in Arid Zones using Dual Absorption Solar system", Proceedings of the First Saudi Engineering Conference, Jeddah, pp.2-21, (In Arabic).
- Willard, T and Andjelkovic, M., ed. (2005) "A Developing Connection: Bridging the Policy Gap between the Information Society and Sustainable Development", *IISD*. Available http://www.iisd.org/publications/pub.aspx?pno=740
- World Bank, (2004), "Knowledge for Development", Knowledge Assessment Methodology (KAM). Available http://web.worldbank.org/WBSITE/EXTERNAL/WBI/WBIPROGRAMS/KFDLP/EXTUNIKAM/0,,menuPK:1414738~pagePK:64168427~piPK:64168435~theSitePK:1414721,00.html
- WSIS (2003), "The World Summit on the Information Society", Geneva, 1st Phase. Available http://www.itu.int/wsis/documents/doc_multi.asp?lang=en&id=1160|0
- WSIS (2005), "The World Summit on the Information Society", Tunis, 2nd Phase. Available http://www.itu.int/wsis/tunis/index.html
- WSSD (2002), "World Summit on Sustainable Development, Johannesburg, 26 August - 4 September 2002. Available http://www.icrc.org/Web/Eng/siteeng0.nsf/iwpList453/777B469BDF7A82DCC1256C2200506DBF

Endnotes

[1] http://www.ibiblio.org/nii/toc.html
[2] http://europe.eu. int/information_society/eeurope/2005/index_en.htm
[3] http://www.kantei.go.jp/foreign/it/network/0122full_e.html
[4] Poverty line is $1/day
[5] PPP: Purchasing Power Parity, it is an estimate of the exchange rate required to equalize the purchasing power of different currencies.
[6] SECI : Socialization- Externalization -Combination- Internalization.
[7] VoIP: **V**oice **O**ver **IP**. A telephone service that uses the Internet as a global telephone network