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# **Enhancing Climate Change Technology Transfer between the Global North and the Global South: Challenges and Opportunities for the United States and Africa**

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# I. ABSTRACT

The transfer of climate resilient technologies has become a key element of climate change response strategies within the the United Nations Framework Convention on Climate Change (UNFCCC). The UNFCCC has established legal obligations, frameworks and mechanisms for achieving Climate Change Technology Transfer (CCTT) with the objective of bridging the gaps between industrialized and developing countries. However, this has had limited success in Africa. This paper examines the current status of, existing constraints to, and opportunities for implementing CCTT between the Global North and Global South, with specific focus on the United States and Africa, respectively. It further provides policy options for more effective design and efficient implementation of CCTT to enhance climate resilience and more inclusive growth in the developed, emerging and developing countries.

The findings show that the prevailing mechanisms for CCTT to Africa have been designed on the basis of linear models of innovation diffusion, with more focus on transferring climate resilient technologies from the Global North (including the U.S.) to the Global South (including Africa). Technology transfer as currently constituted, understood, and implemented will neither achieve the desired goals in Africa nor allow development partners in the Global North to optimize the associated mutual co-benefits. Current models of CCTT also largely regard technology as hardware and fail to embed the systemic nature of technology development, deployment and diffusion in the implementation process. This has often resulted in mixed outcomes in CCTT projects implemented in Africa. We conclude that for the pursuit of CCTT to contribute to global sustainability goals and address Africa's development needs, it is necessary to broaden the framing of and financial mechanisms for CCTT projects to include the complex systemic relationships amongst the social, political, economic and cultural dimensions of technical capabilities and knowledge circulation within and between countries. This, we argue, will enhance socio-technological transitions to low carbon development pathways in Africa.

## II. INTRODUCTION

In the face of persistent and increasing climate change impacts, Africa, like other continents, is gradually taking part in the global effort to reduce greenhouse gas (GHG) emissions and build her adaptive capacity, while also seeking alternative pathways for sustained economic growth. The Intergovernmental Panel on Climate Change reports (IPCC 2000; 2007 and 2012) conclude that any stabilization of GHG concentrations is not possible without spurring technological innovation and transferring new technologies and practices within countries and across national borders. Furthermore, as suggested in United Nations Framework Convention on Climate Change (UNFCCC) facilitated conferences of parties, climate change technology transfer (CCTT) can provide an avenue for developing a sustainable energy framework and thus, promote green growth strategies that allow for emissions cuts and sustainable economic development simultaneously. The UNFCCC has therefore established legal obligations, frameworks and mechanisms for achieving climate resilient technology transfer.

Many perceive effective transfer of climate-friendly technologies developed in the Global North (countries of the northern hemisphere, also referred to as Annex I countries by the UNFCCC) to the Global South (countries of the southern hemisphere, also referred to as Annex II countries by the UNFCCC) as one of the proactive responses to the complex challenges of climate change (IPCC, 2000; 2007). Studies have also shown that the transfer of efficient renewable energy systems and technologies – such as photovoltaic systems, solar thermal systems, or solar powered devices – can reduce the upward pressure on fragile ecosystems, contribute towards better air quality and also give a chance to thousands of lower income households to get access to modern energy and improve their lives (Ockwell, et al., 2008; Ighodalo, 2011). Most studies confirm the benefits of and the greater need for transferring and disseminating technologies to improve industries' competitiveness and grasp new opportunities for fostering economic growth in the developing world (Schnepp, et al., 1990). Yet the UNFCCC negotiations on CCTT have frequently stalled on several issues of divergence between parties. Often, questions regarding the prevailing intellectual property rights regimes, the spirit of technology transfer versus capacity strengthening in the developing world, and the *Common But Differentiated Responsibility* (CBDR) principle in technology development, deployment and diffusion, are amongst the thorny issues in the negotiation process. We argue that the challenge of successful implementation of CCTTs also derive from the very concept of "transferring technologies," which leads to the tacit interpretation of CCTT as movement of "technologies (mainly hardwares) from one location or context to another," rather than the "sharing of skills and know-how amongst actors." Decades of studies on science, technology and innovation diffusion in Africa confirm that technologies are socially-constructed and without full socialization in local contexts, sustainability of impacts cannot be guaranteed (Urama et al, 2010; Mezzana et al., 2011).

In practice, the implementation of several CCTT projects and programs has often given rise to mixed results. In Africa, prevailing technology transfer mechanisms were primarily based on top-down methodologies which have largely precluded the embedding (socialization) of CCTT projects in Africa's social, cultural, political and economic contexts. As a result, previous technology transfer projects implemented in Africa have neither fully taken into

account the heterogeneity in indigenous capacities to adopt, adapt and use the technologies being transferred nor mainstreamed indigenous capacity strengthening as core aspects of the project implementation. These limit the potentials for technological spillovers and reinforces technological dependence. Furthermore, as most climate-friendly technologies originate mainly from developed countries (the Global North), another important concern often expressed by the developing country parties is the potential conflicting interests within the prevailing Intellectual Property Rights (IPRs) regimes and World Trade Rules (WTRs). The prevailing IPR regimes, international trade rules and the unclear arbitration procedures are perceived as major barriers to the transfer of climate-friendly technologies in Africa (Ockwell et al. 2010; Liu and Liang. 2011). While the developing world, Africa included, perceive IPRs as a serious impediment to CCTT and emphasize the role of large-scale public financing at the global scale, industrialized countries tend to promote purely market-driven approaches (Srinivas, 2009, Ockwell et al. 2010; Liu and Liang, 2011). While the debate remains polarized, the balance of evidence in the economic literature suggests that due to inherent market failures, the existing IPR regimes might not always benefit most developing countries.<sup>1</sup> There are simply no level playing fields for perfect competition to occur.

The plurality of perspectives and the North-South divide with regard to the pros and cons of CCTT is not surprising. Technology transfer is a complex process requiring appropriate frameworks for effective action and cooperation at national, regional and international levels (IEA, 2001, UNDP, 2009). It holds great promise for market expansion for technology developers who are mostly based in the Global North and addressing immediate socio-economic needs of the technology consumers in the Global South. But, in practice, success heavily depends on how effectively these demand and supply side opportunities are equitably harnessed. While the African continent presents significant opportunities for high return on CCTT investments for technology developers in the Global South,<sup>2</sup> adopting and adapting transferred technologies and know-how within national contexts has remained a major challenge in Africa (IPCC, 2000). Drawing on previous experiences, technology transfer models are therefore evolving from traditional linear models to more integrated approaches, paving the way for socio-technological transitions.<sup>3</sup>

The paper examines the current status of, existing constraints to, and opportunities for implementing CCTT between the Global North and the Global South, with specific focus on United States of America and Africa, respectively. It provides policy options for more effective design and efficient implementation of CCTT to enhance climate resilience and more inclusive growth in the developed, emerging and developing countries.

The paper is organized in four sections. First, we define the concept of technology transfer and provide an overview of its developments within the context of climate change. Second, we outline the rationale of CCTT projects in Africa, briefly describing the global sustainability imperatives for collective action to mitigate future Green House Gas (GHG) emissions in the Global South, the investment opportunities in climate resilient technologies in Africa, and the multiple co-benefits of CCTT projects to Africa and the Global North. Third, we outline the perceived and existing barriers to successful design and implementation of CCTTs. Fourth, we provide conclusions and policy options for effective design and implementation

of CCTTs to optimize benefits for technology developers and users in the U.S. and Africa, simultaneously.

## Definition of Concepts

Technology transfer was first described in the literature as the moving of innovative technologies, new technical equipment, resources, practices and other specific skills from one setting (technology providers) to another (technology recipients/users) with a view to accelerating technology penetration (Mansfield, 1961; Blackman *et al.* 1973; Mansfield, 1975). Rogers *et al.* (2001) later proposed a non-exhaustive list of technology transfer mechanisms (Table 1):

Table 1: Technology Transfer Mechanisms (Source: Rogers *et al.* 2001)

	Mechanisms	Characteristics
<b>GROUP 1</b>	Foreign Direct Investments (FDI)	Vehicles for transmitting technology, technical know-how or technology-intensive products internationally through joint-ventures, wholly owned subsidiaries or spin-offs companies
	Licensing Agreements	Legal contractual rights for commercial and non-commercial uses of developed intellectual property rights (patents, copyrights, trademarks, utility models, etc.) and other technological assets
	Grants and Cooperative Agreements	Contracts allowing different entities (industry, non-governmental organizations, academia, public institutions, etc.) to collaborate with one another for the purpose of joint R&D activities
<b>GROUP 2</b>	Publications	Open literature (books, articles, academic journals, magazines, etc.) and trade literature to transmit and share knowledge
	Cross-border Movements of Personnel	Site visits, personnel exchanges and labour mobility programs, migration, etc.
	Public meetings	Conferences, seminars, workshops, symposiums, and other public forums

Divided into two groups, these mechanisms describe channels of knowledge flows and bilateral trade between technology developers and technology users, and among countries. This model dominated the transfer of technologies and innovations between the Global North and the Global South during the first and second industrial revolutions.

Since then, technology transfer has been the subject of a plethora of studies. Based on empirical evidences and experiences in implementing technology transfer projects in the developing world, the definition of the term has evolved in recent years to include more holistic perspectives that accounts for technology development, knowledge-sharing, and the effective adoption of the technologies by the end-users (Johnson *et al.* 1997, UNDP, 2009, Karoskosta *et al.* 2010). While Johnson *et al.* (1997) emphasized that end-users' needs and

the context of technology utilization are crucial for successful transfer of technologies, Karoskosta et al. (2010) stressed that the term encompasses all the activities related to hardware transfer and flows of technical knowledge and experiences. UNDP 2009, on the other hand, defined Technology Transfer (TT) as the flow of experience, know-how and equipment between and within countries, which would typically combine market and non-market based technologies.<sup>4</sup> It has therefore been noted that technology transfer also occurs either vertically (from developers to technology recipients at different stages of research, production and diffusion); horizontally (from technology providers to other improved technology users), and also multi-laterally (systemic and dynamic knowledge flows and feedbacks amongst technology actors wearing multiple hats in the technology development – diffusion-deployment chain).

Effective Technology Transfer (TT) cannot therefore be achieved through the movement of technologies or technical know-how to a new environment. It also requires facilitating access to related technical and commercial information and the human skills needed to properly understand it and effectively use it (ICTSD, 2008). In this regard, a critical aspect of the technology transfer process is the development of the domestic capacities to absorb and master the received knowledge, innovate on that knowledge, and commercialize the results within their own local contexts.

As aptly argued by Tenkasi and Mohrman (1995), the focus on only one-way transmission of information is likely to lead to a process of knowledge transfer and absorption that would primarily depend on instructions given by technology providers, but may not accurately address the potential complexities of the technology transfer process in practice. There is an additional need for continued technical assistance to ensure that end-users fully acquire the necessary capacities and skills to adopt, adapt, use and master the technology in the recipient countries.

### From Technology Transfer to Climate Change Technology Transfer

The concept of climate change technology transfer (CCTT) started receiving global attention during the Earth Summit held in Rio de Janeiro in 1992. Later, the concept was defined in the IPCC Report (2000) as:

*“A broad set of processes covering the flows of know-how, experience and equipment for mitigating or adapting to climate change among different stakeholders such as governments, private sector entities, financial institutions, non-governmental organizations (NGOs), and research/education institutions.”*

The IPCC 2000 definition presupposes the dynamic processes that would ensure the applicability of technologies in local contexts, full disclosure of technical information by the technology providers, and built-in sustainability measures, including continued availability of the technology, etc. Clear methodologies and approaches for Technology Needs Assessments (TNAs) and technology transfer have therefore been set out to ensure that the CCTs address the local needs of the target users (UNDP, 2009).<sup>5</sup> It is noted that technologies

include both ‘hard’ technologies such as equipment and machines, which could be easily moved from producers to consumers, and non-market-based ‘soft’ technologies.<sup>6</sup>

We define Climate Change Technology Transfer (CCTT) as a systemic process of co-production and sharing of knowledge, experiences, skills and equipment (hardware and software) for mitigating or adapting to climate change amongst technology producers and users within or between countries. It starts from end-user driven identification of technology needs within their local contexts, through the setting up the required platforms for co-operation and partnerships for the design, development and deployment of knowledge, skills and equipment (hardware and software) to address the identified needs; and equitably designed mechanisms for knowledge and technology flows amongst the stakeholders. The definition derives from the cooperative models of technology transfer that calls for multi-lateral dialogues, multi-dimensional resources and knowledge flows, equal partnerships and effective engagement between technology providers and recipients/users within countries, across national boundaries and among country groups. This, we argue, will effectively enhance transitions toward low carbon (climate resilient) economies in the Global South.

### Climate Change Technology Transfer in Practice

In practice, current CCTT mechanisms appear to be limited in their approach, leading to limited results. Even though the need to transit from linear models of technology transfer and innovation diffusion to more systemic holistic models of knowledge-sharing and socio-technological transitions are increasingly recognized in the literature, most CCTTs in Africa have, in practice, followed the former. The continued use of the term “technology transfer” instead of “technology sharing” is symptomatic of the continued divide between “technology producers” mainly in the Global North and “technology users” in the Global South, the latter primarily treated as consumers in the climate technology market. Our assessments suggest that for the mutual benefits of CCTT projects to be optimized, there is need to pay more attention to: (i) effective technology needs assessments (TNAs) to identify and prioritize needs of technology end-users; (ii) capacity-building in recipient countries for the use, maintenance and mastery of designated climate change technologies with built-in training efforts to enhance future development, deployment and diffusion of these technologies by local expertise; (iii) a focus on providing suitable policies and market conditions for CCTT investments to be bankable (e.g. concerted efforts in education and public awareness, the creation of appropriate policy frameworks and institutions, and appropriate pricing of CCTs). The assessment also underscores the need for equal multi-lateral partnerships with all actors in the value chain – from technology conceptualization and design through its development cycles to its deployment, use, monitoring and evaluation. Mapping the key actors in the chain determines most effective pathways for CCT development, deployment and diffusion.

For most case studies in Africa, CCTT projects have been driven by three types of actors: (i) *government* (transfers initiated by government and associated public bodies); (ii) *private sector* (transfers initiated by businesses and other private entities); and (iii) *community* (transfers initiated by community groups and organizations). The success rates of each type of CCTT in Africa are mixed, depending on type of technology transferred, its affordability by



target consumers, and a number of other socio-economic and political factors. The aspect of enhancing knowledge flows from Africa to the Global North has received only fleeting attention in the current projects. However, ongoing country case studies commissioned by the African Technology Policy Studies Network (ATPS) show that there are various potentially viable climate change adaptation technologies and innovations in Africa's rural communities that could benefit CCT development, deployment and diffusion in the Global North.

We therefore advocate further advancement in the CCTT projects to include multilateral *knowledge-sharing* amongst the global community (North-South, South-South, and South-North) knowledge circulation to enhance the adaptive and resilience capacities of all actors in the CCTT chain. This will enhance the capacities of the least developing countries to evolve from global consumers of technologies and innovations for development to self-producers of technologies to meet local conditions. The history of innovation diffusion confirms that this form of socio-technological transitions is far more sustainable and effective than bilateral transfer of technologies to African communities.

### III. RATIONALE FOR CLIMATE CHANGE TECHNOLOGY TRANSFER IN AFRICA

The following sub-sections of the paper reviews the rationales for investments in CCTTs in Africa. Considering the diverse and complex nature of climate change and its impacts on global sustainability, the rationales provided below are not exhaustive. We have tried to focus on rationales which we consider dominant from the U.S.-Africa perspectives:

#### **The global sustainability imperative for global action to enhance Africa's capacities to adapt to climate change impacts and mitigate future Green House Gas emissions**

Climate change has become a topical global policy subject and the empirical evidences on its impacts on less developed countries and global sustainability are now compelling. The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2007) confirmed earlier conclusions that no country and no region of the world will be unaffected, and in many countries the consequences for all human activities will be profound unless action is taken urgently to reduce GHG emissions. According to the IPCC (2007), the GHG concentration in the atmosphere would need to stay below the level of 450 parts per million (ppm) in order to prevent average global temperatures from rising by more than 2°C above pre-industrial levels. This is widely considered the maximum temperature increase to avoid irreversible damage to global climate and ecosystems (IPCC, 2007). The latest scientific knowledge on climate change indicates that the world is on a GHG emissions trajectory which is worse than the IPCC's worst-case scenario, and that there is a risk of severe disruption of the climate system if urgent action is not taken to reduce CO<sub>2</sub> emissions at the global scale. In addition to the GHG emission and climate change projections, the International Energy Agency's (IEA) *Energy Technology Perspectives 2008* report has estimated global energy demand will double from present levels by around 2030 (IEA,

2008). Forecasts suggest that energy use and resource consumption will grow at 1.2% in industrialized countries and 2.4 - 3.2% annually through 2030 in developing countries (International Energy Outlook, 2006)<sup>7</sup>.

These raise two critical global sustainability challenges. On one hand, the need to reduce GHG emissions to avoid reaching critical sustainability thresholds is urgent. On the other hand global demand for energy is projected to increase with associated carbon dioxide (CO<sub>2</sub>) equivalents. At the same time, it will be a priority to reduce countries' vulnerability to climate change impacts to sustain human livelihoods and ecosystem services. The economic cost of addressing climate change impacts is therefore substantial<sup>8</sup>. It has therefore become clear that the identification and development of technologies, practices, and policies, both for mitigating

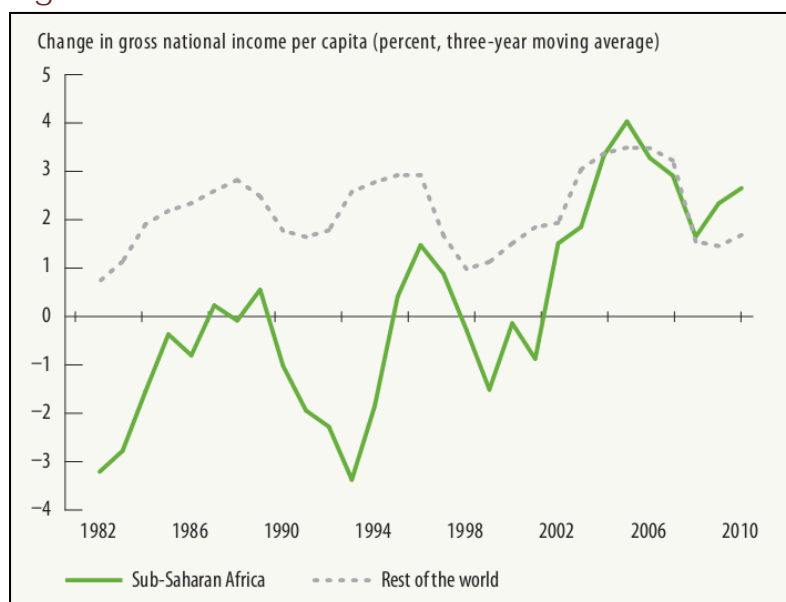
GHG emissions as well as for adapting to the adverse physical impacts associated with climate change, are of key importance to avoid irreversible changes associated with dangerous levels of climate change. Transfer of climate resilient technologies to increase climate adaptation and mitigation capacities of developing countries has therefore become global policy priority under the Bali Action Plan (see Decision 1/CP.13; FCCC/CP/2007/6/Add.1 - UNFCCC, COP13, December, 2007)<sup>9</sup>. Under the Bali Plan of Action, the progress on development and transfer of technologies for mitigation and adaptation is supervised by the UNFCCC Subsidiary Bodies for Scientific and Technological Advice and for Implementation (SBSTA and SBI, respectively, as per Decision 3/CP.13). The Expert Group on Technology Transfer (EGTT) was established at COP7 (Marrakech, 2001) and reinstated at COP13 for another period of five years.<sup>10</sup> Finally, at COP14 (Poznań, December 2008) the Poznań Strategic Program on Technology Transfer was adopted as a step towards scaling up the level of investment in technology transfer in order to help developing countries address their needs for environmentally sound technologies.

Recent studies indicate that African countries, on average, exhibit lower levels of per capita resource use, energy consumption and CO<sub>2</sub> emissions, but at the same time have been growing rapidly during the past decade (McKingsy Global Institute, 2010, UNDP 2012). Africa's collective GDP was estimated at USD 1.6 trillion in 2008 and the real GDP has also increased by 4.9% per year since 2000, more than twice what it was in the late 1990s. According to the African Development report launched by the United Nations Development Program (UNDP, 2012) economic growth has resumed against the backdrop of sustained economic reforms and better terms of trade (Figure 1).

Between 2004 and 2008, African economies grew on an average of 6.5% per year, only slowing down to 2.7% in 2009 in the wake of the global financial and economic crisis. The Sub-Saharan African (SSA) countries rebounded in 2010, regaining its high growth rates, (5.4% in 2010 and 5.2% in 2011), and is expected to continue to grow at more than 5% in 2012. Among the regions tracked by the International Monetary Fund (IMF), only developing Asia is projected to grow faster (UNDP, 2012). This rapid economic growth in Africa is mostly driven by improved political environments, sustained aid flows, significant macroeconomic stability and notable micro-economic reforms (African Development Bank, 2010; McKingsy Global Institute, 2010, UNDP 2012). Other important factors also include urbanization, more youthful educated populations and the increasing number of activities

across the sectors that may inevitably lead to an increasing demand for energy services (Swilling, 2011).

Figure 1: Sub-Saharan Africa's Growth is Accelerating.



*Note: Rest of the world excludes China and India. Changes are calculated based on gross national income expressed in 2008 purchasing power parity dollars (Source: UNDP, 2012).*

However, though welcome development for the African continent, there is growing need to assist African countries to reduce the CO<sub>2</sub> emissions per capita GDP growth achieved. As was experienced during the past decade in China and India (IPCC, 2012), if nothing is done to find alternative low carbon growth pathways for African countries, associated CO<sub>2</sub> emissions per unit of GDP growth (hereinafter referred to as carbon intensity of growth or CO<sub>2</sub> equivalent), will also significantly increase (Figure 2).

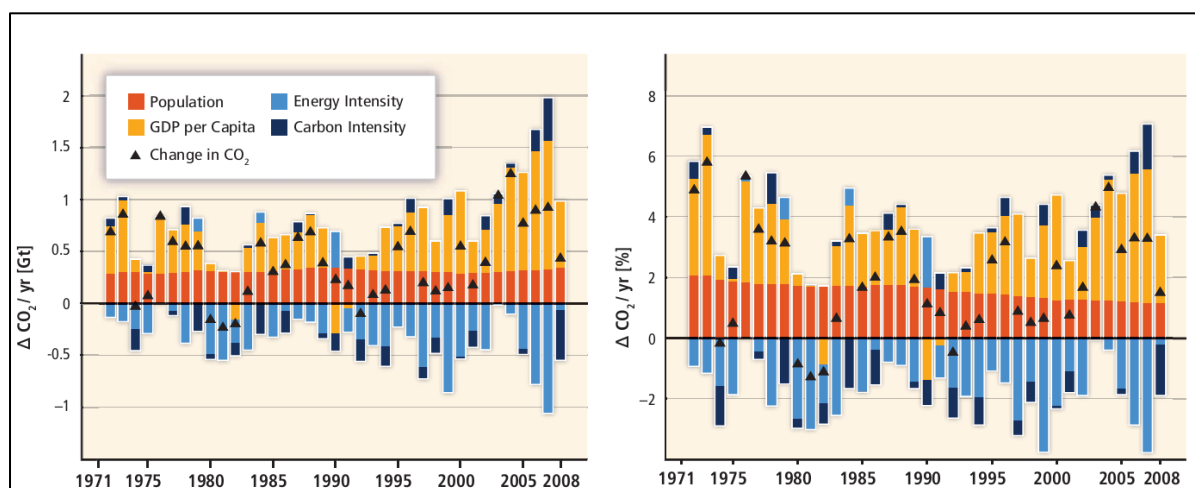


Figure 2: Decomposition of (left) annual absolute change and (right) annual growth rate in global energy-related CO<sub>2</sub> emissions by the factors in the Kaya identity; population (red), GDP per capita (orange), energy intensity (light blue) and carbon intensity (dark blue) from

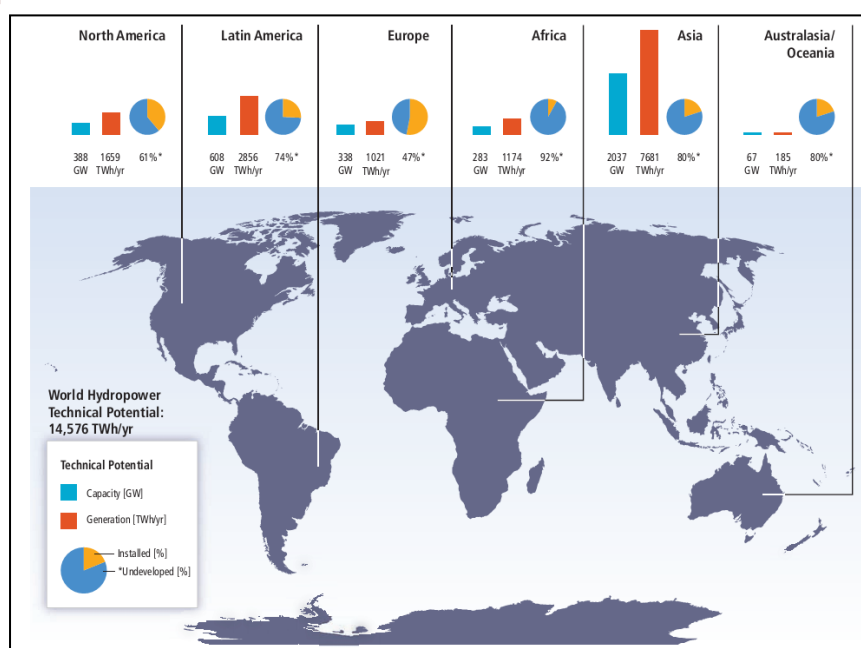
1971 to 2008. The colours show the changes that would occur due to each factor alone, holding the respective other factors constant (Source: IPCC 2012)

As it were, CO<sub>2</sub> emissions know no geographical or regional boundary. Hence while efforts by the developed countries to de-carbonize their economies through climate resilient clean technologies can go a long way to addressing the global emissions challenge, continued emissions from Africa (and the Global South) would likely neutralize the gains if business as usual scenarios continue. For global reductions in CO<sub>2</sub> emissions to required levels, concerted efforts by all countries in Africa (and the rest of the world) will be needed. Africa, being amongst the most vulnerable to climate change impacts, yet amongst the fastest growing economies in the past decade, with vast undeveloped human and natural resources and high potentials for renewable resources development, presents great opportunities for bankable CCTT investments.

### Climate Change Technology Transfer (CCTT) to Africa is Good Business

African countries are endowed with largely undeveloped renewable energy resources (IPCC 2012). According to the recent Special Report of the IPCC on Renewable Energy Sources and Climate Change Mitigation (IPCC, 2012), undeveloped capacity in hydropower ranges from 47% in Europe to 92% in Africa, indicating a large and well-distributed opportunities for hydropower development worldwide, especially in Africa (Figure 3).<sup>11</sup>

Figure 3: Regional Hydropower Technical Potential in terms of annual generation and installed capacity and percentage of undeveloped technical potential in 2009



(IPCC 2012, p. 81).

While Asia and Latin America have the largest technical potentials and largest undeveloped resources, Africa has the highest portion of total potential that is still undeveloped. It is also noteworthy that total installed capacities for hydropower in North America, Europe and Asia

are of the same order of magnitude and, in Africa and Australasia/Oceania, an order of magnitude less; Africa due to underdevelopment, Australasia/Oceania because of size, climate and topography (IPCC, 2012). The average regional hydropower capacity factors in Africa is 47% (a tie with North America) and next to Latin America with the highest capacity factor of 54% (Table 2). This huge undeveloped hydropower potential in Africa could alter due to climate change.

Table 2: Regional hydro power technical potential in terms of annual generation and installed capacity (GW); and current generation, installed capacity, average capacity factors and resulting undeveloped potential as of 2009

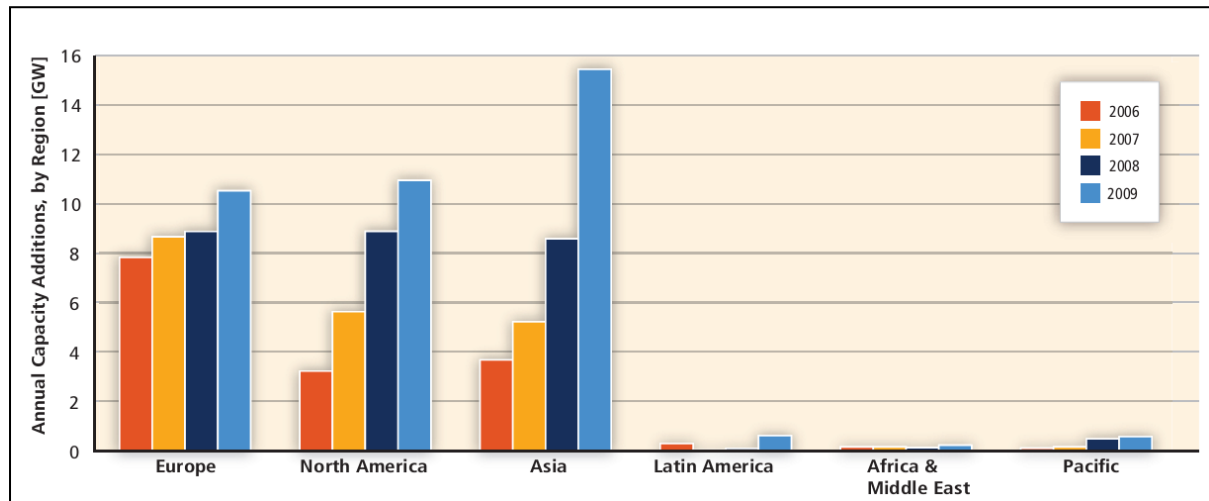
World region	Technical potential, annual generation TWh/yr (EJ/yr)	Technical potential, installed capacity (GW)	2009 Total generation TWh/yr (EJ/yr)	2009 Installed capacity (GW)	Undeveloped potential (%)	Average regional capacity factor (%)
North America	1,659 (5.971)	388	628 (2.261)	153	61	47
Latin America	2,856 (10.283)	608	732 (2.635)	156	74	54
Europe	1,021 (3.675)	338	542 (1.951)	179	49	35
Africa	1,174 (4.226)	283	98 (0.351)	23	92	47
Asia	7,681 (27.651)	2,037	1,514 (5.451)	402	80	43
Australasia/Oceania	185 (0.666)	67	37 (0.134)	13	80	32
World	14,576 (52.470)	3,721	3,551 (12.783)	926	75	44

(Source, IPCC, 2011).

Similarly, as shown in Figure 4, the undeveloped annual wind power capacity additions by regions are highest in Africa, Latin America and the Middle East, and the Pacific (IPCC 2012).

Africa is also endowed with enormous potential for solar energy generation. Africa's solar energy potential is equivalent to 90-100 million tons of oil per annum. The solar insolation in the West Africa varies from 3-4 kWh/m<sup>2</sup>/day in Cotonou to 6.2 kWh/m<sup>2</sup>/day in Agadez (Niger). In North Africa, Morocco receives an average of 4.7 to 5.6 kWh/m<sup>2</sup>/day. In Southern Algeria, overall radiation reaches average levels of 6.1 kWh/m<sup>2</sup>/day. In Southern Africa, the overall average radiation varies 5-6 kWh/m<sup>2</sup>/day. With regard to potential for solar power production, it is estimated that with adequate investment in the Concentrated Solar Power (CSP) technology, Africa can produce enough electricity to meet its own needs and export surplus electricity to Europe (Ram, 2010).

Figure 4: Annual Wind Power Capacity Additions by Region



(IPCC, 2012)

Recent assessments within the Euro-Supergrid with a EU-MENA-Connection sketches possible infrastructure for a sustainable supply of power to EU-MENA and concluded that the largest technically accessible source of energy on the planet can be found in the deserts of the equatorial regions of the earth, including the Sahara (Figure 5):

Figure 5: Euro-Supergrid with a EU-MENA-Connection: Sketch of possible infrastructure for a sustainable supply of power to EU-MENA.



The potential of geothermal energy is stated to be 14,000 MW in East Africa Rift Valley. The geothermal potential for selected African countries include: Kenya (3GW), Ethiopia (more than 1GW), Djibouti (approximates 850 MW), Uganda (450MW) and Tanzania (150MW). To date, only 129 MW has been exploited in Kenya and 7 MW in Ethiopia. The resource potentials hydro, solar, wind and geothermal energy resources in Africa present huge supply side market opportunities for technology development and technology transfer.

On the demand side, Africa still remains a dark continent with regard to energy access. With only about 24% of the population of Sub-Saharan Africa with access to electricity, Africa presents significant un-served population (World Bank Fact Sheet, 2011). Excluding South Africa, the entire installed generation capacity of Sub-Saharan Africa is only 28 Gigawatts, equivalent to that of Argentina. Sub-Saharan Africa has by far the lowest urban and rural access rates at 58% and 12%, respectively. This leaves up to 687 million Africans still without access to electricity (Table 3).

Table 3: Access to Electricity in 2008 Source: World Bank 2010

Region	Population without electricity (millions)	Electrification rate (%)	Urban electrification (%)	Rural electrification (%)
Africa	589	40.0	66.8	22.7
North Africa	2	98.9	99.6	98.2
Sub-Saharan Africa	587	28.5	57.5	11.9
Developing Asia	809	77.2	93.5	67.2
China & East Asia	195	90.2	96.2	85.5
South Asia	614	60.2	88.4	48.4
Latin America	34	92.7	98.7	70.2
Middle East	21	89.1	98.5	70.6
Developing Countries	1,453	72.0	90.0	58.4
Transition economies and OECD	3	99.8	100.0	99.5
World	1456	78.2	93.4	63.2

In addition, to the low access and low installed capacity, poor reliability of energy supply costs African firms up to 6% loss in sales revenue in the informal sector (Ibid). Where back-up generation is limited, losses can be as high as 20 %. Power tariffs in Sub-Saharan Africa are also on average US\$0.13 per kilowatt-hour, higher than in most parts of the developing world which range from US\$0.04 to US\$0.08 per kilowatt-hour. In countries dependent on diesel-based systems, tariffs are even higher. Given poor reliability, many firms operate their own diesel generators at two to three times the cost with attendant environmental costs.

The combination of the huge resource productivity potential in Africa, huge renewable energy resource potentials, growing economies at the average of above 5% in the past decade, and the fast growing population of Africa (currently 15% of the global population)<sup>12</sup> only lead to one conclusion:

*Africa is a huge market with largely untapped profitability potential in low carbon technology development, deployment and use.*

With very low percentage population with access to energy, it is imperative to expect growth in energy demand and diversification of energy sources in Africa. Countries and technology developers who take advantage of CCTT projects to leapfrog sustainable



partnerships with Africa on the development and deployment of climate resilient technologies are expected to reap significant benefits in the medium to long terms.

### **Investments in Sustainable CCTT in Africa will deliver significant co-benefits for inclusive growth, economic prosperity and human wellbeing**

As illustrated in the UNFCCC Report (2006), transferring climate-related technologies may have positive impacts on the economic development in Africa through significant domestic growth opportunities than can be induced by these technologies when local industries are being developed (local spill overs).

For Africa, well designed CCTT would enable member countries to: leverage climate finance for more inclusive sustainable economic development and poverty reduction with reduced impacts on its natural resources and the global environmental assets; improve energy access and human well-being; avoid technology-lock into high GHG emitting technologies, and support climate resilient development by enhancing their adaptive and mitigation capacities (Harper, 2009; Urama et al. 2011). For the Global North, effective CCTT to and from Africa would enhance the achievement of global commitments, including the Millennium Development Goals (MDGs) in Africa, while offering many co-benefits to the technology developers in the Global North. Such co-benefits include: i) new frontiers for new technologies and innovations for economic growth expansion, market diversification and employment creation; and ii) opportunity to avoid the possibility of reaching environmental thresholds or the so called ‘tipping points’ which could limit global growth and sustainability. It will also offer opportunities for capacity strengthening, new forms of North-South and South-North institutional partnerships, knowledge flows and networking; and reduce global vulnerability to climate change impacts.

### **Investments in CCTT now will reduce adaptation and mitigation costs later**

The economic gains of the low-carbon technology transfer can be found in the mitigation of long-term costs associated with climate change. Investments in climate resilient technologies in the most sensitive sectors of the African economy (agriculture, energy, industry, etc.) will not only boost the African economies now, it will also reduce potentiation mitigation costs later. As aptly argued by Kypreos and Turton (2011), subsidized transfer of technology and know-how, when appropriately designed, will contribute to increasing welfare because of induced technological learning and capacities that stem from the deployment of new technologies and hence, generate potential to lower costs of achieving mitigation and adaptation objectives.

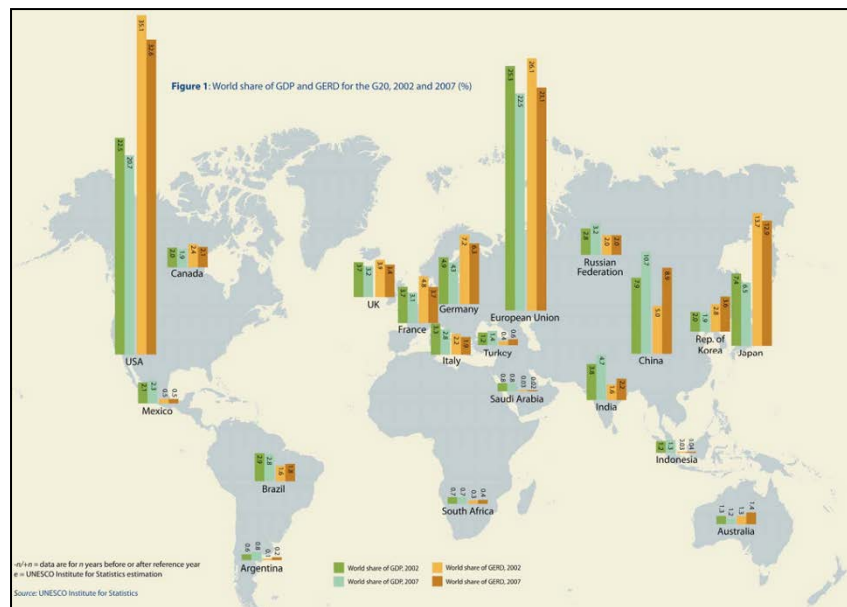
### **Investments in CCTT provides opportunities for capacity strengthening in Science, Technology and Innovation in the Global South**

Africa’s vulnerability to climate change is largely due to lack of technical and institutional capacities to adapt to climate impacts and also low scientific and technical capacity to develop technologies for mitigating GHG emissions. A recent report released by UNESCO (2010) shows that Africa is far behind other continents in gross domestic expenditure on R&D (GERD) in science, technologies and innovations for development (Figure 6).



The world devoted 1.7% of GDP to R&D in 2007, a share that has remained stable since 2002. In monetary terms, however, this translates into USD 1.146 billion, an increase of 45% over 2002. This is slightly higher than the rise in GDP over the same period (43%). In some cases, the rise in gross domestic expenditure on R&D (GERD) has been a corollary of strong economic growth rather than the reflection of greater R&D intensity. In Brazil and India, for example, the GERD/GDP ratio has remained stable, whereas in China it has increased by 50% since 2002 to 1.54% (2008).

Figure 6: World Share of GDP and GERD for the G20; 2002, 2007



(Source, UNESCO, 2010)

China's share of world GERD is approaching its world share of GDP and Korea's world share of GERD is even double its world share of GDP. Brazil and India contributes much more to global GDP than to global GERD. On the contrary, the GERD/GDP ratio has declined in most African countries.

It is therefore not surprising that substantial proportion of the world's total CCT research and development projects are carried out within the industrialised and emerging countries. This leaves Africa as a global consumer of CCT knowledge, technologies and innovations for development. With only South Africa currently investing up to 1% of its GDP on R&D in Sub-Saharan Africa (at the time of the study in 2010), investments in CCTT in Africa would be a welcome platform to leverage knowledge and skills from elsewhere while strengthening Africa's indigenous capacities to address climate change challenges (Urama *et al.* 2010). In this regard, we advocate embedding CCTT programs and projects within existing National Development Plans (NDPs) and National Systems of Innovation (NSI) in the recipient countries to deliver on multiple objectives with institutional capacity strengthening at the core. The aim of CCTT projects should not only focus on enhancing technology adoption and use but also strengthening the inter-relationships among the respective actors (government bodies, private sector, knowledge actors and civil society organizations) for the purpose of

harnessing their synergies for innovation and good practices (Akon-Yamga et al. 2009; Karakosta et al. 2010).

### **Investments in CCTT provides opportunities for Innovation**

Studies have also pointed to opportunities for innovation as core co-benefits of CCTT in developing countries. Meeting the challenge of a growing global energy demand and the need to reduce global GHG emissions and enhance developing countries capacities to adapt to and mitigate GHG emissions, without incurring excessive costs will definitely require intensive and extensive technology innovation. It is, in fact, arguable that the huge landscape of disaggregated renewable energy options and the growing interests by governments, markets and consumers in the developing world provide new opportunities for innovations that will spur the third industrial revolution. Innovative global initiatives on new architectures for low carbon economies have emerged including the Green Economy Initiative (UNEP, 2011), Global Green Growth Initiative, Sustainable Consumption and Production, Green Industries, etc. This has spurred new thinking, institutions and policy formulations at the global and regional scales at levels comparable with the post Great Depression era when the Bretton Woods Institutions (BWIs) were formed<sup>13</sup>. Coupled with the above, there have been advances in renewable energy technologies and innovative financing for technology transfer. Despite some progress in renewable energy penetration in some developing countries, the fact remains that its increased share in the global energy mix has been negligible (IPCC 2012). The same applies to energy efficiency, which can be far more cost effective than building new energy supply infrastructure. Underlying these trends is the fact that projects on energy efficiency and renewable energy face significant difficulties in obtaining commercial funding, related mainly to a lack of risk capital, which multilateral and bilateral funding sources are insufficiently able to mobilize (UNDP, 2009). There remain huge potentials for designing new technologies, innovations and financial products to address the climate change challenges.

## **IV. BARRIERS TO CLIMATE CHANGE TECHNOLOGY TRANSFER IN AFRICA**

**While mutual benefits exist for Africa and USA within the current framing of CCTT projects, potential barriers that might prevent the effective optimization of the opportunities and benefits cannot be overemphasized.**

Documented barriers to optimizing CCTT in Africa include, but are not limited to:

1. The prevailing model of CCTT projects (which preclude socialization of CCTs in African contexts);
2. Economic barriers (market failures, high tariffs, investment risk, etc.);
3. governance-related barriers (fragile institutions and legislative frameworks, non-conducive policy environments, and poor leadership and regulatory frameworks);
4. International trade rules and tariffs structures (IRP regimes and other WTO agreements);

5. Lack of local capacities to adopt and use the transferred technologies;
6. Poor National System of Innovation; and
7. Low investments in science technology and innovation in most recipient African countries.

However, the magnitude and influence of these barriers to technology transfer differ by countries and types of technologies involved. Some of these barriers are briefly discussed below.

### **The prevailing models of CCTTs preclude socialization of CCTs in African contexts**

Assessments show that the prevailing mechanisms for CCTT to Africa have been predominantly designed on the basis of the linear models of innovation diffusion, with more focus on transferring climate resilient technologies (and innovations) from the Global North (including US) to the Global South (including Africa). This top-down methodology of North-South cooperation has often resulted in mixed outcomes and also raised various contentions amongst parties. Also, linear models of technology transfer do not, in practice, allow for equal partnerships and participatory technology needs assessments (TNAs) for sustainable socio-technological transitions in Africa. Though the UNFCCC emphasises the need for equal partnerships and country driven TNAs,<sup>14</sup> this has not been fully implemented in the African case studies reviewed. Existing TNA projects still give the experts (technology producers and other consultants) central roles in the sector prioritization and development of the technology selection criteria. Studies on the continent have shown that different actors in the innovation systems hardly cooperate with each other due to multiple limiting factors (Urama et al., 2010). This has led to poor socialisation of climate change technologies in the socio-cultural and political economy of the recipient countries, resulting in low success and sustainability rates.<sup>15</sup> For CCTTs to be successful there is need for more collaborative learning and co-production of knowledge and technologies (Choi, 2009). Engaging African institutions with reputation and respect from key African stakeholders in the area of climate science, technology and innovation policy research, such as the African Technology Policy Studies Network (ATPS) and the African Climate Policy Centre (ACPC), in the administration of TNA projects would be much more successful than having external Consultants and/or Individual African Experts conduct the exercise. Decades of studies in social surveys and environmental valuation confirm that results of environmental surveys are dependent on the interviewer and interview contexts.

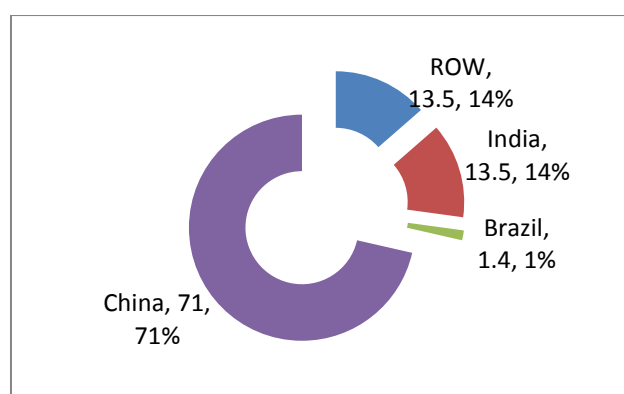
### **Economic Barriers**

Most studies show that the initial investment costs of clean technologies are currently higher than existing carbon-intensive alternatives. For example, IPCC, (2012) shows that levelized costs of renewable energy technologies are currently higher than fossil fuel alternatives. From a neo-classical economic policy perspective, many of the current low carbon technology alternatives are not yet competitive with carbon-intensive options and so market demand for the former tends to be weak or marginal (Ockwell and Mallet, 2012). Besides, investments in some of these technologies are likely to be risky at their early stages of commercialization (Karakosta et al. 2010). This is often due to the lack of information

from both technology providers and recipients on (investment opportunities, advantages of the technology, local needs and technological capabilities of the recipients, transaction costs, associated risks, etc.), but also unstable markets and policy environments in most African countries. The combined effects of inherent market failures and information asymmetry, high import tariffs and high initial investment risk in many African countries contribute to the low rates of adoption of climate change-related technologies in Africa.

Also, inappropriate financing instruments and other difficulties in accessing capital for both small and large scale CCTT projects hinder most African countries from getting investments financed by public and private funding. The existing climate finance mechanism such as the Clean Development Mechanism (CDM) is heavily biased towards the emerging markets in China and India. This bias is reflected in the CDM. China has received over 70% of the finance available so far, while India has been the next best beneficiary with 13.5% of the investments. Brazil has received 1.4%, leaving the rest of the participating countries with 13.6% among them (Figure 7)<sup>16</sup>. Though the CDM has proven successful in generating emissions reduction projects in several developing countries, and more particularly in large emerging economies, it has been less successful in Africa.

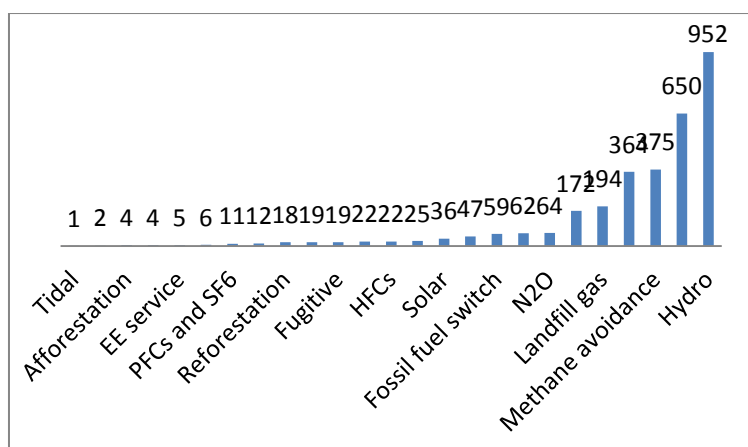
Figure 7: CDM registered projects and accumulated investment value (USD billion), as at end of May 2011. Key: Country, USD billion, percentage, ROW: Rest of the world



(Source: UNEP Risø, 2011, also cited in Byrne et al., 2012)

As a market mechanism, the CDM also creates incentives for firms to invest in low carbon projects that are least-cost and/or will produce the highest returns through the sale of emissions credits.<sup>17</sup> As such, 'mature' technologies, large-scale projects and low-risk investment environments tend to be the most attractive (Byrne et al., 2012). Analysis of registered CDM projects as at the end of May 2012, show that CDM finance favors only few technology options including hydropower, wind energy, methane avoidance, biomass energy, landfill gas and own energy generation (Figure 8).

Figure 8: Number of registered CDM projects as of the end of May 2011, disaggregated by project type (3145 total registered projects)



Source: UNEP Risø (2011); also cited in Byrne et al., (2012)

As a result, it is unlikely that the mechanism will contribute meaningfully to development goals such as improving energy access amongst the world's poorest people and industrialisation in the poorer countries, or to achieving widespread sustainability in the developing world (Byrne et al., 2012). The low capacity to mobilize private sector capital is due to a number of other complex factors, including high overall cost of doing business; lower public energy R&D spending; market distortionary policies such as subsidies for conventional fuels; absence of credit-worthy off-takers; low access to early-stage financing; and less wealthy consumers with reluctance to pay premiums for 'green products,' social and political instability, poor market infrastructure, and weak enforcement of the regulatory frameworks. These usually increase the investment risk factor and hence limit public and private sector willingness to invest. Establishing better mechanisms for leveraging private sector finance through innovative financing is therefore essential and being explored (EGTT, 2008).

### Governance-related barriers

Other barriers to CCTT in Africa include existence of ineffective policy and regulatory capacity, such as enforcing fair and equitable power of purchase agreements, market entry, and Intellectual Property Rights (IPR) regimes.

Most African governments lack the institutional and policy frameworks required for the development, regulation, mediation and use of CCTs. Muller (2010) observed that CCTT are not embedded in a broader policy framework of countries in the Global South, and this has resulted in institutions failing to utilize the inherent potentials of the technology, including available climate finances. In most cases, there is no existing climate policy to provide direction and frameworks for institutional operation in the development and use of CCTs thereby making it more difficult to engage with CCT developers.

Furthermore, even though some African countries have made significant gains in the area of democratic governance, this has also been associated with political violence and instabilities in some African countries. The frequency of changes in government and cabinet reshuffles leads to different kinds of uncertainties and feelings of insecurity amongst Africa's political class. Responsible ministries, therefore, find new ideas and shifts in policy priorities away

from the mainstream economic growth policies challenging. Emphasizing the need for effective leadership in Africa, the Mozambican President Armando Guebuza noted during the African Union Heads of States Summit in 2007,

*“It must be made clear that without the commitment of the leadership; there can be no scientific and technological development on our continent.”*  
(Mutume, 2007).

### **International trade rules and tariffs structures constrain CCTTs in Africa**

Climate Change and international trade, investment and technology transfer issues have intersected in diverse institutional contexts and at several levels of governmental activities. Amongst the thorny issues include how to offset border measures that address international competitiveness and ‘free rider’ concerns in CCTT projects; trade tariffs and non-tariff barriers to investment and technology transfer of climate-friendly goods and services; streamlining programs that promote exports, foreign direct investments and technology transfers, especially to developing and emerging economies within international climate change technology cooperation agreements; managing subsidies for renewable energy and energy efficiency goods and services; and carbon pricing and eco-labelling of products, and managing intellectual property rights in CCTT projects. The complex relationship between the WTO regimes and CCTT is best described in the following quotations from the Stern Review (2006) and also from negotiation Statements by Trade Ministers at different UNFCCC Conference of Parties:

*“The Stern Review, 2006, for example, recommends that the reduction of tariff and non-tariff barriers for low-carbon goods and services, including within the Doha Development Round of international trade negotiations, could provide further opportunities to accelerate the diffusion of key [climate friendly] technologies.”* (The Stern Review, 2006, p. xxv).

*“One way to look at the Kyoto Protocol - and whatever global agreements will follow - is as an investment and trade agreement.... [A]n important hidden imperative behind Kyoto is the creation of an open global market in environmental technologies....[W]herever possible, restrictive national rules on investment or services trade that prevent this transfer of expertise and technology must be removed.”* (E.U. Trade Commissioner Mandelson, speech on 18 December 2006).

*“[T]he relationship between international trade — and indeed the WTO — and climate change, would be best defined by a consensual international accord on climate change that successfully embraces all major polluters.... Trade, and the WTO toolbox of trade rules more specifically, can - at best - offer no more than part of the answer to climate change. It is not in the WTO that a deal on climate change can be struck, but rather in an environmental forum, such as the United Nations Framework Convention on Climate Change. Such an agreement must then send the WTO an appropriate signal on how its rules may best be put to the service of sustainable development; in other words, a*



*signal on how this particular toolbox of rules should be employed in the fight against climate change.” (Pascal Lamy, Director-General, speech at the Informal Trade Ministers' Dialogue on Climate Change in Bali on 8-9 December 2007).*

Most scholars of the interactions between WTO regimes and the emerging ‘climate change regime’ have sought to find potential win-win arrangements with minimal success (see for example, Hoerner and Müller, 1996; Werksman, 1999; Werksman and Santoro, 1999, and Palmer and Tarasofsky, 2007; World Bank 2008; European Parliament, 2007; U.S National Foreign Trade Council, 2007; Kopp and Pizer, 2007; Morgenstern, 2007; and Morgenstern, et al. 2007). Brewer, (2004a) identifies four terms that encapsulate the kinds of generic environmental policy intersections with trade and foreign direct investment (FDI): Environment Related Trade Measures (ERTMs), Environment Related Investment Measures (ERIMs), Trade Related Environment Measures (TREM), and Investment Related Environment Measures (IREMs). For climate friendly goods and services, in particular, the following are examples: tariffs on biofuels (ERTMs), restrictions on FDI in wind turbine manufacture (ERIMs), subsidies for production of renewable fuels (TREM), and government R&D subsidies for investments in pilot projects in carbon sequestration (IREMs). From a political economy perspective, it is arguable that the climate regimes including CCTTs provide opportunities for “free riding” on international agreements hence affecting free market competitiveness. There is plethora of studies on climate regime–WTO compatibility which are not covered in this paper due to space limitations (see for example: Assuncao, 2000; Brack et al., 2000; Brewer and Young, 2001; Brewer, 2003a; Brewer 2003b; Brewer, 2004b; Barton, 2007).

Suffice it for the purposes of the paper to mention some major concerns for African countries, including but not exclusive to the unilateral trade measures (UTMs), tariffs and non-tariff trade barriers adopted by developed countries, which could be an arbitrary or discriminatory restriction on international trade practices.<sup>18</sup> Of the many countries that have tariffs on imports of biofuel *feedstocks*, the U.S. has a relatively high rate of 19.1 percent on soybean oil, which is the principal feedstock used to make biodiesel fuel in the U.S. (Kerr and Loppacher, 2005; UK, Department of Transportation, 2003). Such unilateral measures violate the 'principle of common but differentiated responsibilities' as envisaged in Article 3 Para 1 of the United Nations Framework Convention on Climate Change (UNFCCC). It also violates the non-discriminatory principle of the WTO and hamper efforts at strengthening multilateralism (Ahmed, 2012). Border measures could adversely impact the overall export basket of African countries, and more particularly the export competitiveness of their energy-intensive sectors. In the complex process of transfer of technology, the role of IP protection—despite being only one of many influential factors—has proven particularly contentious<sup>19</sup>. By offering protection against a loss of control of information in technology-related transactions, IP is, in part, an instrument aimed at facilitating the transfer of technology. While studies have shown that such a positive impact does exist, including by establishing a link between stronger patent rights and productivity, trade flows, foreign direct investment and the sophistication of the technologies transferred, issues like compulsory licensing, parallel imports, and carbon labelling have continued to remain contentious. In all, the emerging consensus is that current IPR regimes do not work in favour of African countries who are net importers of technologies and products (Osuji, 2010). More

so, the formal channels which involve multinationals in transferring technologies mainly from North to South do not receive a lot of attention since the concept of Intellectual Property Rights (IPR) regime only came into limelight in Africa during the last three decades. Only few African countries have developed relevant IPR policies and implementation remain challenging<sup>20</sup>. The potential contributions of the provisions of the WTO TRIPS Agreement in promoting CCTT require further research.

### **Lack of local capacities to adopt and use transferred technologies**

Another barrier to optimizing CCTT benefits in Africa is the lack of technical capacity for R&D; development and deployment; and operations and management (O&M) support for CCTs (UNDP 2009). Africa's sustainable development will depend more and more on its capacity to find innovative solutions to its peculiar problems especially in the areas of food insecurity, health issues and environmental challenges. Having the required technical and institutional capacities to adopt, adapt, use and manage CCTs is a pre-requisite for successful application of the technology. There is high probability that proven CCTs transferred from North to South might not lead to the expected results due to lack of adequate capacity to adopt, adapt and use them. Technological capacity is positively correlated with education and hence in a knowledge economy, education (especially tertiary) is a significant driver to access the technological capability of a country. Unfortunately, the gross enrolment ratio (GER) in the tertiary level of education in High-income countries (HIC) is higher than in Africa. For instance, in 2006, the GER in HIC was 13.4 times higher than in Sub-Saharan Africa. Specifically, when comparing countries, the same ratio for the USA was 16.4 times higher than Ghana and 13.6 times higher than Bangladesh. It is therefore not surprising to take note of major disparities in country's capacities to harness and use technologies such as the CCT.

Furthermore brain drain leads to loss of existing capacities in Africa to the Global North. A statement on brain drain submitted by the Network of African Science Academies to the G8+5 Summit in July 2009 indicates that at least one-third of African Scientists and technologists live and work in developed countries. Key factors encouraging the brain drain include; the paltry funding of education, poor incentives for research and innovation, political and religious crisis, a lack of adequate regulations to protect intellectual property and, most importantly, a poor reward system for researchers, teachers and technologists working in research institutions and universities. The overriding issue however should not be how to lure African expatriates back home but rather how to transform brain drain into brain gain by improving the conditions at home.

### **Poor National System of Innovation**

The coordination and integration of STI programmes and activities into one single innovation system that brings actors from different ministries and agencies working together remains an illusion in many African countries. This is because of the weak or absence of a National Systems of Innovation (NSIs) in most African countries. Climate change is a phenomenon that cuts across all facets of life and therefore demands a trans-disciplinary approach and equitable engagement of all actors in the NSIs in the development, deployment, adaptation and use of emerging CCTs. Poor NSI has resulted in



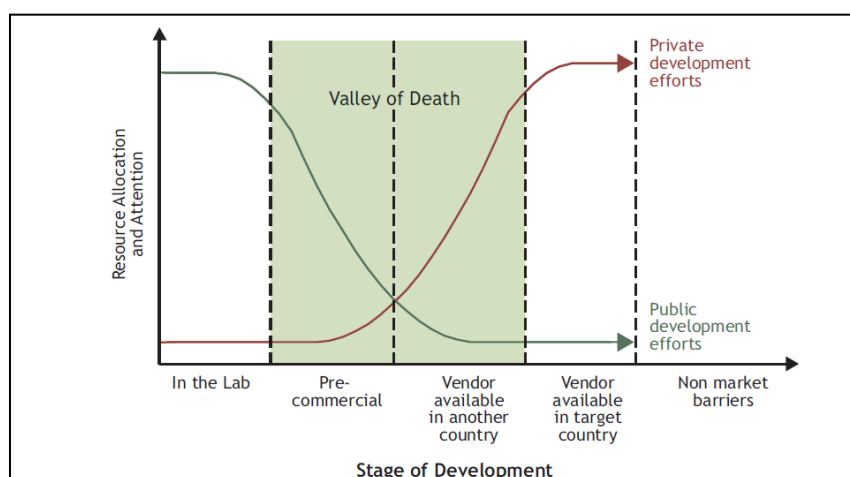
resource wastages, duplication of efforts, and most importantly discouraged interaction and linkages amongst key stakeholders.

### Low investments in science, technology and innovation in most recipient African countries

African leaders have pledged to devote more resources to the development of science and technology, an area deemed vital for economic development, yet long neglected and poorly funded in many countries. At a January 2007 summit of the continent's political body, the African Union, Heads of State urged all AU countries to allocate at least 1 per cent of their gross domestic product to research and development by 2020 (Mutume, 2007) - an idea already recommended by UNESCO. As at 2010, available data suggest that only few countries had met this target (Urama, et al 2010b). The low investment in R&D has consequently resulted in low scientific productivity in the form of patents, publications, commercializable products, and spin-off industries, etc.

Africa's participation in the CCT market has also suffered from the high expectations and dependence of foreign investments and low capacity to meet the stringent conditions and requirements for GEF funds. As aptly noted by UNDP 2009, development and commercialization of any technology require passing through a number of stages from basic research to widespread deployment (Figure 9).

Figure 9: Stages of Technology Development



(Source: UNDP 2009).

Most technology transfer projects in Africa are likely to end up in the so-called 'Valley of Death' which lies between proof of scientific concept by basic, mostly publicly- (and Donor) funded research and the uptake by the private sector to develop a commercial, profitable product. Neither governments nor private sector actors in Africa have the proper motivation or resources to advance technologies at this stage and, as a result, otherwise promising options can fail. While the 'Valley of Death' is a substantial impediment to timely technology commercialization in all parts of the world, it is even more pronounced in Africa. It will

therefore be difficult to realize a sustained CCT development, deployment and diffusion under such a scenario.

## V. CONCLUSION

The paper examined the current status of, existing constraints to, and opportunities for implementing CCTT between the Global North and the Global South with specific focus on United States of America and Africa, respectively. It emerged that the current design of CCTTs mostly treats technologies as hardware and technology transfer as movement of the hardware and the associated skills and know-how from the Global North to the Global South. This top-down methodology of North-South cooperation has often resulted in mixed outcomes.

It has constituted barriers to optimizing the potential mutual benefits from effective implementation of CCTT projects. Such barriers include, but are not limited to: global market failures; international trade rules and tariffs structures including the existing intellectual property rights (IPR) regimes; non-conducive policy environments in the recipient countries; lack local institutional and human capacities to adopt and use the transferred technologies; lack of political will, corruption, and poor leadership; non-existent and/or poor national systems of innovation, and low investments in science technology and innovation in most recipient African countries. The current linear models of technology transfer also lead to poor socialization of climate change technologies (CCTs) in the socio-cultural and political economy of the recipient countries. Furthermore, CCTT financing mechanisms such as the CDM is designed primarily to identify the cheapest and most profitable opportunities for reducing greenhouse gas (GHG) emissions in developing countries. Consequently, it encourages investments in those technologies and contexts that can offer lower technical and business risks. This reinforces static comparative advantages, marginalizing poorer countries and communities and further entrenching poverty. These constraints lead to sub-optimal outcomes and low sustainability rates in CCTT projects implemented in Africa.

Nevertheless, the existing evidence show that there could be many opportunities and mutual co-benefits of well-designed CCTT for climate sensitive sectors in Africa and technology developers in the Global North, including the United States. For Africa, well designed CCTT, with pro-poor financial mechanisms, would enable African countries to: leverage climate finance for more inclusive sustainable economic development and poverty reduction with reduced impacts on natural resources and the global environmental assets; improve energy access and human wellbeing; avoid technology-lock in to high Green House Gas (GHG) emitting technologies, and support transitions towards more climate resilient development in the region. For the Global North, effective CCTT to Africa would enhance: the achievement of many global commitments including the Millennium Development Goals (MDGs) in the less developed countries while offering many co-benefits to the technology developers. Such opportunities and co-benefits include: new frontiers for new technologies and innovations for economic growth expansion, new markets for investment diversification and employment creation; opportunity to avoid the possibility of reaching environmental thresholds or the so called “tipping points” which could limit global growth and

sustainability. It will also offer opportunities for capacity strengthening, new forms of North-South and South-North institutional partnerships, knowledge flows and networking; and reduce global vulnerability to climate change impacts. In addition, it could offer the global community an opportunity to avoid the future mitigation costs that would accrue if Africa, and the rest of the Annex II countries, continues with a 'business as usual' (BAU) development pathway. Continued BAU in the Annex II countries would have high GHG emissions as an unavoidable externality of economic growth and, *ipso facto*, limit the sustainability of the global space ship – "the earth."

We conclude that designing and implementing effective programs to foster socio-technological transitions in the developing countries is a necessary condition for global sustainability. To be more effective in achieving its desired objectives, CCTT projects require additional measures to: (i) enhance multi-lateral capacity strengthening at both institutional and individual scales; (ii) address market failures at the global, regional and national scales to improve regulations, codes and standards; legal systems reforms to enhance enforcement of CCTT contracts, provide intellectual property rights regimes that foster innovation, address bottlenecks in current climate finance facilities to encourage flexible pro-poor financial products; (iii) facilitate new forms of partnerships and knowledge-sharing amongst leading science and technology institutions and knowledge communities (centers of excellence) in both continents; (iv) encourage proactive effort to strengthen National Systems of Innovation and Science, Technology and Innovation (STI) policy environment in recipient countries; and (v) fully embed CCTT projects in local contexts of the recipient countries to encourage 'spin-offs' and 'spill over' effects. A reform of the global governance frameworks to ensure favorable intellectual property rights regimes and trade rules that enhance open access technologies, more flexible financial resources and information; joint research agenda for technology needs assessments and proactive engagement of all stakeholders throughout the life cycle of CCTs to foster social innovations are imperative. There is also urgent need to support African countries with enhanced investments in capacity strengthening in STI policy research and building national systems of innovation and favourable policy formulation to sustain the development, deployment, and diffusion of CCTT projects in Africa. Finally, we argue that for the pursuit of CCTT to contribute to global sustainability goals, there is need to broaden the framing and finance of CCTTs to include the relationships between social, political, economic and cultural dimensions of technical capabilities and knowledge circulation within and between countries. This, we argue, will enhance 'socio-technological transitions' to low carbon economies in Africa; not 'technology transfer.'

## Recommendations

### ***From Technology Transfer to Socio-Technological Transitions***

A recurring theme in technology and innovation studies is that fact that technologies are socially constructed, and its development, deployment and diffusion should be democratically governed. This is also a key recommendation of the recently launched African Manifesto for Science, Technology and Innovation developed after a 3 year multilateral dialogue with stakeholders in Africa, Europe and India, 2007 - 2010. Alternative conception of technology, rooted in the literature on innovation, emphasizes its systemic quality. From this perspective, technology is based on knowledge, skills and experience

distributed among firms and other organizations in particular contexts – for its development, deployment and diffusion. Transferring technologies from one context to another would not lead to sustainable outcomes. Though the conception of technology transfer has evolved from the linear to more holistic systems models in the literature, current CCTT implementation projects still emphasize the principles of the former. We therefore recommend that for CCTT to achieve sustainable development outcomes there is urgent need to broaden the framing and finance of CCTT projects to include the complex systemic relationships amongst the social, political, economic and cultural dimensions of technical capabilities and knowledge circulation within and between countries. This calls for more equal partnerships and effective engagement amongst all actors in the CCTT development, deployment and diffusion chain. This, we argue, will enhance socio-technological transitions to low carbon development pathways in Africa.

### ***Enhance Stakeholder participation in TNAs at country levels***

The first step toward a sustainable socio-technological transition will be to engage local expertise and practitioners in identifying the technology capacity gaps, needs and priorities. Though the UNFCCC provisions for TNAs emphasize the need for TNA activities to be carried out at national levels, the landscape is currently dominated by international consultants and individual experts often working with select Ministries and Government agencies in Africa. The spirit and principle of TNA requires full engagement of all stakeholders in the identification of needs and priority sectors. Identifying lead experts to implement TNAs has often been a challenge in Africa. Engaging longstanding STI institutions with pan-African mandates such as the African Technology Policy Studies Network (ATPS) and the Africa Climate Policy Centre (ACPC) could be helpful in ensuring broader engagement in TNA implementation in African countries.

### ***Mainstream CCTTs in National Development Plans***

African countries have not always given due attention to cooperation in the context of climate-related technology transfer. Consequently, most Global Environmental Facility (GEF) and CDM projects are not considered as part of the overall national development strategies. Embedding CCTT in national development policies and plans would go a long way to fostering national interest and effective implementation of CCTTs.

### ***Diversify CCTT investments to include adaptation and mitigation projects***

Assessments show that most projects supported by the GEF and the CDM in Africa have mainly been concentrated on reducing carbon dioxide emissions mainly through commercialization of renewable energy technologies, application of energy efficient technologies and the enhancement of forest carbon stocks through some forestry projects. Adaptation measures have been dealt with at the analytical level but no effective implementation projects have been implemented in Africa under the GEF financing mechanism (GEF, 2010). For Africa, adaptation is much more urgent than mitigation of GHGs.

### ***Prioritize capacity strengthening for African governments and technology based institutions in CCTT projects***

For CCTT projects to be sustainable, there is urgent need for institutional capacity strengthening for technology gate keepers on the continent and also all the key actors in the

national systems of innovation in Africa. Longstanding experiences in technology diffusion studies show that strengthening institutional capacities in African countries is key to successful diffusion of new technologies and innovations. In this regard, it is worth noting that there have been bilateral efforts between the U.S. government and a number of developing countries, among which are Egypt and the Southern African Development Community, to foster climate change technology transfer in the developing world through programs such as the Technology Cooperation Agreement Pilot Project (TCAPP) and the Climate Technology Partnership (CTP). Up-scaling such joint projects to reach other countries in the continent will be a positive step. These projects and programs can be implemented in partnership with academia, independent research organizations and laboratories with the African institutions and countries cost-sharing research with the U.S. to foster innovations and entrepreneurship culture in African countries. A number of pan African institutions have been established to assist the countries in capacity strengthening in science, technology and innovation to provide favourable policy environments for effective technology sharing. The U.S. government can for example, provide support to these institutions, such as the African Technology Policy Studies Network (ATPS) and the African Climate Policy Centre (ACPC), while also assisting the countries in achieving their development goals through bilateral aid. This will provide the necessary platforms for engaging more African actors and the civil society in the process of climate technology development and knowledge-sharing

***Conduct further research on the role of IPR and TRIPS agreements***

Though the divisiveness of issues related to IPR and TRIPS agreements is dominant in negotiations, there are not enough case studies in Africa to provide empirical evidence for more informed discussion on the subject. An in-depth study of the various aspects of the interaction between IP and the transfer of climate-related technologies could provide the basis for more productive and evidence-based discussions. Such studies will provide opportunities for the use of existing TRIPS flexibilities to promote the transfer of climate-related technologies to be explored in full. Possible measures related to IP and other incentive schemes to promote transfer of technology within the climate regime should also be explored.

## **African Technology Policy Studies Network (ATPS)**

ATPS is a multidisciplinary network of researchers, policymakers, private sectors and civil society actors promoting the generation, dissemination, use and mastery STI for Africa's development, environmental sustainability and global inclusion. It was established in 1994 and was incorporated as an independent African organization in August 2001. Subsequently, the ATPS Secretariat was accorded full Diplomatic status in Kenya on 3<sup>rd</sup> December 2003. ATPS operates through chapters in 29 countries across Africa and the Diaspora in Europe and USA. The overall objective of the ATPS is to build Africa's Science Technology and Innovation (STI) capacity today for sustainable development tomorrow. The strategic vision is to become the leading centre of excellence and reference in science, technology and innovation systems research, training and capacity building, communication and sensitization, knowledge brokerage, policy advocacy and outreach in Africa. The institution's mission is to improve the quality of science, technology and innovation systems research and policy making in Africa by strengthening capacity for science and technology knowledge generation, communication and dissemination, use and mastery for sustainable development in Africa. The overall policy-making body of ATPS is the international Board of Directors comprising African and non-African scholars, policymakers and private sector actors, who formulate and monitor the implementation of ATPS policies and procedures designed to fulfill the network's objectives. The ATPS Secretariat has an independent and dynamically evolving staff complement to provide executive direction, administrative implementation and physical infrastructure to the network. The Secretariat is led by a Secretariat Management Committee (SMC) chaired by the Executive Director. The ATPS has been funded by several donors and sponsors, among which include the International Development Research Centre (IDRC), the Royal Dutch Government, the Rockefeller Foundation, African Development Bank (AfDB), Technical Centre for Agriculture (CTA/Netherlands), Ford Foundation, Coca-Cola Eastern Africa, Carnegie Corporation, World Bank, OPEC Fund, Federal Government of Nigeria, World Bank-infoDev, UNESCO, UN-IDEP, NEPAD, OSF, and UNEP among others.

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<sup>1</sup> The historical experience is that stronger IPRs do not always result in more technology transfer and technology absorption. Hence the argument that developing countries should provide stronger protection of IPRs to encourage technology transfer has been challenged. The technology transfer under UNFCCC and Kyoto Protocol has been minimal and insufficient to meet the needs of developing countries. The harmonization of IPRs through TRIPS has also limited the options of countries to use compulsory licensing and competition policy. TRIPS agreements have not facilitated technology transfer, particularly to Least Developed Countries (LDCs) and the North-South divide on this issue has resulted in a stalemate. Under these circumstances it is futile to expect that TRIPS alone will result in more transfer of climate-friendly technologies. Using Common But Differentiated Responsibility principle in technology development and transfer is desirable (Srinivas, 2009).

<sup>2</sup> Ighodalo (2011) stressed that in terms of CCTT projects, local material research development can be easily pursued in Africa thanks to its endowment with natural and abundant energy resources.

<sup>3</sup> An important insight in the literature is that technology is not simply hardware. Embedded in the hardware is a reflection of the knowledge required to create it; and knowledge and skills are needed to adopt, use and adapt it – sometimes referred to as the software – (Bell and Pavitt, 1993; Ockwell et al, 2010).

<sup>4</sup> Technologies include not only market technologies, such as wind energy, but also non-market technologies, such as behavioural change in decreasing energy consumption (UNDP, 2009, p. 35). For sustainable solutions, special attention may need to be given to indigenous and non-market technologies, which often represent low cost solutions to local needs. These do not often follow the linear logic of technology development, deployment and diffusion.

<sup>5</sup> Technology needs is defined as the evolving need for new equipment, techniques, practical knowledge or skills to meet development priorities through provision of low greenhouse gas services or reduction of the vulnerability of sectors to promote sustainable livelihoods and minimize the extent and adverse impacts of climate change. Technology needs are further defined by both the context of national development priorities and the extent of international opportunities (UNDP, 2009).

<sup>6</sup> Soft technologies include technologies which contain soft elements such as organization, behaviour, information, knowledge networks, indigenous coping strategies, insurance schemes, and environmental dispatch protocols for electricity supply, etc., which are connected to the use of a technical solution. For example, an early-warning system for adaptation would rely on hard technologies such as measuring devices and information technology, but also on knowledge and skills to strengthen awareness and promote appropriate action when a warning is given.

<sup>7</sup> Over the next 25 years, 90% of the projected growth in global energy demand comes from non-OECD economies; China alone accounts for more than 30%, consolidating its position as the world's largest energy consumer. Compared to the energy consumption growth rate in OECD countries in 2010 (3.5%, the strongest growth rate since 1984), Non-OECD consumption grew by 7.5% and was 63% above the 2000 level. China surpassed the US as the world's largest energy consumer (IEA, 2011).

<sup>8</sup> The additional financing needs for climate change mitigation technologies are estimated to span a range of USD 262–670 billion per year, which is around three to four times greater than the current global investment levels. Of this increase, 40–60%, or an additional USD 105–402 billion per year, is projected to be needed in developing countries (Brewer, 2008).

<sup>9</sup> The need for enhanced action on technology transfer to developing countries has been recognized by EGTT (2009) as follows: "...not all countries have the technologies needed or the ability to innovate new technologies to mitigate and adapt to climate change. Those countries that are lacking in the technologies or capacity, mainly the developing countries, need

to be helped not merely to adopt the existing environmentally friendly technologies but also to develop the capacity to innovate new technologies and practices in cooperation with others.... Technology transfer includes not merely transfer of hardware but also of best practices, information and improvement of human skills, especially those possessed by specialized professionals and engineers. The acquisition and absorption of foreign technologies, and their further development, are complex processes that demand considerable knowledge and efforts on the part of those that acquire them. It is the capacity of the countries and the enabling environment in those countries that will enable them to change to a low carbon economy.”

<sup>10</sup> The EGT coordinates activities to support technology transfer.

<sup>11</sup> Regional hydro power technical potential was measured in terms of annual generation and installed capacity (GW); and current generation, installed capacity, average capacity factors and resulting undeveloped potential as of 2009.

<sup>12</sup> The world's population as of today is estimated to number 7.014 billion according to the [United States Census Bureau](#) (USCB). Africa's population is estimated to be 1.032 billion as at mid-2012 representing 15 percent of the total population of the world (United Nations Population Division).

<sup>13</sup> Originally created primarily to finance the reconstruction of war-torn Europe, the World Bank has become the primary financier of development projects in the Third World. It has also become the Third World's largest creditor. Together the countries of the Third World owe the World Bank more than US\$160 billion.

<sup>14</sup> Decision4/CP.7 of the UNFCCC defines TNAs as “a set of country-driven activities that identify and determine the mitigation and adaptation technology priorities of developing countries”. The same decision emphasises the need to involve different stakeholders in a consultative process to identify the barriers to T&T and measures to address these barriers through sectoral analyses.

<sup>15</sup> Many TNA studies document a number of barriers to successful implementation including: (i) how to identify the right experts and stakeholder representatives to be in the survey sample and what is the appropriate scale of the sample?, (ii) Weak awareness of climate and thus low rate of reply to questionnaire; (iii) Limitation of knowledge background across sectors of the investigated experts from specific sectors, etc.

<sup>16</sup> As of October 2008, Sub-Saharan Africa accounted for only 1.4 percent of all registered CDM projects—only 17 out of 1,186 projects—and most of these projects (14 out of 17) were located in just one country, South Africa (Bryan et al., 2008). UNECA, (2009) later revised this figure to less than 3% of registered CDM projects and enumerates factors limiting access to CDM facilities by African countries, ranging from the complex structure of the CDM facility, to its stringent procedures to safeguard the integrity of emissions reduction credits, and types of projects eligible for CDM, but also reasons attributable to the African context itself, such as the small size (and therefore small volume) in relative global terms of emissions reductions that could be generated by projects in Africa, perceptions of investment risk, lack of institutional capacity, lack of financing and information, etc.

<sup>17</sup> As argued by Byrne et al., 2012, this reflects the still-dominant (neo-liberal) assumption that markets will deliver social benefits more efficiently than other forms of economic organisation, and contributes an important element of what Newell and Paterson (2009, p81) call climate capitalism.

<sup>18</sup> Tariff rates in the biofuels industries had already been receiving some scrutiny in the context of U.S. renewable energy and agricultural legislation providing for increased subsidies for ethanol production, while extending a tariff on ethanol imports. In September 2007, Brazil added U.S. ethanol subsidies to a WTO dispute case (DS 365) against U.S. agricultural subsidies filed in July (FarmPolicy.com, 2007).

<sup>19</sup> Indeed, IP is potentially both an incentive and an obstacle the transfer of technology. IP rights were conceived as private rights to reward innovation and promote the dissemination of knowledge in the context of broader societal goals.

<sup>20</sup> The exact role of IP in the transfer of climate-related technologies remains unclear. No comprehensive study has been conducted on the impact of IP rights in the different categories of climate-related technologies.