Understanding the Concept of Technology Transfer and Sustainable Development in Sudan: An Overview

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Abstract: This introductory paper was carried out to provide a background paper for the conference "*The Role of Diaspora in Technology Transfer and Achieving Sustainable Development in Sudan*" held in Brighton, UK (24th - 25th January 2009). The paper will therefore provide an overview about three major issues relating to the relationship between the diaspora and their home country which will be discussed during the conference. These major issues include migration and brain drain; technology and knowledge transfer; and sustainable development. However, it is important to note that understanding the nature of problems, challenges and opportunities in Sudan is a very difficult task for many people outside its territories. Equally important to mention the fact that there are limited contributions in the conference from scholars in the Southern and Western regions of Sudan which is probably due to the current situation is both regions.

1 Country Background

Understanding complex issues relating to diaspora such as migration, brain drain, technology transfer (TT) and sustainable development (SD) in a country like Sudan can only be possible in the context of understanding the socio-economical, political, technological, behavioural aspects in Sudan as well as issues to do with production and consumption.

With an area of 2.5 million square kilometres (1 million square miles), Sudan is the "largest country in Africa" and "9th largest in the world" (IMF, 2007, 1999; Salopek, 2003). Sudan has boasted the "largest farm in the world" in the Gezira irrigated Cotton scheme (Mohamed, et al, 2008; Yousif, 1997), the "world's largest sugar-producing complex" in the Kenana project and was also until recently the "biggest producer of Gum Arabic in the world". Sudan was optimistically referred to as an 'awakening giant' by the hype merchants of the 1970s, and its vast plains were seen by development experts as a potential 'bread-basket' – either for Africa or for the Arab World across the Red Sea (O'Brian, 1981).

Sudan is a low-density populated country and its population, estimated at 28, 33 and 40 million people in 1995, 2003 and 2008 respectively of whom some 80% are rural, form a great mosaic of more than 500 ethnic (52% African, 39% Arab, 9% others), tribal, linguistic, religious (70% Muslim, 25% traditional African, and 5% Christian), and cultural affiliations and traditions (The World Fact Book online; Salopek, 2003).

Economic development indicators depict Sudan with the majority of its people depending on agriculture (80%), a large population of livestock (2nd largest in Africa), a low degree of industrialisation, a disproportionately large and costly public sector, a high rate of consumer price inflation, a state budget hit by soaring $15 billion foreign debt, employment levels are threatened with a rising 30% unemployment in 2002 as well as immense war expenditure (IMF, 1999; Salopek, 2003; Grawert, 1998).

Sudan's economy is booming on the back of increases in oil production, high oil prices, and large inflows of foreign direct investment. Oil is one of the main Sudanese exports particularly

during the last fifteen years providing revenues of more than $2 million a day and estimated reserves of three billion barrels (Salopek, 2003). GDP growth registered more than 10% per year in 2006 and 2007 (IMF, 2007; The World Fact Book online). However the Darfur conflict, the aftermath of two decades of civil war in the south, the lack of basic infrastructure in large areas, and a reliance by much of the population on subsistence agriculture ensure much of the population will remain at or below the poverty line for years despite rapid rises in average per capita income.

2 Migration and Brain Drain

A major feature of the Sudanese economy is the large number of its highly qualified labour force working abroad. In recent years, growth in urban labour force has been much faster than that of the rural labour force. Because of social, political, cultural reasons and economic downswing in many African countries, Sudan suffers a significant 'brain drain', particularly of its professionally qualified university graduates, losing nearly 17% of its doctors and dentists, 20% of its university teachers, 30% of its engineers, and 45% of its surveyors between 1985 and 1990 (Ahmed, 2006; Ahmed and Newton, 2005). Often, good researchers and research managers with superior performance seek employment elsewhere to get their rewards. Mostly the migration is to countries in Europe and North America (Todaro, 1997).

On the other hand, reasons for migration are usually many and varied, but largely include: poor performance of Sudanese economy; access to better health facilities; further studies; political asylum; employment and associated financial rewards; better opportunities for potential investment and hence personal security; favourable climate and cross-cultural marriages.

Brain drain is a major problem for most Sudanese institutions including research and academic institution, and most institutions have some areas of expertise where they cannot compete for the best brains (Ahmed, 2006). Since the demand for subject matter specialists, scientists, specialised teaching staff, economists, and increasingly also for biophysical scientists is rising fast in the private sector, many institutions will likely have even more difficulty in recruiting and retaining skilled employees. It doesn't help that donor interest in supporting long-term training has declined, resulting in the pool of young well-trained scientists actually shrinking in Sudan.

Staffing instability plagues most of Sudanese institutions including universities and research institutions, and the turnover rate in most of them reaches 10% (see Ahmed and Newton, 2005). Reasons include: poor management, unattractive conditions of service, lack of job satisfaction, lack of funding, etc (for more discussion on these issues see Ahmed, et al, 2008). Both donor-driven projects and civil service procedures used by the Sudanese government have failed dismally in rewarding individuals who perform and in targeting funds at entities that use them well. The good news is that both donors and the government are now showing great interest in learning from their errors.

3 Technology Transfer and Diffusion

Technology has been one of the main engines of economic development since the Industrial Revolution. Technological literacy is fundamental, as the emerging global economy requires people at all levels who understand technology and can use it as a tool to transform inputs into outputs or generally to achieve goals and objectives. The concept of technology has been defined

in many ways and from different angles. Simply put, it refers to a class of knowledge for making a specific product. The technical skills necessary to use a production technique and a product are often included in the definition of technology.

3.1 Technical Change

The critical factor in raising productivity is technical change and the role of the government is to promote technical change (Schultz, 1964). Schultz believes that technical change and price are the prime agents of growth. The unambiguous message from this approach is that free markets provide the best incentive to speed technological advance. This goes beyond the static argument that market prices encourage *appropriate* techniques (see Ahmed et al, 2003).

Little was written about technology transfer as a separate field of study before the 1970s. The study of this area has slowly emerged as a result of awareness of the technology's key role in economic development. Its study has been driven by the need to understand the process, its determinants, its effects on transferor and transferee, and the factors affecting its control. It is widely held that multinational activity by more efficient foreign multinationals promotes technology transfer to the benefit of domestic companies.

3.2 Definition of TT

While technology transfer typically 'refers to the development of a technology in one setting which is then transferred for use in another setting' (Markert, 1993), diffusion is used to describe the 'spreading' or use of a technology within a society, organisation or group of individuals (Rogers, 1995). Technology transfer tends to focus on the *producer* of the technology while much of the focus of diffusion relates to the *end user* of the technology. Viewed from the holistic perspective of technology development and use, these two areas are closely interrelated and must be considered together.

Therefore, the term technology transfer will be defined broadly to include both the movement of technology from the *site of origin* to the *site of use* and issues concerning the ultimate acceptance and use of the technology by the *end user*. Adopting this broad definition of technology transfer implies that a technology has not been successfully transferred until it has been accepted and used by the *end user*.

3.3 Key Success Factors

In its most basic form, the technology transfer triangle includes the transfer item itself, the developer of the technology, various channels to accomplish the transfer, and the technology recipient. According to the above conceptual approach to technology transfer, several issues should be considered:

The process used to transfer a technology influences the success of the transfer (Johnson et al, 1999). This process is described as *models of transfer*.

Regardless of the degree of technology development within any institution, the technology providers must have a *linkage policy* that defines its degree of commitment to interaction with the *end users* and *transfer agencies* (Ahmed, 2005; Eponou, 1996).

The end users should be the *principal consideration* in the design of technologies. Through early and regular contact with the end users, technologies can be developed that suit their needs.

This interactive development becomes even more important when differing cultural and social values are involved. Without sensitivity for the needs of the end users and a recognition of the environment in which the technology will ultimately be used, the transfer will be a difficult process (Ahmed et al, 2003).

Technology does not stand alone, but encompasses *political*, *social*, *economic*, *and cultural values* that can serve as *barriers* to the diffusion or transfer of technology. These barriers exist for all innovations, but some transfers are more affected than others.

The *appropriateness* of technology seems to have a significant impact on its ability to overcome transfer barriers. The assumption is that the characteristics of a technology underlying a user's ecological, socio-economic and institutional contexts play the central role in the adoption decision and diffusion process (Biggs, 1990; Scoones and Thomson, 1994). Another way to consider the appropriateness of a technology is to examine its characteristics (Ahmed et al, 2003; Ahmed, 2003). Rogers (1995) describes five characteristics – relative advantage, compatibility, complexity, trialability, and observability – that influence the rate at which an innovation is transferred and diffused.

Successful technology transfer is not achieved through the simple movement of technology to a new environment; it requires the development of a process and infrastructure that will help the technology *break through* the different barriers. Communication is a key element in the transfer process. If researchers develop a new technology but the end users are not aware of it, this new technology will never reach its intended end users. Transfer requires human intervention for a technological innovation to become part of a larger system. Transfer agencies are therefore the most important communication channel that support the transfer process. Linkages between research institutions and transfer agencies are vital.

The availability of *funding* greatly influences the transfer of technology (see Ahmed, 2005a).

The *timing* of the transfer is critical and an important factor in the success or failure of an innovation's ability to progress from the technological activity output phase to beneficial use. The optimum time when the innovation is needed will also help to overcome the transfer barriers.

The process of technology transfer should take place in a continuous progression over time. The stages include: importation of technology and application; compatibility stage, including the adaptation of new technology to the local environment, labour force, raw material, and so on; establishing the supporting technologies by producing some tools internally in order to modify and develop the imported tools and equipment; and finally the production of new technologies by the simple mixing of what is available locally or by the new addition of an independent new technology.

4 What is SD?

In simple terms, SD refers to maintaining development over time but, so far, there are well over four hundred definitions of SD currently available in the literature (see Ahmed and Stein, 2004; Pearce et al., 1989; Holmberg, 1992; Morita et al., 1993; Murcott, 1997; Elliot, 2001) providing different concepts, perspectives, concerns and solutions for SD. How they relate to each other and provide a clear understanding of our common future still remain a key question to be addressed.

The concept of SD is multi-dimensional and often unclear and there is no single definition or perspective necessarily fully captures the concept, but by being clear about our meaning of the concept and the underlying assumptions, we can progress our understanding of SD and our future challenges. It is therefore essential that research and policy development fully takes account of the differing perspectives of SD and make explicit the particular perspective(s) that they are taking.

SD encompasses many different meanings, but the most frequently quoted definition is from the report *Our Common Future* (also known as the Brundtland Report). The Brundtland report (WCED, 1987, p.43) defined SD as "*development that meets the needs of the present without comprising the ability of future generations to meet their own needs*."

The Brundtland report recommended seven critical actions needed to ensure a good quality of life for people around the world: *revive growth; change the quality of growth; meet essential needs and aspirations for jobs, food, energy, water, and sanitation; ensure a sustainable level of population; conserve and enhance the resource base; reorient technology and manage risk; and include and combine environment and economics considerations in decision-making*.

These recommendations remain valid today (see Sarre et al., 1991, SDCN, http://www.sdcn.org/; Earth Council, http://www.ecouncil.ac.cr/) and are a call to change our actions and to do things differently. In particular, they underscore a need to: produce differently by applying concepts of eco-efficiency and sustainable livelihoods; consume differently; and organize ourselves differently by increasing public participation while reducing corruption and perverse subsidies.

However the Brundtland definition has also been criticised by many scholars and leading international institutions, such as the United Nations Economic Commission for Europe (UNECE) (2004), as vague since it does not specify the time horizon of future generations, gives no indication of the role of the environment and refers to the opaque concept of human needs. Accordingly, a variety of definitions of sustainability and SD are used in different contexts.

For the World Bank (2003), SD is a multi-dimensional concept, which combines five key perspectives: financial; physical; human; social and natural capital.

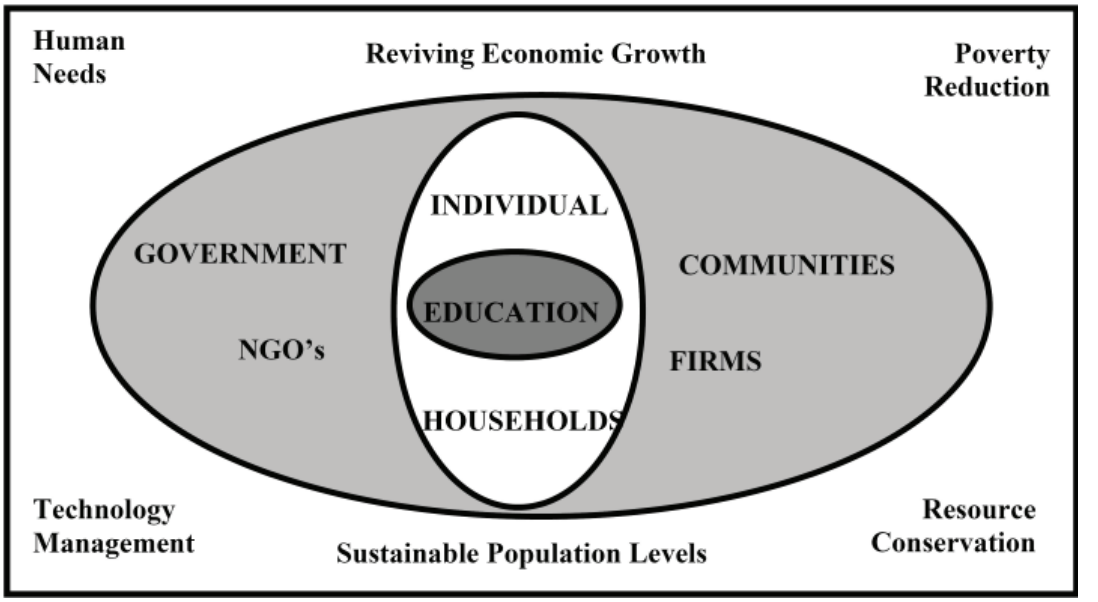
4.1 Dimensions of SD

The different dimensions of SD based on the different definitions explored above have been summarized in Figure 1 as a framework that involves all issues such as science, technology, economic growth and development, health, education, foreign direct investment (FDI), international debt & aid, trade, politics, war, natural disasters, population growth, terrorism, etc.

5 Can Sudan Achieve SD?

Table 1 presents the performance of Sudan against the different countries in the world using the most widely accepted different international indicators, measurements and indexes (world ranking) such as Population Level (POP); Human Development Index (HDI); Digital Opportunity Index (DOI); Environmental Performance Index (EPI) and Ease of Doing Business Index (EDB).

Fig. 1 Dimensions of SD



Source: Adopted from Ahmed and Stein (2004)

Table 1 Sudan International Performance (2006)

Sudan	POP	HDI	DOI	EPI	EDB
	36.2	141	136	124	154

Population (POP) calculated in million peoples, HDI (171 countries), DOI (181 countries), EPI (133 countries) and EDB calculated from 125 countries.

Source: Adopted from WISR (2006 and 2007); ITU World Telecommunication Indicators Database; Yale Centre for Environmental Law and Policy (2006); Human Development Report (2006); World Economic Outlook Database (2007); World Bank (2006) and the World Economic Forum (Arab World Competitiveness Report 2007 and Global Competitiveness Report 2006-2007).

5.1 Human Development Index (HDI)

According to the IMF latest reports on the Middle East and North Africa (MENA) region (2007), despite the economic significance of Sudan's oil, Sudan score lower on HDI world ranking. It is, therefore, generally recognised that the dominant economic model of Sudan – based on the public sector, agriculture, oil incomes and workers' remittances – is not up to the challenges of globalisation. Given the apparently contradictory needs of economic growth and environmental conservation, it comes as no surprise that SD has had such a powerful influence in contemporary discussions on the future of Sudan.

5.2 Digital Opportunity Index (ODI)

According to WISR (2006-2007) reports, DOI is the only e-index based solely on internationally agreed ICT indicators, developed for 181 countries in 2006. This makes it a valuable tool for benchmarking the most important indicators for measuring the Information Society.

The DOI is a standard tool that governments, operators, development agencies, researchers and others can use to measure the digital divide and compare ICT performance within and across countries. The index reveals an alarming picture for Sudan despite the telecommunication revolution in the last ten years with Sudan placed at the bottom of the MENA region.

Bartholomew (1997) argues that technology development is embedded in a country's history, cultural values and attitudes. Therefore, attitude to IT could also have something to do with national culture. Therefore in the case of Sudan issues to do with Freedom of Information could be one of the reasons behind Sudan's lack of success as access to the Internet brings with it free access to information and therefore if the political climate of the country does not permit such access, then rapid progress towards information society cannot succeed in that country (see Ahmed, 2007; Ahmed and Nwagwu, 2006).

5.3 Environmental Performance Index (EPI)

The Environmental Performance Index (EPI) released during the 2006 World Economic Forum to focus on current on-the-ground outcomes across a core set of environmental issues tracked through 16 indicators in six policy categories for which all governments are being held accountable. These categories include: *Environmental Health, Air Quality, Water Resources, Biodiversity and Habitat, Productive Natural Resources, and Sustainable Energy*. As a quantitative gauge of pollution control and natural resource management results, the Index provides a powerful tool for improving policymaking and shifting environmental decision-making onto firmer analytic foundations. The Index reveals that nations at all levels of economic development face serious environmental challenges. The top-ranked countries all commit significant resources and effort to environmental protection, resulting in strong performance across most of the policy categories.

Sudan has a lower EPI ranking as the country is relatively unpolluted due to its underdevelopment, but still Sudan is not meeting the challenge of providing environmental infrastructure (drinking water and waste water treatment) for its people and creating systems for pollution control and ecosystem protection. However despite considerable public investment in potable water supply services (World Water Forum, 2006), deteriorating environmental conditions will lead to a serious water shortage problem. The sustainability of the human and economic development of the country will thus depend on long-distance water transfers projects.

5.4 Ease of Doing Business (EDB)

The recent in-depth study by the World Bank entitled *Doing Business 2007: How to Reform* ranks countries on their ease of doing business (EDB) with first place being the best. EDB averages the country's percentile rankings on 10 topics, made up of a variety of indicators, giving equal weight to each topic. These indicators include: starting a business (STA); dealing with licenses (LIC); employing workers (EMP); registering property (REG); getting credit (CRE); protecting investors (PRO); paying taxes (TAX); trading across borders (TAB); enforcing contracts (CON); and closing a business (CLO). However despite the large inflows of foreign direct investment into the country, Sudan scores very low in EDB!

6 The Way Forward

There is an increasing role of technology in our daily activities –there is an urgent need for the Sudanese government to formulate comprehensive national programmes for TT and diffusion, perhaps drawing on the experience of its diaspora living across the world. The most important benefit of the diaspora to Sudan is access to new and more productive appropriate technologies and scientific knowledge. However the government must ensure that all necessary requirements (physical, technical and institutional) are available and adequate for the successful transfer of technologies and scientific knowledge. There is also an urgent need for strong commitment by the government to education and training.

According to Shetty and Buehler (1991), productivity and quality are two major keys to competitive advantage and therefore managers must recognize that productivity and quality improvement efforts require major changes in organisations' philosophy, culture and operating systems.

Finally, given the space limitations in this introductory paper, these different issues discussed in this paper will also be examined and explored in more details in other papers in the book by many scholars, researchers and policymakers from allover the world. However as we work towards achieving sustainable development and growth, we must strive not to lose sight of the big picture and that we must think *and* act both globally and locally.

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